PHYTOMEDICINES, HERBAL DRUGS, *and* POISONS

BEN-ERIK VAN WYK & MICHAEL WINK

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IMPORTANT WARNING
This book is a scientific review of medicinal and poisonous plants and not a medical handbook. Some of the plants described may result in death, serious intoxication, severe allergies and other harmful effects. None of the statements in this book can be interpreted as a recommendation to experiment with any of the plants. Neither the authors nor the publishers can be held responsible for claims arising from the mistaken identity of plants or their inappropriate use. Do not attempt self-diagnosis or self-treatment. Always consult a medical professional or qualified practitioner.

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Contents

Preface 6
Introduction 7
Traditional systems of medicine 8
Phytomedicines 16
Functional foods and nutraceuticals 18
Plant-derived chemical compounds 20
Mind-altering drugs and stimulants 22
Plant poisons 24
Plant parts used 28
Dosage forms 30
Methods and routes of administration 34
Extraction and analysis of compounds 36
Quality control and safety 40
Efficacy of herbal medicine 42
Pharmacological and toxic effects 44
Regulation and legal aspects 46
Overview of secondary metabolites 48
Photographic index of plants 92
Glossary 274
Further reading 285
Acknowledgements and photo credits 288
Index 289

Preface

Aide-mémoire to the Medicinal Plant Sciences or *Natural Products in a Nutshell* could have been equally appropriate titles for this bird's eye view of medicinal and poisonous plants.

The aim is to present the reader with a compact, fully illustrated, multilingual and user-friendly reference guide. The book covers 360 species of commercially relevant and well-known medicinal plants, including those used for their poisonous or mind-altering activities. It also briefly explains the basic concepts related to the botany, chemistry, pharmacology and use of these plants.

There are few books that cover the entire spectrum of medicinal, poisonous and mind-altering plants, a wide and complicated field of study. Not only are there thousands of plant species that are used in one way or another, but also many different medicinal systems and cultural groups that each have their own *materia medica* and their own ways of using plants. This makes for a fascinating and never-ending scientific exploration, to discover and to learn.

At the request of readers and publishers, we have attempted to condense a large volume of data and concepts into a limited number of pages, in order to present an affordable yet colourful summary of the most important facts relating to medicinal and poisonous plants from all corners of the earth.

This book should be viewed as a convenient and user-friendly starting point (a desk-top reference guide) to get quick, scientifically accurate answers to basic questions. Those who want to delve deeper into the subject can refer to our two other, more comprehensive reviews: *Medicinal Plants of the World* and *Mind-altering and Poisonous Plants of the World*, as well as the many scientific references that are cited there. In our fast-moving modern world, knowledge has become freely available on an unprecedented scale. There are excellent books on almost any conceivable aspect of medicinal botany and hundreds of thousands of scientific papers describing the details of chemical studies and pharmacological evaluations of plant compounds and extracts. Added to this is the worldwide web, where huge amounts of data can be accessed instantaneously. These sources generally provide the long answers, not the short ones. Our target audience covers the full range of readers: interested lay people who may want to use the book as an illustrated encyclopaedia, students of botany and pharmacology who need to prepare for an examination, professional persons working in the commercial environment and even academics and researchers who want to save time and need a quick reference guide and mnemonic aid.

Ben-Erik van Wyk and Michael Wink

1 September 2014

Introduction

This book is intended to be a handy desktop reference book to well-known medicinal and poisonous plants of the world. It is aimed at providing health care professionals, pharmacists, doctors, students and all other interested persons with quick answers to basic questions about medicinal and poisonous plants.

Fundamental concepts, terms and methods relevant to the subject are briefly defined and discussed in short introductory chapters. The aim is to provide scientifically rigorous and accurate information in a study field that is rapidly changing and adapting to the modern way of life.

The use of medicinal, mind-altering and poisonous plants is often associated with folk medicine, practised in distant rural areas where access to modern health care is not available. However, the popularity of natural remedies and botanicals in the modern world cannot be denied, as is seen in the rapid growth of over-the-counter medicines, dietary supplements and functional foods. Many people are taking control of their health by eating a balanced diet, getting regular exercise and using natural medicines and supplements that may help with the prevention and cure of ailments and imbalances. It therefore seems likely that basic knowledge about plant products and their chemical constituents will become increasingly important in the future, as we strive towards better health and a longer, happier life.

There are still many questions about the safety and efficacy of plant-derived products. Some of the answers can be found in this book. It is, however, likely that modern science will not only make dramatic new discoveries in health care, but also provide a deeper understanding of age-old principles that seemed implausible from a reductionist perspective. It took science more than 200 years to discover why limes (lemons) can prevent scurvy; it is not unreasonable to expect that profound new insights still lie ahead in the distant future, despite our best efforts to apply modern technology and the principles of science. When it comes to biology and human health, we know what we do not yet know (and therefore try to find answers to our questions through scientific research) but we also do not know what we do not yet know (and therefore eagerly await ground-breaking discoveries that will allow us to ask the right questions).

Mallow (*Malva sylvestris*): source of anthocyanin pigments

Traditional systems of medicine

The majority of people on earth still rely on traditional medicine for their primary health care needs. Modern allopathic medicine not only co-exists in parallel to the systems from which it was derived, but is often enriched by new discoveries based on ancient knowledge and experience. In general, traditional herbal remedies are used to alleviate the symptoms of chronic and self-terminating illnesses, while allopathic medicines are called upon in case of serious and acute health conditions.

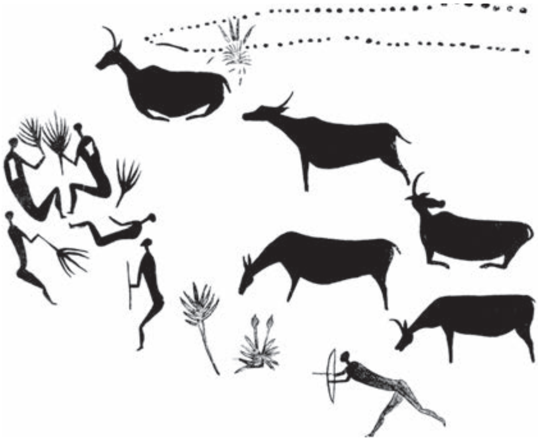
Ancient origins

There is evidence that primates such as chimpanzees and gorillas sometimes ingest particular plants not as food but for their medicinal value. The use of plants as medicine may therefore have a very long history. Recent evidence from southern Africa shows that human abstract thinking dates back to at least 140 000 years ago. This means that most of the history of how medicines developed was never recorded. It is likely that a lengthy process of trial and error resulted in some remedies being rejected as ineffective and perhaps dangerous, while others became important cures. The results of these experiments were no doubt passed on verbally from one generation to the next. In the absence of written records and to ensure maximum mnemonic value, important elements of the cure (i.e., the diagnosis of the ailment, the identity of the plant and the methods of administration) may have been intricately linked to one another within mythological stories, songs or poems. It is also likely that superstition and magic played important roles as ways in which people without scientific insights tried to make sense of what they observed. For example, disease is often associated with evil spirits, which is quite understandable if you have no access to a microscope. The act of "chasing away evil spirits" is almost certainly equivalent to our modern-day practice of using disinfectants and antiseptics.

Traditional medicine is also dynamic and adaptive, as can be seen by the rapid incorporation of recently introduced plant species into the *materia medica*. The process of trial and error was sometimes guided by the "doctrine of signatures", based on the belief that the Creator has provided the plants themselves with clues as to how they should be used. Milky latex, for example, may indicate therapeutic value in promoting lactation; red sap is associated with blood and may suggest efficacy in treating menstrual ailments; yellow sap suggests value as cholagogue, to increase or decrease bile flow, and so on. In traditional cultures there is not such a sharp distinction between food and medicine. Some products are eaten more for their health benefits than for their nutritional value; others are used not to cure any ailments but to prevent them in the first place. It is very likely that all medicines were originally eaten or chewed, as can still be seen in hunter-gatherer communities. Dosage forms such as infusions, decoctions and tinctures must have been a much later development. Some plants were used for ritual and religious purposes, especially those with hallucinogenic properties that provided insights into other realms and other worlds. Ancient systems also incorporate mental health, harmony and balance as important underlying principles of a good life.

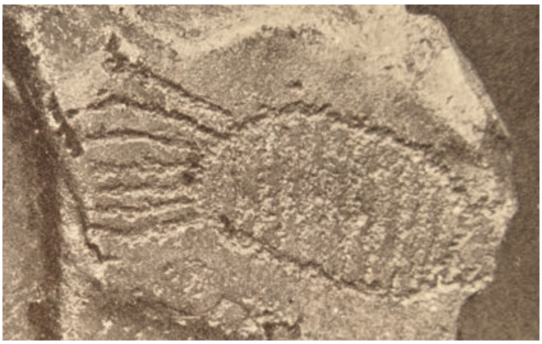
African medicine

African Traditional Medicine probably dates back to the origins of our species and represents the most diverse but also the least systematised and most poorly documented of all medicinal systems. There are many regional differences, reflecting the extreme biological and cultural diversity of sub-Saharan Africa, including local plant endemism and local cultural customs. Common to all is holism, in which both body and mind are treated: the underlying psychological basis of the illness is first attended to, after which herbs and other medicines are prescribed to alleviate the symptoms. The ancient practices of the click-speaking people of southern Africa are particularly interesting, not only because they represent the most ancient of human cultures, but also because their traditional home is an area of exceptional plant endemism. In South Africa, an integration of Khoi-San and Cape Dutch healing methods has resulted in a distinct and unique healing system, for which the name **Cape Herbal Medicine** was recently proposed. The remarkably diverse *materia medica* typically includes general tonics, fever remedies, sedatives, stomachics, diuretics, laxatives and many wound-healing plants. Tropical Africa and especially West and East Africa represent a rich diversity of medicinal plants and human cultures. Examples of locally important medicinal plants in Ethiopia include *Echinops kebericho*, *Embelia schimperi*, *Glinus*



San rock art showing aloes

San healing dance



Ancient rock engraving showing bushman poison bulb (*Boophone disticha*)

Juice resembling blood (*Pelargonium antidysentericum)*

Coffee (*Coffea arabica*) – the most popular of all stimulant beverages

Khat (*Catha edulis*) –wrapped in banana leaves to keep fresh

lotoides, *Hagenia abyssinica*, *Lepidium sativum*, *Moringa stenopetala*, *Phytolacca dodecandra*, *Ruta chalepensis* and *Taverniera abyssinica*. The commercially most relevant African medicinal plants have been described in a recent *African Herbal Pharmacopoeia*. It includes *Acacia senegal* (gum arabic), *Agathosma betulina* (buchu), *Aloe ferox* (Cape aloe), *Artemisia afra* (African wormwood), *Aspalathus linearis* (rooibos tea), *Boswellia sacra* (frankincense), *Commiphora myrrha* (myrrh), *Harpagophytum procumbens* (devil's claw), *Hibiscus sabdariffa* (hibiscus or roselle), *Hypoxis hemerocallidea* (African potato), *Ricinus communis* (castor oil plant) and *Prunus africana* (African cherry or red stinkwood). There are many hunting poisons [e.g. *Adenium obesum* (desert rose), *Boophone disticha* (bushman poison bulb)], ordeal poisons [e.g. *Physostigma venenosum* (calabar bean), *Erythrophleum suaveolens* (ordeal tree)] and stimulants [e.g. *Catha edulis* (khat), *Coffea arabica* (coffee) and *Sceletium tortuosum* (*kanna* or *kougoed*)].

European medicine

European medicine or Galenic medicine has a recorded history dating back to Hippocrates (460–377 BC), Aristotle (384–322 BC) and especially Galen (AD 131–199). The system was based on the four elements (earth, air, fire and water), corresponding with cold, heat, dampness and dryness and also with four humours (blood, phlegm, black bile and yellow bile) and four temperaments (respectively sanguine, phlegmatic, melancholic and choleric). Herbs were used to restore balance but sometimes drastic measures such as bloodletting and purging were used. The system was strongly influenced by what is considered to be the first European herbal, namely *De Materia Medica,* written by the Greek physician Dioscorides in the first century AD. Other famous names include Hildegard of Bingen (1098–1179) and the Swiss alchemist Paracelsus (1493–1541), who is remembered for recognising that the distinction between medicine and poison is only a matter of dose. Amongst the most famous herbals (medicinal handbooks) are the *Historia Stirpium* (1542) and *New Kreüterbuch* (1543) by the German physician Leonhart Fuchs, the *Kruydtboeck* (1581) by the Flemish botanist Matthias de Lobel, the *Herball* (1597) by the English horticulturalist John Gerard and *The English Physician* (1652) by the English pharmacist Nicholas Culpeper.

Herbal medicines are still widely used in countries such as Germany, Austria, France, Italy, Great Britain and Switzerland as natural alternatives to synthetic chemicals, or as supportive treatments. The system incorporates remedies from many parts of the world and is now highly regulated (e.g. through modern pharmacopoeias). Crude drugs are still widely used but sophisticated phytomedicines are becoming increasingly popular because their safety and efficacy have been proven through clinical studies. Commercialised European herbal medicines include *Arnica montana* (arnica), *Drimia maritima* (squill), *Matricaria chamomilla* (chamomile), *Silybum marianum* (milk-thistle), *Urtica dioica* (nettle), *Valeriana officinalis* (valerian) and many others. Famous poisons, formerly used for suicide, murder, execution and political purposes, include *Aconitum napellus* (aconite), *Conium maculatum* (poison hemlock) and *Veratrum album* (white hellebore). The most famous aphrodisiac and hallucinogen is *Atropa belladonna* (deadly nightshade). Pure chemical compounds originally derived from European plants that are used in modern medicine include aspirin and atropine.

Several more holistic approaches to health care had their origins in Europe, including aromatherapy, homoeopathy, anthroposophical medicine and Bach flower remedies. It is interesting and surprising that these somewhat controversial alternative systems had their origins in a region that is dominated by the Western allopathic system with its strong emphasis on evidence-based medicine.

Aromatherapy is a healing system that uses volatile oils as inhalations, massages, baths and perfumes to treat the symptoms of disease and to maintain health. The term aromatherapy was first used in 1928 by the French chemist René Gattefossé. Perhaps the oldest form of aromatherapy was practised by the Sanqua (bushmen) of southern Africa, who habitually massaged themselves with powdered aromatic bushes (*san*) mixed with fat (hence *Sanqua*, *-qua* meaning people). Frankincense and myrrh are still widely used as perfumes and aromatic products, in the same way as was done in ancient Egypt. Essential oils can be absorbed through the skin and mucosa and they are known for their antiseptic, anti-inflammatory and spasmolytic effects. As is the case with perfumes, they are likely to stimulate the mind and mood and along this route also contribute to the restoration of good health and vigour.

Homoeopathy (or homeopathy) is a system of healing proposed by Samuel Hahnemann in Leipzig, Germany, between 1811 and 1820. It is based on the theory that substances can be ingested in very dilute form to treat illnesses associated with the symptoms that would be produced by high doses of the same substances. If a high dose is emetic, for example, then a dilute dose is used as anti-emetic. The word comes from the Greek *homoios* (like) and *-pathy* or *patheia* (suffering). The number of times a mother tincture has been diluted ten-fold (through the so-called process of potentising) is stated after the name of the medicine. For example *Arnika* D3 means a three-times ten-fold dilution; it is considered to be weaker than the more potentised *Arnika* D30. Potentising involves vigorous shaking of the solution with the idea that this action releases immaterial forces from the extracts. Products such as minerals (e.g. arsenic, sulfur) and animal products (e.g. bee venom) are also used.

Anthroposophical medicine is based on principles proposed by the Austrian philosopher and

Title pages of classical medicinal texts: Dioscorides, Galen and Avicenna

Examples of European medicinal plants: poison hemlock (*Conium maculatum*), wall pepper (*Sedum acre*) and cranberry (*Vaccinium oxycoccus*) [Hand-coloured Dutch copper plate engravings from 1815]

social reformer Rudolf Steiner in the 1920s. It is a holistic approach that is based on elements of Galenical theories and on homoeopathy in order to stimulate the body into a natural process of healing. It is considered to be partly a replacement and partly an alternative to conventional medicine. An example of a popular (but controversial) treatment is the use of mistletoe extracts to treat cancer patients.

Bach Flower Remedies is a healing system similar to homoeopathy that was proposed by the English homeopath Edward Bach in the 1930s. The system is based on the belief that the healing power of flowers is transferred to water and alcohol by sunlight. The remedies are mainly used to treat emotional and spiritual disorders such as anxiety, insomnia, stress and depression. The range of products originally included 38 different Flower Remedies, each supposedly suitable for a specific personality type. A review of clinical studies indicated efficacy similar to that which would be expected from the placebo effect.

Middle Eastern medicine

Middle Eastern Traditional Medicine (including Mediterranean North Africa) is associated with the cradle of civilisation and the earliest of all written records of medicinal plants. Clay tablets dating back at least 4 000 years, show that the ancient Assyrians, Babylonians and Sumerians used not only herbal medicines but also prescription pads. Egyptian tomb walls from the Old Kingdom (ca. 2700–2200 BC) show herbal remedies. The Babylonian Code of Hammurabi (carved in stone, ca. 1700 BC) included a list of medicinal plants. The famous Ebers Papyrus (1500 BC) contains Egyptian hieroglyphics showing 800 ancient medicinal recipes, of which 700 include medicinal plants. Herbs are also recorded in the Bible (1500 BC or earlier) and on numerous cuneiform marble tablets made during the reign of the Assyrian King Ashurbanipal of Nineveh (ca. 668–626 BC). It is likely that many of the healing systems of the Old World are directly or indirectly linked to the Middle East. The famous *Canon Medicinae* of the Arabian physician Avicenna (AD 980–1037) formed the basis of a distinct Islamic healing system known as *Unani-Tibb*. Examples of two influential scholars and botanists of the 13th century are Ibn Zuhr (Avenzoar) who wrote the *Kitab al-taysis* and Ibn al-Baytar known for his *Compendium of Simple Medicaments and Foods*. Well-known Middle Eastern and Egyptian medicinal plants include *Allium cepa* (onion), *Aloe vera*, *Astracantha gummifera* (tragacanth), *Carthamus tinctorius* (safflower), *Carum carvi* (caraway), *Ferula assa-foetida* (asafoetida), *Lawsonia inermis* (henna), *Prunus dulcis* (almond), *Punica granatum* (pomegranate), *Rosa ×damascena* (Damask rose), *Salvadora persica* (toothbrush tree), *Senna alexandrina* (senna), *Sesamum indicum* (sesame), *Trachyspermum ammi* (ajowan), *Trigonella foenum-graecum* (fenugreek) and *Vitis vinifera* (grape). Stimulants include *Papaver somniferum* (opium), *Peganum harmala* (Syrian rue) and wine from *Vitis vinifera* (grape).

Chinese medicine

Traditional Chinese Medicine is an ancient system (more than 5 000 years old), based on the principles of *yin* and *yang* (opposites that complement each other) and five elements (*wuxing*), namely earth, metal, water, wood and fire, linked to organ systems of the body (respectively the spleen, lungs, kidneys, liver and heart), the emotions (reflection, grief, fear, anger, joy), the climates (damp, dry, cold, windy, hot), the seasons (late summer, autumn, winter, spring, summer) and tastes (sweet, pungent, salty, sour, bitter). Ancient records include the *Shen Nong Ben Cao Jing* or *The Great Native Herbal* (ca. 2737 BC) by the Chinese emperor and scholar Shen Nong of the Sung Dynasty (translated by Tao Hung Jing and well known as *Comment on The Divine Husbandman's Classic of the Materia Medica*), *Formulas for the 52 Ailments* by Wu Shi Er Bing Fang (403 BC), the *Classic of the Mountains and the Seas* by Shan Hai Jing (ca. 403–221 BC) and especially the *Huang Di Nei Jing* or *Yellow Emperor's Inner Classic* (ca. 100–200 BC) and the more recent *Ben Cao Gang Mu*, compiled by Li Shi-Zhen (AD 1590). Amongst several modern pharmacopoeias is the *Modern Day Encyclopaedia of Chinese Materia Medica* (1977) which lists 4 800 plant-based remedies. In common with Western herbal teas and African Traditional Medicine, Chinese herbs are used to restore balance and to alleviate the symptoms of chronic and self-terminating illnesses. They are mostly used in fixed mixtures (called formulas) of up to 20 herbs, prepared strictly according to the traditional recipes of the ancient compendia. In 1956, the Chinese authorities established the concept of Integrative Medicine, with the aim of strengthening the ancient system by selectively applying modern scientific methods, so that the two systems can more easily co-exist, with mutual benefits. The formulas are therefore widely used in hospitals and pharmacies alongside conventional medicine. Many of the East Asian traditional medicine systems have their roots in Chinese traditional medicine, such as the Korean and Japanese traditional systems (the latter is known as *kampo*). Chinese traditional medicine, including practices such as acupuncture and moxibustion, is becoming popular in many countries around the world. Famous medicinal plants include *Angelica sinensis* (*dang gui*), *Artemisia annua* (*qing hao*), *Ephedra sinica* (*ma huang*), *Paeonia lactiflora* (*bai shao yao*), *Panax ginseng* (*ren shen*) and *Rheum palmatum* (*da huang*). The worldwide trend towards more holistic health care is also reflected in the popularity of Chinese tonics and functional food items such as *Lycium chinense* (*go ji*), *Panax ginseng* (*ren shen*) and *Ziziphus jujuba* (*da zao*). Stimulants include *Camellia sinensis* (*chai* or tea), now a global favourite and second only to coffee as the most popular stimulant beverage.

Ayurvedic medicine

Ayurvedic medicine is the ancient medicinal system that is still followed in India. It was first

Aloe vera (from the *Codex Aniciae Julianae,* ca. AD 512)

Middle Eastern medicinal plants: asafoetida (*Ferula assa-foetida)* and senna (*Senna alexandrina*)

Wild-harvested Chinese ginseng root (*Panax ginseng*)

Indian body art using henna (*Lawsonia inermis*)

recorded in the four-part *Veda* (ca. 2000 BC) but represents a very old custom of passing down knowledge and wisdom in the form of songs and poems. *Ayurveda* is actually a set of guidelines on how to live a long life (from *ayur*, life and *veda*, knowledge or science) in order to achieve righteousness (*dharma*), wealth (*artha*) and happiness (*sukha*). The principles of Ayurvedic medicine and the uses of herbs are found in the form of poems in the *Rig Veda,* the *Atharva Veda,* the *Charaka Samhita* and the *Sunshrita Samhita*. The classical *Astangasangraha* and the popular *Astangahrdaya,* a shortened text comprising 7 120 poems, are attributed to Vagbhata, son of Simhagupta (ca. AD 550–600). Ayurveda is based on the concept of balance in bodily humours (*dosas*), an inner life force (*prana*) and six tastes or *rasas* (sweet, sour, salt, bitter, pungent and astringent). Herbal remedies are formulated to maintain or restore balance in the *dosas* and tastes. Well-known Ayurvedic medicinal plants include *Andrographis paniculata* (*kalmegh*), *Azadirachta indica* (*neem*), *Centella asiatica* (*gotu kola*), *Cinnamomum verum* (cinnamon), *Curcuma longa* (*haridra* or turmeric), *Rauvolfia serpentina* (Indian snakeroot), *Elettaria cardamomum* (*ela* or cardamom), *Santalum album* (sandalwood), *Terminalia* species (*myrobalan*) and *Withania somnifera* (*ashwagandha*). Murder and suicide are associated with *Cerbera odollam* (suicide tree), while traditional stimulants and narcotics include *Areca catechu* (betel), *Cannabis sativa* (marijuana) and *Papaver somniferum* (opium).

Australian and Southeast Asian medicine

Australian and Southeast Asian traditional medicine has remained relatively unknown but is likely to become more prominent in the future. There is a renewed interest in traditional medicine throughout the region and many countries are actively promoting the use of traditional remedies through the development of pharmacopoeias and research programmes. This is true not only for Australia, where efforts are being made to record and study the medicinal plants of the Aborigines, but also Borneo, Malaysia, Singapore, New Zealand, Polynesia, Thailand and Vietnam. Maori traditional medicine is called *Rongoa Maori* and makes use of well-known plants such as *koromiko* (*Hebe stricta*) and *pohutukawa* (*Metrosideros excelsa*) for diarrhoea and dysentery and *harakeke* (New Zealand flax, *Phormium tenax*) and *kowhai* (*Sophora tetraphylla*) for wounds and skin ailments. Malaysian traditional medicine includes *tongkat ali* (*Eurycoma longifolia*) and *kacip fatimah* (*Labisia pumila*), respectively male and female tonics. Other well-known medicinal products originating from this region are *Croton tiglium* (purging croton), *Duboisia hopwoodii* (*pituri*), *Eucalyptus globulus* (bluegum), *Melaleuca alternifolia* (tea tree), *Myristica fragrans* (nutmeg and mace), *Piper methysticum* (kava kava), *Strychnos nux-vomica* (strychnine), *Styrax benzoin* (benzoin) and *Syzygium aromaticum* (cloves). Traditional stimulants include *Mitragyna speciosa* (*kratom*) in Thailand, *Duboisia hopwoodii* (*pituri*) in Australia and *Piper methysticum* (kava kava) in Polynesia.

Latin American medicine

Latin American traditional medicine is practised in Central and South America. The system is similar to the African system in having a rich diversity of medicinal plants and cultural practices that are relatively poorly known outside the region. In contrast, many major food crops of the world originated here (e.g. maize, potatoes, tomatoes, pumpkins, cassava, peanuts and sweet potato). The three main pre-Columbian civilisations were the Aztecs (Mexico), the Incas (Peru to Chile and Argentina) and the Maya (southern Mexico to Guatemala, Belize, Honduras and Costa Rica). Traditional knowledge was sometimes recorded but the original manuscripts did not survive the Spanish conquests. An exception is the *Codex de la Cruz-Badiano*, an Aztec herbal that was originally written in 1552 by Martín de la Cruz in *Nahuatl* (the manuscript is no longer extant) but it was fortunately translated into Latin by Juan Badiano. The manuscript (also known as the *Libellus*) was returned from Europe to Mexico in 1990. Rural people in Latin American countries still use Native American medicine but there are many Spanish, European, Indian and African influences, resulting from non-indigenous plants as well as immigrant populations. Examples of medicinal plants that have become well known internationally include *Chenopodium ambrosioides* (wormseed goosefoot), *Cinchona pubescens* (Peruvian bark), *Myroxylon balsamum* (Tolu balsam), *Peumus boldus* (boldo), *Psidium guajava* (guava), *Smilax aristolochiaefolia* (sarsaparilla), *Spilanthes acmella* (Brazilian cress), *Tabebuia impetiginosa* (lapacho), *Turnera diffusa* (damiana) and *Uncaria tomentosa* (cat's claw). A special feature of the region is the rich diversity of stimulants, of which tobacco (*Nicotiana tabacum*) is the best known and most widely used in all parts of the world. Other famous stimulants include *Erythroxylum coca* (coca), *Ilex paraguariensis* (maté), *Paullinia cupana* (guaraná) and *Theobroma cacao* (cacao and chocolate). Poisons and hallucinogens include *Anadenanthera peregrina* (yopo), *Banisteriopsis caapi* (ayahuasca), *Brugmansia suaveolens* (angel's trumpet), *Cestrum parqui* (green cestrum), *Chondrodendron tomentosum* (pareira root), *Datura stramonium* (thorn-apple), *Ipomoea* species (morning glory) and *Lophophora williamsii* (peyote cactus).

North American medicine

North American traditional medicine is based on the holistic and shamanic methods of the indigenous people combined with European practices. Some of the plants have been incorporated in the United States Pharmacopoeia and have been developed as commercial products that became household names in many parts of the world. Early pioneers such as Samuel Thompson (1794–1868) started using indigenous remedies. Eclecticism, which became popular around the turn of the 19th century, is a system based on indigenous and European medicines that was first proposed by Wooster Beech (ca. 1830). This was followed by the Physiomedicalism movement (1850–1900) during which time indigenous remedies became popular. Several North American plants are still popular in Britain, mainly as a result of the influence that this movement had in Europe. The popularity of herbal remedies declined steeply during the 20th century, when attention shifted to pure chemical compounds, driven by technological developments and the success achieved by pure chemical compounds extracted from plants. In recent years, however, herbal medicines have

Examples of medicinal and poisonous plants: benzoin (*Styrax benzoin*), wormseed goosefoot (*Chenopodium ambrosioides*), winter bark (*Canella winterana*), poison sumac (*Rhus vernix*), quassia (*Quassia amara*) and potato (*Solanum tuberosum*)

once again gained in popularity but are mostly viewed (and indeed regulated) as dietary supplements (called "botanicals") rather than medicines in their own right. No direct medical claims are allowed and the products are typically sold as over-the-counter health products, used as supportive treatments. Some, however, have been subjected to clinical studies and are regarded as phytomedicines, used in much the same way as allopathic medicines. Examples of well-known medicinal plants are *Aralia racemosa* (American spikenard), *Capsicum frutescens* (chilli, cayenne), *Cimicifuga racemosa* (black cohosh), *Echinacea purpurea* (echinacea), *Gaultheria procumbens* (wintergreen), *Hamamelis virginiana* (witch hazel), *Hydrastis canadensis* (goldenseal), *Lobelia inflata* (Indian tobacco), *Mahonia aquifolium* (Oregon grape) and *Serenoa repens* (saw palmetto). Poisonous plants include *Gelsemium sempervirens* (yellow jasmine) and the infamous poison ivy (*Rhus toxicodendron*). Damiana (*Turnera diffusa*) is an example of a well-known stimulant.

Phytomedicines

Phytomedicines are plant parts or plant-derived natural substances that are used to treat ailments or alleviate their symptoms (*phyto* is Latin for "plant") in the same way as conventional drugs. The concept of phytomedicine is usually associated with products that have been adequately tested for safety and efficacy so that the consumer can expect real therapeutic benefits without serious risk. In contrast, traditional medicine or folk medicine may be equally effective but there is some degree of uncertainty about its ability to cure the intended ailment or alleviate its symptoms. The uncertainty may arise from questions about the level (concentration) of active ingredients, the proper dose level and its frequency and the most effective method of administration.

In rural societies, roughly 10% of all plants are typically used to some extent for medicinal purposes. This means that 25 000 plant species out of the estimated global total of 250 000 may already have empirical evidence for their therapeutic value. Scientists are continuously exploring the chemistry and pharmacological activities of poorly known medicinal plants in a quest to discover new remedies or to explain the modes of action of these plants. Through this process, the most promising plants (in terms of safety and efficacy) gradually become more popular and may end up as commercialised over-the-counter products.

Of the many traditional medicines that are used worldwide, relatively few have been subjected to rigorous human studies. The term phytomedicine should perhaps be reserved for standardised products (extracts or preparations) that have convincing proof of safety and efficacy in the form of at least one controlled clinical trial with a favourable outcome.

The following is a list of the best-known plant products that meet the criteria for being regarded as phytomedicines. Pure chemical entities are not really phytomedicines but are used in the same way as chemical compounds in prescription medicines (see page 20).

ashwagandha (*Withania somnifera*); roots: ergostane steroidal aglycones (withanolides), alkaloids (physical and psychological stress)
barley (*Hordeum vulgare*); fruit husks (cereal): β-glucans (reducing serum (LDL) cholesterol and controlling diabetes)
black cohosh (*Actaea racemosa*/*Cimicifuga racemosa*); rhizome and roots: triterpenoids (menopausal symptoms)
bloodroot (*Sanguinaria canadensis*); rhizome: sanguinarine (dental plaque, gingivitis)
bugleweed (*Lycopus europaeus*); herb: depsides of hydrocinnamic acids (antithyrotropic)
butterbur (*Petasites hybridus*); rhizomes: sesquiterpenes (petasin, isopetasin) (chronic headache and migraine)
chamomile (*Matricaria chamomilla*); flower heads: essential oil with α-bisabolol (anti-inflammatory, antibiotic)
chaste tree (*Vitex agnus-castus*); standardised extract from fruit: diterpenes (premenstrual stress syndrome, dysmenorrhoea, corpus luteum deficiency, mastalgia)
chilli pepper (*Capsicum* species); fruits: capsaicin (topical pain relief)
Chinese mock-barberry (*Schisandra chinensis*); fruits: lignans (schizandrin A, gomisin) (adaptogenic tonic, increased resistance to stress, hepatoprotective)
Chinese wormwood (*Artemisia annua*); herb: sesquiterpene lactones (artemisinin and derivatives) (antimalarial)
devil's claw (*Harpagophytum procumbens*); secondary roots: iridoid glycosides (low back pain)
echinacea (*Echinacea* species); whole herb and/or root: polysaccharides, alkamides, polyacetylenes, caffeic acids (colds, infections of the respiratory and urinary tracts)
evening primrose (*Oenothera biennis*); seed oil: gamma-linoleic acid (atopic eczema, pruritus, inflammation of skin)
fenugreek (*Trigonella foenum-graecum*); seeds: mucilage, steroidal saponins, alkaloids, peptides (hypoglycaemic, cholesterol-lowering)
feverfew (*Tanacetum parthenium*); herb: sesquiterpene lactones (migraine prophylactic)
flax (*Linum usitatissimum*); seeds: fatty acids, mucilage, lignans (managing high cholesterol and diabetes)
garlic (*Allium sativum*); bulbs: sulfur-containing compounds (antibiotic, lipid-lowering, platelet aggregation inhibiting)
ginger (*Zingiber officinale*); rhizome: pungent gingerols, diterpene lactones, sesquiterpenes (anti-emetic, post-operative nausea and travel sickness)
ginkgo (*Ginkgo biloba*); leaf: flavonoids, diterpene lactones (ginkgolides) (cerebrovascular insufficiency and Alzheimer's dementia)

Examples of phytomedicines: evening primrose, garlic, valerian and echinacea

ginseng (*Panax ginseng*); root: triterpenoid saponin (ginsenosides) (enhancement of mood, performance, immune response and convalescence)

griffonia (*Griffonia simplicifolia*); seeds: indole alkaloids (5-hydroxytryptophan) (neurological and psychiatric disorders)

hawthorn (*Crataegus monogyna*); leaves and flowers: procyanidins and flavonoids (cardiac insufficiency; heart rhythm disorders)

horse chestnut (*Aesculus hippocastanum*); seeds: triterpene saponins (venous and lymphatic insufficiency)

Iceland moss (*Cetraria islandica*); whole herb (thallus): polysaccharides (dry cough; inflammation of the mouth and throat)

Indian pennywort (*Centella asiatica*); whole herb: asiaticoside (wound treatment, prevention of scar tissue formation)

ivy (*Hedera helix*); leaf: saponins (cough, bronchitis, chronic catarrh)

kava kava (*Piper methysticum*); rhizome with roots: styrylpyrones (anxiolytic; anxiety, sleep disturbances, stress)

large cranberry (*Vaccinium macrocarpon*); fruit juice/extracts: acids, polyphenols, tannins, procyanidins, anthocyanins (urinary tract infections)

milk-thistle (*Silybum marianum*); fruits: silymarin (mixture of flavanolignans) (cirrhosis, chronic liver inflammation, liver damage)

mistletoe (*Viscum album*); herb: special extract: lectins, viscotoxins, polysaccharides [degenerative inflammation of joints, malignant tumours (palliative treatment)]

onion (*Allium cepa*); bulbs: sulfur-containing compounds (appetite loss, arteriosclerosis)

pale purple coneflower (*Echinacea pallida*); roots: polysaccharides, alkamides, polyacetylenes, caffeic acids (colds and influenza)

peppermint (*Mentha ×piperita*); leaf/essential oil: menthol (digestive ailments, catarrh, irritable bowel syndrome)

purple coneflower – see echinacea

pygeum – see red stinkwood

red stinkwood (*Prunus africana*); bark: phytosterols (benign prostate hyperplasia)

saw palmetto (*Serenoa repens*); fruits: phytosterols (benign prostate hyperplasia)

St John's wort (*Hypericum perforatum*); whole herb: hypericin, hyperforin (mild depression)

stinging nettle (*Urtica dioica*); roots: polysaccharides, a lectin, sitosterols and their glycosides (benign prostate hyperplasia, urological ailments)

tea tree (*Melaleuca alternifolia*); essential oil: terpinen-4-ol, α- and γ-terpinene and 1,8-cineole (acne, fungal infections)

umckaloabo (*Pelargonium sidoides*); root: coumarins (umckalin), tannins, flavonoids (bronchitis, immune stimulant)

valerian (*Valeriana officinalis*); roots: valerenic acid, essential oil, sedative; valtrate, didrovaltrate (minor nervous conditions)

white willow (*Salix alba*); bark: salicin (inflammation, rheumatism, pain)

winter cherry – see ashwagandha

witch hazel (*Hamamelis virginiana*); bark and leaves: tannins (varicose veins, haemorrhoids, diarrhoea)

yellow gentian (*Gentiana lutea*); rhizome and root: bitter secoiridoids (digestive disorders and loss of appetite; bitter tonic)

Functional foods and nutraceuticals

In old and holistic traditional healing systems such as Ayurveda and Chinese Traditional Medicine there has never been a strong distinction between medicine and food: some food items are eaten more for their medicinal than nutritional value. The modern trend in Western countries has been to develop and market functional foods and dietary supplements in order to escape the very strict regulations that apply to medicine. Dietary supplements, for example, do not need approval from the USA Food and Drug Administration but no medical claims may be made. Nutraceuticals can be defined as food items that are eaten for their extra health benefits, in addition to their basic nutritional value. The claims that are typically made include the alleviation of the symptoms of chronic diseases, the prevention of disease, improvement in general health, the delay of ageing, increased life expectancy and the support of the structure and/or function of the body. Functional foods resemble conventional food in appearance and use but often contain added ingredients that enrich the nutritional value and/or provide added medicinal or physiological benefits. In Japan, products sold as functional food have to be used in their natural form (tablets or powders are not allowed), they must be consumed as part of a normal daily diet and they should have some value in preventing or controlling diseases.

Prebiotics are non-digestible fibre compounds (mostly cellulose) that act as a substrate for the growth of beneficial microorganisms in the large bowel. **Probiotics** are beneficial living microorganisms (bacteria and fungi), usually consumed as part of fermented products such as yoghurt, that are claimed to provide added health benefits when ingested in adequate amounts.

Carotenoids are considered to be important dietary supplements: β-carotene acts as an antioxidant and is a precursor for vitamin A, lutein is believed to reduce the risk of macular degeneration, zeaxanthin is also associated with eye health while lycopene is linked to the support of a healthy prostate. Good sources of these nutraceuticals are carrots (carotene), broccoli (lutein), cooked tomatoes (lycopene) and goji berries (zeaxanthin).

Dietary fibres include four main groups of products with typical "soft claims" to promote their use. Insoluble fibres (wheat bran, corn bran and fruit skins) act as prebiotics and are considered to be important for digestive health; beta glucan (oat bran, oatmeal and rye) may reduce the risk of coronary heart disease; soluble fibres (e.g. psyllium seed husks, peas, beans, apples, citrus fruits, baobab) have the same claim but may also reduce the risk of some types of cancer; whole grains (cereal grains, whole wheat bread, oatmeal, brown rice) usually have the same claims as soluble fibres but also support the maintenance of healthy blood sugar levels.

Unsaturated fatty acids are believed to reduce the risk of coronary heart disease by lowering cholesterol. They include monounsaturated fatty acids (found in canola oil, olive oil and tree nuts) and polyunsaturated fatty acids (omega-3-fatty acids) found in flaxseed oil, flax seeds, walnuts and chia (seeds of *Salvia hispanica*; it has had novel food status in the EU since 2009).

Flavonoids are believed to be beneficial in acting as antioxidants and free-radical scavengers. These phenolic compounds include anthocyanins such as cyanidin, delphinidin, pelargonidin and malvidin (the pigments in berries, cherries and red grapes), flavonols and their derivatives such as catechins, epicatechins and epigallocatechins (in cocoa, chocolate, tea, apples and grapes), procyanidins and proanthocyanidins found in apples, grapes, red wine, chocolate, cinnamon, cranberries, peanuts and strawberries, flavanones such as hesperetin and naringenin in citrus fruits, and flavonols such as quercetin, kaempferol, isorhamnetin and myricetin in apples, broccoli, onions and tea.

Isothiocyanates (present in Brassicaceae such as broccoli, cabbage, cauliflower, horseradish and kale), plant stanols and sterols (present in pumpkin seeds and many types of oily seeds), phenolic acids (present in many fruits), minerals (e.g. calcium and magnesium) and vitamins are all included in the concept of dietary supplements. The classification of medicinal herbs as dietary supplements is a regulatory anomaly unique to the United States.

Examples of plants that are commonly promoted as health foods and dietary supplements are listed by their common names below.

acai berry (*Euterpe oleracea*)
African potato (*Hypoxis hemerocallidea*)
alfalfa – see lucerne
aloe vera (*Aloe vera*)
American spikenard (*Aralia racemosa*)

Berries are rich in anthocyanins and other antioxidants

Camu camu (*Myrciaria dubia*)

baobab (*Adansonia digitata*)
barley (*Hordeum vulgare*)
bear's garlic (*Allium ursinum*)
ben (behen) oil (*Moringa oleifera*)
bilberry – see blueberry
bitter aloe (*Aloe ferox*)
black chokeberry (*Aronia melanocarpa*)
black seed (*Nigella sativa*)
blackcurrant (*Ribes nigrum*)
bladder wrack (*Fucus vesiculosus*)
blueberry (*Vaccinium myrtillus*)
borage seed oil (*Borago officinalis*)
Brazilian cocoa – see guarana
buckthorn (*Hippophae rhamnoides*)
cacao (*Theobroma cacao*)
Cape aloe – see bitter aloe
camu camu (*Myrciaria dubia*)
carob powder (*Ceratonia siliqua*)
carrot juice (*Daucus carota*)
chia (*Salvia hispanica*)
Chinese date – see jujube fruit
Chinese wolfberry – see goji berry
chocolate – see cacao
chokeberry – see black chokeberry
cluster bean (*Cyamopsis tetragonolobus*)
cowberry (*Vaccinium vitis-idaea*)
cranberry (*Vaccinium macrocarpon*)
cress – see garden cress
evening primrose oil (*Oenothera biennis*)
fenugreek (*Trigonella foenum-graecum*)
flax – see linseed
garden cress (*Lepidium sativum*)
ghaap – see hoodia
ginger (*Zingiber officinale*)
goji berry (*Lycium chinense*)
grape (*Vitis vinifera*)
guar – see cluster bean
guarana (*Paullinia cupana*)
hibiscus tea (*Hibiscus sabdariffa*)
hoodia (*Hoodia gordonii*)
Indian mulberry – see noni fruit
Japanese raisin tree – see raisin tree
Japanese rose (*Rosa roxburghii*)
jujube fruit (*Ziziphus jujuba*)
kalonji – see black seed
karkade – see hibiscus
knotted wrack (*Ascophyllum nodosum*)
lemon verbena (*Aloysia citrodora*)
lingonberry – see cowberry
linseed (*Linum usitatissimum*)
lucerne (*Medicago sativa*)
miracle fruit (*Synsepalum dulciferum*)
miraculous berry – see miracle fruit
moringa leaf (*Moringa oleifera*)
nasturtium (*Tropaeolum majus*)
noni fruit (*Morinda citrifolia*)
oats (*Avena sativa*)
pineapple (*Ananas comosus*)
pomegranate juice (*Punica granatum*)
raisin tree (*Hovenia dulcis*)
ramsons – see bear's garlic
red clover (*Trifolium pratense*)
red-sorrel – see hibiscus
rooibos tea (*Aspalathus linearis*)
roselle – see hibiscus
safflower seed oil (*Carthamus tinctorius*)
sesame (*Sesamum indicum*)
soy lecithin (*Glycine max*)
stevia (*Stevia rebaudiana*)
sugar-leaf – see stevia
tamarind (*Tamarindus indica*)
tea, green tea (*Camellia sinensis*)
tomato (*Lycopersicon esculentum/Solanum lycopersicum*)
vervain – see lemon verbena
wild garlic – see bear's garlic

Plant-derived chemical compounds

There are many chemical compounds derived from plants that are used commercially for therapeutic and other purposes. Most widely used and best known of all is aspirin (Aspirin™), the acetylated form of salicylic acid. It was named after the original source of the latter, *Spiraea ulmaria* (now called *Filipendula ulmaria*). Other success stories include paclitaxel (Taxol®) from *Taxus* species (highly effective in the treatment of ovarian and breast cancer), reserpine from *Rauvolfia* species (effective in treating high blood pressure) and morphine from *Papaver somniferum* (a powerful painkiller). The following commercially important chemical compounds are either isolated from medicinal plants or produced through semi-synthesis from isolated precursors found in plants (marked by *) or directly synthesised but using the natural compound as lead (marked by **).

acetyldigoxin (cardiotonic): *Digitalis lanata*
aconitine (analgesic): *Aconitum napellus*
adoniside (cardiotonic): *Adonis vernalis*
aescin (anti-inflammatory): *Aesculus hippocastanum*
aesculetin (antidysentery): *Fraxinus rhynchophylla*
agrimophol (anthelmintic): *Agrimonia eupatoria*
ajmalicine (antihypertensive): *Rauvolfia serpentina*
ajmaline (antihypertensive): *R. serpentina*
allantoin (vulnerary): *Symphytum officinale* and others
allyl isothiocyanate (rubefacient): *Brassica nigra*
anabasine (insecticide): *Anabasis aphylla*
andrographolide (bacterial dysentery): *Andrographis paniculata*
anisodamine (anticholinergic): *Anisodus tanguticus*
anisodine (anticholinergic): *A. tanguticus*
apomorphine** (dopamine agonist; Parkinson's): *Papaver somniferum*
arecoline (anthelmintic): *Areca catechu*
artemether* (antimalarial): *Artemisia annua*
artemisinin (antimalarial): *A. annua*
asiaticoside (vulnerary): *Centella asiatica*
aspirin** (analgesic): *Salix alba*
atropine (anticholinergic): *Atropa belladonna*
benzyl benzoate [acaricide (scabicide)]: *Myroxylon balsamum* and others
berberine (bacterial dysentery, psoriasis treatment): *Berberis vulgaris*
bergenin (antitussive): *Ardisia japonica*
betulinic acid (antitumour agent): *Betula alba*
α-bisabolol (anti-inflammatory; skin care): *Matricaria chamomilla*; *Vanillosmopsis erythropappa*
borneol [insecticide, analgesic (moxa)]: *Artemisia argyri* and several others
bromelain (anti-inflammatory; proteolytic): *Ananas comosus*
caffeine (CNS stimulant): *Paullinia cupana*; *Coffea arabica*, *Camellia sinensis*
camphor (rubefacient): *Cinnamonum camphora*
camptothecin (antitumour): *Camptotheca acuminata*
capsaicin (topical analgesic; riot control): *Capsicum*
carotene (antioxidant): *Daucus carota*
catechin (haemostatic): *Potentilla fragaroides*
chymopapain (proteolytic; mucolytic): *Carica papaya*
cissampeline (skeletal muscle relaxant): *Cissampelos pareira*
cocaine (local anaesthetic): *Erythroxylum coca*
codeine* (analgesic; antitussive): *Papaver somniferum*
colchicaine amide* (antitumour): *Colchicum autumnale*
colchicine (antitumour; anti-gout): *C. autumnale*, *Gloriosa superba*
convallatoxin (cardiotonic): *Convallaria majalis*
curculin [sweetener (taste modifier)]: *Curculigo latifolia*
curcumin (choleretic): *Curcuma longa*
cynarin (choleretic): *Cynara scolymus*
dantron (laxative): *Senna*
demecolcine* (antitumour): *Colchicum autumnale*
deserpidine (antihypertensive; tranquilliser): *Rauvolfia canescens*
deslanoside (cardiotonic): *Digitalis lanata*
digitalin, digitoxin (cardiotonic): *Digitalis purpurea*
digoxin (cardiotonic): *D. lanata*
diosgenin (steroidal hormone synthesis): *Dioscorea villosa*
emetine (amoebicide; emetic): *Psychotria ipecacuanha*
ephedrine (sympathomimetic; respiratory): *Ephedra*
etoposide* (antitumour): *Podophyllum peltatum*
eugenol (dentistry): *Syzygium aromaticum*
galanthamine (Alzheimer's): *Galanthus woronowii*; *Lycoris squamigera*
gitalin (mixture) (cardiotonic): *Digitalis purpurea*
glaucaroubin (amoebicide): *Simarouba glauca*
glaucine (antitussive): *Glaucium flavum*
glaziovine (antidepressant): *Ocotea glazovii*
glycyrrhizin (sweetener): *Glycyrrhiza glabra*
gossypol (male contraceptive): *Gossypium*
guaiacol (anti-inflammatory; antioxidant): *Guaiacum officinale*
gymnemic acid (sweetness inhibitor): *Gymnema sylvestre*
hemsleyadin (bacterial dysentery): *Helmsleya amabilis*
hesperidin (capillary fragility; venotic): *Citrus*
huperzine A (Alzheimer's): *Huperzia serrata*; *Lycopodium clavatum*
hydrastine (haemostatic; astringent): *Hydrastis canadensis*

hyoscyamine (parasympathomimetic; anticholinergic): *Hyoscyamus niger*
ingenol mebutate (keratosis): *Euphorbia peplus*
irinotecan* (antitumour): *Camptotheca acuminata*
kainic acid (ascaricide): *Digenea simplex*
kawain (tranquilliser): *Piper methysticum*
khellin (bronchodilator): *Visnaga daucoides*
lanatosides A, B, C (cardiotonic): *Digitalis lanata*
L-DOPA (Parkinson's disease): *Mucuna deeringiana*
lobeline (smoking deterrent; anti-asthmatic): *Lobelia inflata*
mangiferin (antioxidant): *Mangifera indica*, *Cyclopia genistoides*
menthol (rubefacient, rhinitis, antispasmodic): *Mentha*
methyl salicylate (rubefacient): *Gaultheria procumbens*
miraculin [sweetener (taste modifier)]: *Synsepalum dulciferum*
monatin (sweetener): *Sclerochiton illicifolius*
monocrotaline (antitumour): *Crotalaria sessiliflora*
morphine (analgesic): *Papaver somniferum*
neoandrographolide (bacterial dysentery): *Andrographis paniculata*
nicotine (addiction therapy; insecticide): *Nicotiana*
nordihydroguaiaretic acid (antioxidant): *Larrea divaricata*
norpseudoephedrine (sympathomimetic): *Ephedra*
noscapine [antitussive (not analgesic)]: *Papaver somniferum*
ouabain (cardiotonic): *Strophanthus gratus*
pachycarpine (oxytocic): *Sophora pachycarpa*
paclitaxel* **Taxol**® (antitumour agent): *Taxus brevifolia*; *T. baccata*
palmatine (antipyretic; detoxicant): *Coptis japonica*
papain (proteolytic; mucolytic): *Carica papaya*
papaverine (smooth muscle relaxant): *Papaver somniferum*
permethrin* (insecticide; synthetic pyrethroid): *Chrysanthemum cinerariifolium*
phyllodulcin (sweetener): *Hydrangea macrophylla*
physostigmine (cholinesterase inhibitor; Alzheimer's): *Physostigma venenosum*
picrotoxin (analeptic): *Anamirta cocculus*
pilocarpine (parasympathomimetic; anti-glaucoma): *Pilocarpus jaborandi*
pinitol (antidiabetic): *Lessertia frutescens* and many others
podophyllotoxin (condylomata acuminata): *Podophyllum peltatum*
protoveratrines A and B (antihypertensive): *Veratrum album*
pseudoephedrine (sympathomimetic): *Ephedra*
pyrethrum (insecticide): *Chrysanthemum cinerariifolium*
quinidine (anti-arrhythmic): *Cinchona ledgeriana*
quinine [antimalarial; tonic (*amarum*)]: *C. ledgeriana*
quisqualic acid (anthelmintic): *Quisqualis indica*
rebaudioside A (sweetener): *Stevia rebaudiana*
rescinnamine (antihypertensive; tranquilliser): *Rauvolfia serpentina*
reserpine (antihypertensive; tranquilliser): *R. serpentina*
rhomitoxin (antihypertensive): *Rhododendron molle*
rorifone (antitussive): *Rorippa indica*
rotenone (piscicide): *Lonchocarpus nicou*; *Derris eliptica*
rotundine (analgesic; sedative): *Stephania sinica*
rutin (capillary fragility; venotonic): *Fagopyrum esculentum*; *Styphnolobium japonicum*
salicin (analgesic): *Salix alba*
sanguinarine (dental plaque inhibitor): *Sanguinaria canadensis*
santonin (ascaricide): *Artemisia maritima*
scillaren A (cardiotonic): *Drimia maritima*
scopolamine (sedative): *Datura metel*; *Hyoscyamus*
sennosides A and B (laxative): *Senna*
silymarin (anti-hepatotoxic): *Silybum marianum*
sparteine (anti-arrhythmic; oxytocic): *Cytisus scoparius*
spilanthol (local anaesthetic; toothache): *Spilanthes acmella*
stevioside (sweetener): *Stevia rebaudiana*
strychnine (CNS stimulant): *Strychnos nux-vomica*
teniposide* (antitumour): *Podophyllum peltatum*
tetrahydrocannabinol (anti-emetic; anti-glaucoma): *Cannabis sativa*
tetrahydropalmatine (analgesic; sedative): *Corydalis ambigua*
tetrandrine (antihypertensive): *Stephania tetrandra*
thaumatin (sweetener): *Thaumatococcus daniellii*
theobromine (diuretic; bronchodilator): *Theobroma cacao*
theophylline (diuretic; bronchodilator): *Camellia sinensis*
thymol (colds, disinfectant, topical antifungal): *Thymus vulgaris*
topotecan* (antitumour; anticancer agent): *Camptotheca acuminata*
trichosanthin (abortifacient): *Trichosanthes kirilowii*
tubocurarine (skeletal muscle relaxant): *Chondrodendron tomentosum*
valepotriates, valtrate (sedative): *Valeriana officinalis*
vanillin (masking agent; experimental medicine): *Vanilla planifolia*
vasicine, peganine (expectorant; bronchodilator): *Justicia adhatoda*
vinblastine (antitumour): *Catharanthus roseus*
vincamine (cerebral stimulant): *Vinca minor*
vincristine (antitumour): *Catharanthus roseus*
vindesine* (antitumour): *C. roseus*
vinorelbin* (antitumour): *C. roseus*
xanthotoxin (psoriasis; leukoderma; vitiligo): *Ammi majus*
yohimbine (aphrodisiac): *Pausinystalia yohimbe*
yuanhuacine (abortifacient): *Daphne genkwa*
yuanhuadine (abortifacient): *D. genkwa*
ziziphin (sweetness inhibitor): *Ziziphus jujuba*

Mind-altering drugs and stimulants

Mind-altering and psychoactive plants affect the brain and the central and peripheral nervous system, resulting in stimulant, sedative, hypnotic, narcotic and hallucinogenic effects. These plants and their chemical compounds are often poisonous and even lethally toxic at high doses. Recreational drugs are sometimes defined as substances taken to enhance enjoyment of life, creativity and spiritual growth. Psychoactive substances have a long history of use and most people routinely use caffeine (coffee, tea, maté, guarana) and theobromine (cacao, chocolate) as universally acceptable mild stimulants. Others such as alcohol, khat, ephedra and coca are often considered less desirable, depending on local preferences and prejudices. They may be socially acceptable in some communities and countries but classified as illegal drugs in others.

Sedatives, hypnotics and narcotics have sedating, sleep-inducing, anxiolytic or narcotic effects that may include euphoria, changed perceptions and vivid dreams. Examples include hops, opium, canna (sceletium), kava kava and valerian.

The larger and more controversial group of mind-altering drugs is the hallucinogens, also known as empathogens, entheogens, psychedelics, psychomimetics and psychotics. The plants or compounds cause pronounced changes in the perception of emotions, objects, time and space that appear to be real to the person who is under the influence of the drug. Hallucinogens have been used since ancient times for ritual, religious or magic purposes. They are nowadays also used by many people as recreational drugs. Some chemical compounds and designer drugs are similar to natural products, such as amphetamines, Ecstasy (MDMA or 3,4-methylenedioxy-*N*-methylamphetamine), LSD (synthetic ergot alkaloid), opiates and opioids, and tranquillisers (sedatives) such as barbiturates and benzodiazepines. Many of them are highly addictive and can lead to severe side effects, ultimately resulting in poor health, personality disorders and even in a fatal final outcome in severe cases. Most countries and societies attempt to limit or eradicate drug abuse by strict laws and severe penalties, especially for those who trade in illegal substances.

The following is a list of the best-known psychoactive plants and plant products (some fungi are included here).

African rue – see harmala
alcohol – see grape vine
angel's trumpet (*Brugmansia suaveolens*); all parts: tropane alkaloids (scopolamine, hyoscyamine)
ashwagandha (*Withania somnifera*); roots, leaves, aerial parts: withaferin A, withanolides (steroid lactones)
ayahuasca (*Banisteriopsis caapi*); bark and wood: β-carboline alkaloids; *N,N*-DMT
betel (*Areca catechu*); seeds: alkaloids (arecoline)
betel vine (*Piper betle*); leaves: eugenol, chavicol and monoterpenes
bitter lettuce (*Lactuca virosa*); tuber, herb: lactucin, lactucopicrin (sesquiterpene lactones)
bushman poison bulb (*Boophone disticha*); bulb: isoquinoline alkaloids (buphanidrin)
cannabis (*Cannabis sativa*); herb (resin): cannabinoids (tetrahydrocannabinol)
chacruna (*Psychotria viridis*); leaves: *N,N*-DMT; MMT; 2-methyltetrahydro-β-carboline
Chilean cardinal flower (*Lobelia tupa*); herb: lobeline, lelobine, lobinine
coca plant (*Erythroxylum coca*); leaves: cocaine, cuskohygrine, truxilline
cocaine – see coca plant
cacao (*Theobroma cacao*); seeds: theobromine (1.45%), caffeine (0.05%), tannins
coffee (*Coffea arabica*); seeds (leaves): purine alkaloids (caffeine)
corkwood duboisia (*Duboisia myoporoides*); leaves: scopolamine, hyoscyamine, tigloidine, and other tropane alkaloids; nicotine and related pyridine alkaloids
deadly nightshade (*Atropa belladonna*); all parts: tropane alkaloids (hyoscyamine, scopolamine, atropine)
desert tea – see ephedra
dream herb (*Calea ternifolia*); herb: diterpenes, sesquiterpene lactones
ephedra (*Ephedra sinica*); herb and roots: *L*-ephedrine, *D*-pseudoephedrine, *L,D*-norephedrine, *D*-norpseudoephedrine (0.5–3.3%)
ergot (*Claviceps purpurea*); fungal fruiting bodies: ergot alkaloids
fly agaric (*Amanita muscaria*); fruiting body: nitrogen-containing compounds (muscimol)
grape vine (*Vitis vinifera*); fruits: 20% sugar, anaerobically fermented to alcohol (ethanol)

Examples of popular psychoactive drugs: cocaine and cannabis (marijuana)

guaraná (*Paullinia cupana*); seeds, aerial parts: seeds with caffeine (3–8%); saponins
harmala (*Peganum harmala*); seeds and roots: harman alkaloids; aerial parts: quinoline alkaloids (peganine, vasicine)
hemp – see cannabis
henbane (*Hyoscyamus niger*); leaves, seeds, roots and herbs: hyoscyamine, atropine, scopolamine
Jimson weed – see thorn-apple
kava kava (*Piper methysticum*); roots, rhizome: kawa lactones (kavain, methysticin, yangonin)
khat (*Catha edulis*); fresh leaf: cathinone, cathine
kougoed – see sceletium
magic mint (*Salvia divinorum*); leaves: salvinorin A and B
magic mushroom – see teonanactl, fly agaric
mandrake (*Mandragora officinarum*); roots: hyoscyamine, atropine, scopolamine and other tropane alkaloids
marijuana – see cannabis
maté (*Ilex paraguariensis*); leaves: caffeine (up to 1.6%), theobromine (up to 0.45%)
monkshood (*Aconitum napellus*); all parts (tubers): terpene alkaloids (aconitine)
morning glory (*Ipomoea violacaea*); seeds: ergometrine; lysergic acid amide and other derivatives of lysergic acid
mu huang – see ephedra
nutmeg (*Myristica fragrans*); seeds: essential oil: myristicin (4%), eugenol, safrole, sabinene
ololiuqui (*Turbina corymbosa*); seeds, leaves, roots: ergot alkaloids: ergine, erginine
opiates and opioids – see opium poppy
opium lettuce – see bitter lettuce
opium poppy (*Papaver somniferum*); fruit, latex: papaverine, morphine, codeine, thebaine
peyote cactus (*Lophophora williamsii*); herb, aerial parts: mescaline and other phenylethylamines (4.5–7%)
pituri – see corkwood duboisia
prickly lettuce – see bitter lettuce
prickly poppy (*Argemone ochroleuca*); herb, seeds: isoquinoline alkaloids
sceletium (*Sceletium tortuosum* or *Mesembryanthemum tortuosum*); whole herb with roots: mesembrine, mesembrenol and other alkaloids
scopolia (*Scopolia carniolica*); rhizome, herb: hyoscyamine, scopolamine and other tropane alkaloids (up to 0.8%)
sinicuiche (*Heimia salicifolia*); aerial parts: lythrine, cryogenine, heimine and other atypical quinolizidine alkaloids
tea (*Camellia sinensis*); leaf: purine alkaloids (caffeine, theobromine, theophylline)
teonanacatl (*Psilocybe mexicana*); fruiting body: psilocybin, psilocin, baeocystine
thorn-apple (*Datura stramonium*); all parts: tropane alkaloids (hyoscyamine, scopolamine, atropine)
tobacco (*Nicotiana tabacum*); leaves: nicotine, nornicotine and other pyridine alkaloids (to 4%)
valerian (*Valeriana officinalis*); rhizome, roots: didrovaltrate and other valepotriates (iridoids)
virola (*Virola calophylloidea*); bark, seeds, resin: *N,N*-DMT; 5-MeO-DMT and other tryptamines; 6-methoxyharmaline and other β-carboline alkaloids
white henbane – see henbane
winter cherry – see ashwagandha
wormwood (*Artemisia absinthium*); herb: thujone (combined with alcohol)
yopo (*Anadenanthera peregrina*); seeds: bufotenin; *N,N*-DMT; 5-MeO-DMT

Plant poisons

Any substance that has a negative effect on an organism and its metabolism can be considered as toxic or poisonous. Toxicology is the scientific study of toxins and their effects. It is an important component (subdiscipline) of pharmacology and forensic science. Poisons are generally considered to be substances that can be lethal in small quantities, while toxins are less dangerous and toxicants only dangerous in high concentrations. Neurotoxins are generally more dangerous than cytotoxins and metabolic toxins. The former affects the brain and nervous system, while the latter disturbs organ systems such as the liver, kidneys, heart and lungs. It is a common misconception that *natural substances are safe*. Some of the most deadly poisons are natural substances produced by plants to deter or even kill pathogens, parasites and herbivores.

"Poisonous" and "toxic" are relative concepts. All natural substances with some physiological effect on the human body are potentially poisonous. What determines if a substance is poisonous or not? There are five important factors. (1) The potential harm of any substance is determined by the **dose**. Any substance, even vitamins, nutrients and water, can be toxic when ingested in large quantities. This principle was famously stated in 1537 by Paracelsus (1493–1541) as "*sola dosis facet venetum*" ("It is only the dose that makes a poison"). (2) The **route of administration** is critical. When substances are injected directly into the bloodstream they are generally much more poisonous than when they are ingested. The human body has several mechanisms by which toxins can be rendered harmless; they may be chemically converted (mostly in the liver) to less harmful substances that can be excreted. Curare alkaloids, for example, are harmless when ingested but lethal when injected. This allows them to be used as hunting poisons, because the meat of a poisoned animal can be safely eaten. Some medicines are used only as masticatories or enemas because exposure to acid in the stomach renders them ineffective. (3) The **dosage form** (solubility) determines if a substance is toxic or not. An infusion (tea) may be harmless while a tincture can be deadly, because toxic substances may dissolve in alcohol but not in water. Ricin, the extremely poisonous lectin in castor oil seeds, is not fat-soluble, so that the oil is can be safely ingested in small amounts. (4) The **frequency of exposure** can play a role (acute, sub-acute or chronic). Some compounds such as pyrrolizidine alkaloids are not particularly poisonous but may cause severe liver damage over a period of many years. (5) There are **individual differences** between people. Some people are more sensitive than others, so that doses have to be adapted to individual needs. This is not only due to genetic differences and various levels of enzymes, but is also related to age (children are more susceptible than adults, old people more than younger people), sex (women are more vulnerable than men), state of health (sick persons are more sensitive than healthy ones). Humans and animals also differ widely in their tolerance of toxins. Dogs and cats are surprisingly sensitive.

The relative toxicity of substances is determined in laboratory animals such as mice, rats, guinea pigs and rabbits. The LD_{50} value is that Lethal Dose that kills 50% of the test animals. It is easier to determine than the LD_{100} value, the dose that kills all the animals. LD values only make sense if the test animal and the route of administration are specified. These latter can be by mouth (*per os*, p.o.) or by injection – intravenous (i.v., into veins), intraperitoneal (i.p., into the peritoneum or abdominal cavity), intramuscular (i.m., into muscles) or subcutanous (s.c., below the skin). The testing of toxicity in living animals has become controversial, partly because small mammals are more sensitive than humans, so that only an indication can be obtained of the actual toxicity to be expected in humans.

Toxins have been classified by the World Health Organisation (WHO) into four classes, based on oral toxicity data (LD_{50} values) for rats:
Class Ia: extremely hazardous (less than 5 mg per kg body weight)
Class Ib: highly hazardous (5–50 mg per kg body weight)
Class II: moderately hazardous (50–500 mg per kg body weight)
Class III: slightly hazardous (more than 500 mg per kg body weight)

Typical symptoms of poisoning may include loss of appetite, salivation, nausea, vomiting, gastrointestinal disturbance, diarrhoea, respiratory and cardiac effects, delirium, spasms, convulsions, coma and death.

German postal stamp depicting Paracelsus


Ergot, growing on rye (*Secale cereale*)


Fly agaric (*Amanita muscaria*), one of the oldest hallucinogens

Strychnine (from *Strychnos nux-vomica*) was once a popular rodent poison

A list of the most deadly of all plant poisons is presented below. These are all classified in the WHO category Ia (extremely hazardous). Note that many of these species have close relatives that may be equally poisonous.

angel's trumpet (*Brugmansia suaveolens*); all parts: scopolamine, hyoscyamine, tigloidine, 3-tigloyloxytropane-6β-ol and other tropane alkaloids (up 0.4%); neurotoxin, mind-altering, medicinal plant

aspergillus (*Aspergillus flavus*); mycelia: aflatoxin; cell toxin, disturbance of GI tract, mutagenic

autumn crocus (*Colchicum autumnale*); all parts, especially seeds and bulbs: colchicine and related alkaloids; cell toxin, neurotoxin, medicinal plant, disturbance of the GI tract

bushman's poison (*Acokanthera oppositifolia*); stems, leaves, seeds: cardiac glycosides (ouabain); cell toxin, heart poison

calabar bean (*Physostigma venenosum*); seeds: physostigmine, eseramine, physovenine, and other indole alkaloids; neurotoxin, mind-altering, medicinal plant

castor oil plant (*Ricinus communis*); seeds: ricin (a mixture of four lectins), ricinine (pyridine alkaloid), ricinoleic acid (fatty acid); cell toxin, inflammatory, disturbance of the GI tract, medicinal plant

climbing lily – see flame lily

climbing potato (*Bowiea volubilis*); all parts, especially bulbs: scillaren-type bufadienolides: bovoside A, C, bowienine (alkaloid); cell toxin, heart poison, disturbance of GI tract, animal poison

cuckoo pint (*Arum maculatum*); aerial parts, fruits: aroin, cyanogenic glucosides, saponins, Ca^{2+}-oxalate crystals (sharp raphides which can penetrate cells); cell toxin, inflammatory, disturbance of GI tract

curare (*Strychnos toxifera*); all parts: toxiferine; neurotoxin, medicinal plant

curare vine (*Chondrodendron tomentosum*); aerial parts: curarine, tubocurarine; neurotoxin, mind-altering, medicinal plant

deadly nightshade (*Atropa belladonna*); all parts: hyoscyamine, scopolamine and other tropane alkaloids; neurotoxin, mind-altering, medicinal plant

dead-man's tree (*Synadenium cupulare*); all parts, latex: 12-*O*-tigloyl-4-deoxyphorbol-13-isobutyrate and several other tigliane-type diterpene esters of the 4-deoxyphorbol type; cell toxin, inflammatory, disturbance of the GI tract, animal poison

death camas (*Zigadenus brevibracteatus*); bulbs: zygadenine, zygacine, protoveratrine and related steroidal alkaloids; cell toxin, neurotoxin, mind-altering

death cap (*Amanita phalloides*); fruiting body: several peptides (amanitin and phalloidin); hallucinogen

desert rose (*Adenium obesum*); all parts: cardiac glycosides (obebioside); cell toxin, neurotoxin, heart poison

English yew (*Taxus baccata*); all parts (except red aril of fruits): taxin A, B, C; taxicin I, II; cell toxin, neurotoxin, medicinal plant

ergot (*Claviceps purpurea*); spore bodies (sclerotia): ergot alkaloids (ergotamine and others); neurotoxin, mind-altering

false morels (*Gyromitra esculenta*); fruiting body: monomethyl hydrazine; cell toxin, neurotoxin, disturbance of the GI tract

flame lily (*Gloriosa superba*); all parts, especially bulbs and seeds: colchicine, gloriosine, superbiine; cell toxin, neurotoxin, disturbance of the GI tract

fly agaric (*Amanita muscaria*); fruiting body: nitrogen compounds (ibotenic acid, muscimol, muscarine); neurotoxin, mind-altering

foxglove (*Digitalis purpurea*); all parts: several cardenolides (purpurea glycoside, lanatoside, digitoxin, digoxin); cell toxin, heart poison, disturbance of the GI tract, medicinal plant

gilled mushroom (*Lepiota helveola*); fruiting body: amanitins, phalloidins; cell toxin, neurotoxin, disturbance of the GI tract

green lily (*Schoenocaulon drummondii*); all parts, especially seeds: cevadine, veratridine, sabadine and other steroidal alkaloids; cell toxin, neurotoxin, mind-altering, disturbance of the GI tract

hellebore (*Helleborus viridis*); aerial parts: cardiac glycosides (bufadienolides), hellebrin, steroidal saponins (helleborin), ranunculoside, alkaloids (celliamine, sprintillamine); cell toxin, heart poison, disturbance of the GI tract, medicinal plant

henbane (*Hyoscyamus niger*); all parts, roots and seeds: hyoscyamine, atropine, scopolamine and other tropane alkaloids; neurotoxin, mind-altering, medicinal plant

jute mallow (*Corchorus olitorius*); seeds: cardenolides (corchorin, helveticoside, evonoside); cell toxin, heart poison, disturbance of the GI tract

karra (*Cleistanthus collinus*); all parts, leaves: heart poison, cleisthanin A, B (lignan glycoside); cell toxin, heart poison, disturbance of GI tract

larkspur (*Consolida regalis*); all parts, especially seeds: delcosine, lycoctonine and other terpene alkaloids; cell toxin, neurotoxin, mind-altering, animal poison

larkspur (*Delphinium elatum*); all parts, especially seeds: delphinine, nudicauline, staphisine, ajacine and other terpenoid alkaloids; cell toxin, neurotoxin, disturbance of the GI tract

lords and ladies – see cuckoo pint

mandrake (*Mandragora officinarum*); mainly roots: hyoscyamine, atropine, scopolamine and other tropane alkaloids; neurotoxin, mind-altering, disturbance of the GI tract, medicinal plant

mezereon (*Daphne mezereum*); all parts, especially red berries: mezerein (phorbol ester), daphnin (coumarin glycoside); cell toxin, inflammatory, disturbance of the GI tract

monkshood (*Aconitum napellus*); all parts (tubers): terpene alkaloids (aconitine); neurotoxin

naucleopsis (*Naucleopsis* species); latex: toxicariosides, cardenolides; cell toxin, neurotoxin, heart poison, disturbance of the GI tract

nux vomica (*Strychnos nux-vomica*); aerial parts, especially fruits and seeds: strychnine, brucine, colubrine and other monoterpene indole alkaloids; cell toxin, neurotoxin, mind-altering, medicinal plant

odollam tree – see suicide tree

oleander (*Nerium oleander*); all parts; nectar, even honey: oleandrin and several other cardenolides; cell toxin, heart poison, disturbance of the GI tract, medicinal plant

ordeal tree (*Erythrophleum suaveolens*); bark, aerial parts: cassaine, erythrophleine and other diterpenoid alkaloids; heart poison, disturbance of the GI tract, medicinal plant

Osage orange (*Maclura pomifera*); latex: taxicarioside, cardenolides; cell toxin, neurotoxin, heart poison, disturbance of the GI tract

poison hemlock (*Conium maculatum*); all parts, seeds: coniine, conhydrine and other piperidine


Curare poisons are traditionally used for South American blow darts


Bushman's poison (*Acokanthera oppositifolia*) – heart glycosides


Flame lily (*Gloriosa superba*) – colchicine


English yew (*Taxus baccata*) – diterpene pseudoalkaloids

alkaloids; neurotoxin, medicinal plant, mind-altering

poison leaf (*Dichapetalum cymosum*); aerial parts: monofluoroacetate is the main toxin; also dictamine and other furanoquinoline alkaloids, monoterpenes; cell toxin, mutagenic, neurotoxin, inflammatory, disturbance of the GI tract

poison olive (*Peddiea africana*); roots, aerial parts: Peddiea factor A1 and other diterpenoids (phorbolesters of the daphnane-type); cell toxin, neurotoxin, inflammatory, disturbance of the GI tract

purging croton (*Croton tiglium*); seeds: TPA, phorbol esters, crotonide (purine alkaloids), crotin (a toxic lectin); cell toxin, inflammatory, disturbance of the GI tract

rosary bean (*Abrus precatorius*); seeds: lectins (abrin A–D); cell toxin, neurotoxin

savin (*Juniperus sabina*); all parts, especially young twigs: 3–5% essential oil with sabinene and sabiylacetate, thujone, other monoterpenes; cell toxin, abortifacient, inflammatory, neurotoxin, mind-altering, animal poison

strophanthus (*Strophanthus gratus*); all parts, especially seeds: *k*-strophantoside, *k*-strophanthin, cymarin, strophantidol, periplocymarin and other cardenolides; cell toxin, neurotoxin, disturbance of the GI tract, heart poison, medicinal plant

suicide tree (*Cerbera odollam*); seeds: tanghin and other cardiac glycosides; cell toxin, heart poison, inflammatory

tamboti (*Spirostachys africana*); all parts, latex: diterpenes such as stachenone, stachenol; cell toxin, inflammatory, disturbance of the GI tract

thorn-apple (*Datura stramonium*); all parts, especially seeds and roots: hyoscyamine, scopolamine, atropine; neurotoxin, mind-altering, medicinal plant

upas tree (*Antiaris toxicaria*); aerial parts, latex: cardioactive glycosides (toxicariosides, antiarin derivates); cell toxin, heart poison

wild passion flower (*Adenia digitata*); all parts: lectin (modeccin), cyanogenic glucosides; cell toxin

witches tree (*Latua pubiflora*); all parts: hyoscyamine, atropine, scopolamine and other tropane alkaloids; neurotoxin, mind-altering

yellow heads (*Gnidia kraussiana*); all parts, fruits: phorbol esters of the daphnane type (kraussianin, gnidilatin, gnidilatidin), gnidicin, gnididin, gniditrin; cell toxin, inflammatory, neurotoxin, disturbance of the GI tract, animal poison

yellow jasmine/jessamine (*Gelsemium sempervirens*); all parts, roots, nectar: gelsemine, sempervirine and other indole alkaloids; cell toxin, neurotoxin, mind-altering

Plant parts used

The pharmaceutical names of plants and plant products are given in Latin in official documents and on product labels. This is not only to avoid confusion (with potentially fatal consequences), but also to make sure that the relevant plant part to be used is clearly specified. The chemical composition of roots, leaves, bark, fruits or seeds may be quite different, so that it is important to stipulate which part is suitable for use as medicine. Seeds, for example, may be quite toxic because of an accumulation of alkaloids, while the rest of the plant can be harmless in small doses. The latex from the fruit capsules of opium poppy (*Papaver somniferum*) is a source of opium alkaloids, while poppy seeds are practically alkaloid-free and used as a food and spice. (Be careful, however, as drug tests at airports may give a positive result even if you have only eaten a hamburger with poppy seeds on the bun!)

The following examples show how plant parts are indicated (in pharmaceutical names):

Entire plant (*herba tota*): the whole plant is used, roots and all (e.g. *Taraxacum officinale herba tota*).

Root (*rad.* or *radix*): fleshy or woody roots (or root bark) are used. Roots may be fibrous (stinging nettle, *Urtica dioica; Urticae radix*), solid (liquorice, *Glycyrrhiza glabra; Liquiritiae radix*) or fleshy (devil's claw, *Harpagophytum procumbens; Harpagophyti radix*).

Rhizome (*rhiz.* or *rhizoma*): a rhizome is a woody or fleshy elongated stem that usually grows horizontally below or at ground level, bearing leaves and roots. There is a clear distinction between roots and rhizomes yet the two are often confused. Examples of medicinal rhizomes include kava kava (*Piper methysticum; Kava-kava rhizoma*) and ginger (*Zingiber officinale; Zingiberis rhizoma*).

Bulb (*bulbus*): a bulb is a fleshy structure comprising several layers of fleshy leaf bases known as bulb scales. Examples are onion (*Allium cepa; Cepae bulbus*), garlic (*Allium sativum; Allii sativi bulbus*) and the European squill (*Drimia maritima; Scillae bulbus*).

Tuber (*tub.* or *tuber*): a tuber is a swollen, fleshy structure below the ground (often representing both stem and root). It is called a corm when a fibrous layer is present. Examples are hypoxis (*Hypoxis hemerocallidea*; *Hypoxidis tuber*) and autumn crocus (*Colchicum autumnale; Colchici tuber*).

Bark (*cort.* or *cortex*): bark is the outer protective layer of a tree trunk that is often periodically shed. It is formed from a layer of living cells (called the cambium) just above the wood itself. Chemical compounds often accumulate in bark (e.g. tannins and saponins), hence the reason why it is frequently used as medicine. Well-known medicinal barks include quinine (*Cinchona* species; *Chinae cortex*), pepperbark (*Warburgia salutaris*), oak bark (*Quercus* species; *Quercus cortex*) and willow bark (*Salix* species; *Salicis cortex*).

Wood (*lig.* or *lignum*): thick stems or the wood itself (often presented as wood chips) may be used as medicine. Examples include sandalwood (*Santalum album; Santali album lignum*) and quassia wood (*Quassia amara; Quassiae lignum*).

Leaf (*fol.* or *folium*): leaves alone may be used (*folium*), or leaves may occur in a mixture with petioles and twigs (*herba*). **Stems** (*stip.*, *stipes* or *stipites*) and even **stem tips** (*summ.* or *summitates*) are sometimes specified. Examples are the maidenhair tree (*Ginkgo biloba; Ginkgo folium*) where only the leaves are used, and bittersweet (*Solanum dulcamara*; *Dulcamarae stipites* or *stipes*) where the leafless stems (two or three years old) are used.

Aerial parts (*herba*): all aboveground parts are harvested as medicine, often just before or during flowering. Examples include spilanthes (*Spilanthis oleraceae herba*) and St John's wort (*Hypericum perforatum; Hyperici herba*).

Flowers (*flos*): flowers are sometimes used, such as cloves (the flower buds of *Syzygium aromaticum*; *Caryophylli flos*), chamomile flowers (*Matricaria chamomilla*; *Matricariae flos*) and Roman chamomile flowers (*Chamaemelum nobile*; *Chamomillae romanae flos*). Particular flower parts may be specified, such as hibiscus calyces (*Hibiscus sabdariffa*; *Hibisci flos*), the style branches of saffron (*Crocus sativus*; *Croci stigma*), the stigmas ("beard") of maize (*Zea mays*; *Maidis stigmas*) or even pollen (*pollinae*). The whole inflorescence or young infrutescence is sometimes used, such as the "cones" of hops (*Humulus lupulus*; *Lupuli strobulus*).

Fruit (*fr.* or *fructus*): fruits vary in structure and are sometimes wrongly referred to as seeds. An example is the small dry schizocarps in the Apiaceae

Examples of plant parts used in herbal medicine: roots (liquorice), rhizomes (ginger), bark (oak), wood (quassia), leaves (ginkgo), all aerial parts (St John's wort), flowers (chamomile), fleshy fruits (rose hips), dry fruits (cumin) and resin (myrrh)

family, each comprising two one-seeded mericarps that usually split apart at maturity. Examples are fennel fruits (*Foeniculum vulgare*; *Foeniculi fructus*) and anise (*Pimpinella anisum*; *Anisi fructus*). Small dry one-seeded nutlets (achenes) may be used, such as milk-thistle achenes (*Silybum marianum*; *Cardui mariae fructus*) or fleshy fruits or cones may be specially dried, such as saw palmetto fruits (*Serenoa repens; Sabal fructus*) or juniper "berries" (*Juniperus communis*; *Juniperi fructus*). Only specified parts of the fruit may be suitable, such as edible rose hip pericarps (*Rosae pericarpium*), or inedible pomegranate peel (*Punica granatum; Granati pericarpium*) and bitter-orange peel (*Citrus aurantium*; *Aurantii pericarpium*).

Seed (*sem.* or *semen*): seeds are contained within a fruit and may be used with or without the fruit pericarp. Examples include the true seeds (nuts) of the castor oil plant (*Ricinus communis; Ricini semen*) and fenugreek seeds (*Trigonella foenum-graecum*; *Foenugraeci semen*).

Gum (*gummi*): gums are solids consisting of water-soluble mixtures of polysaccharides. Gum may function as a defence mechanism to stop wood-boring insects and to seal off wounds so that wood-rotting fungi and bacteria are kept out. An example of an exudate gum is gum arabic (from *Acacia senegal; Gummi acaciae*) that is still used in the pharmaceutical industry. Gums mixed with water are known as gels. An example is the gel present in the inner leaf pulp of *Aloe ferox* and *A. vera*.

Resins (*resina*): plants have specialised ducts, glands or cells that excrete resins. Resins are mixtures of essential oils and polymerised terpenes. Unlike gums, they are usually insoluble in water. Examples are frankincense (from *Boswellia sacra*; *Olibanum*), myrrh (from *Commiphora myrrha; Myrrha*) and mastic (*Pistacia lentiscus; Resina mastix* – used as an adhesive for dental caps). Balsams (or balsamic resins) are resins with a high content of benzoic acid, cinnamic acid or their esters. Well-known examples include Tolu balsam (from *Myroxylon balsamum* var. *balsamum*), Siam benzoin (from *Styrax tonkinensis*) and Sumatra benzoin (*Styrax benzoin*). Storax balsams are collected from *Liquidambar* species (do not confuse them with balsams from *Styrax* species): Levant storax ("balm of Gilead" in the Bible) comes from *Liquidambar orientalis*; common storax from the sweet gum tree (*L. styraciflua*).

Fatty oil (*oleum*): non-volatile vegetable oils, insoluble in water, that are found in seeds or fruits. Oils are described as acylglycerides because they are formed from a glycerol molecule that is attached to various types of fatty acids. Castor oil (from *Ricinus communis* seeds) is an example with direct medicinal (laxative) properties, while others (almond oil, olive oil, safflower oil) are used as carrier oils in liquid formulations and ointments (e.g. in aromatherapy).

Essential oil (*aetheroleum*): these are volatile oils (= essential oils), selectively obtained from plants through steam distillation or through extraction with a non-polar solvent such as hexane. They consist mainly of monoterpenoids, sesquiterpenoids, phenylpropanoids and coumarins, and are important as biologically active ingredients of plants. Examples are camphor (from the wood of *Cinnamomum camphora; Camphorae aetheroleum*) and peppermint oil (from leaves of *Mentha ×piperita; Menthae piperitae aetheroleum*).

Dosage forms

Initially, phytomedicines were simply eaten, chewed, snuffed or applied externally; more sophisticated dosage forms such as infusions and tinctures developed later. The traditional methods of preparation were often aimed at eliminating some toxins or increasing the efficacy. The volume of plant materials used in relation to the volume and type of solvent used are critical. Plants are typically very variable but experienced traditional healers knew how to adjust dosages after an appraisal of the effects that the medicine had on their patients. Today, phytomedicines are carefully manufactured and standardised to ensure safety and efficacy. Dried leaves, roots and other plant parts are still widely used in the form of tea but specialised extracts and tablets are also available. Drug delivery systems of the future may involve microtechnology and nanotechnology. Sometimes the extract is manipulated to increase the concentration of desired compounds while eliminating or reducing unwanted substances. Since plants cannot be patented, such special extracts are often registered, branded and sold as proprietary products. There is a tendency to disregard traditional dosage forms (such as the old-fashioned tea) in favour of modern galenic dosage forms such as tablets and pills but the former is often much more appropriate and cost-effective.

Various dosage forms are listed alphabetically below.

Capsule: a small container (usually two gelatin halves sliding over one another) that contains powdered medicinal products or extracts in an exact dose. The content is protected from moisture, light and air. The capsule wall contains a softening agent such as glycerol or sorbitol to ensure that it readily dissolves. It is made from gelatin (an animal product) but special vegecaps (Vcaps™) are available for vegetarians. Soft gelatin capsules are spherical or ovoid containers used for oily (water-free) extracts, in liquid or semisolid form.

Decoction (*decoctum*): an extract prepared by adding cold water to the crude dug and then boiling it for 5–10 minutes (sometimes longer, for several hours). The concentration of some substances may be much higher than in an infusion prepared with the same weight and volume of starting materials.

Extract (*extractum*): a mixture of soluble chemical compounds, separated from the unwanted fibrous and non-soluble portion of a crude drug using water or alcohol (ethanol). An extract may be liquid or viscous but is often dried and powdered. Volatile oil can be extracted in hexane but is more often separated by steam distillation. The herb to extract ratio (HER) is typically 5:1 for normal extracts, or about 100:1 for essential oils. A modern method is supercritical fluid extraction, using liquid carbon dioxide. Liquid extracts are usually prepared in such a way that one part by volume of the preparation is equivalent to one part by weight of the crude drug. Soft extracts are prepared by evaporating the solvent until a soft mass is produced.

Granules: small particles produced by combining a concentrated powdered extract with a soluble excipient such as gelatin, lactose or sucrose. The granules are usually included in capsules or pressed to form tablets.

Infusion (*infusum*): an extract (usually referred to as "tea") prepared by adding boiling water to the crude drug and allowing it to steep for 5–10 minutes (without boiling). Infusions are easily contaminated by microbial growth and should be used within 12 hours.

Inhalation: a liquid preparation with volatile substances that are inhaled in order to treat the lining of the respiratory tract (nose, throat and lungs). The active ingredients may be volatile at room temperature or they are heated with hot (65 °C, not boiling) water and the vapour inhaled for 5–10 minutes.

Instant tea: a dried herbal extract mixed with a suitable filler or carrier. The carrier (typically lactose, sucrose or maltodextrin) increases bulk, reduces viscosity and improves solubility. Spray-drying is mostly used, where a concentrated infusion of the herb is sprayed at high pressure (as a mist) into a heated column with suspended particles of the carrier, which become coated with the herbal extract as it dries.

Juice (*succus*): a liquid prepared by crushing fresh plant material in water and then expressing the juice. Commercial juice is pasteurised or treated with ultra-high temperature to extend the shelf life.

Linctus: a viscous liquid preparation, usually containing sugar and medicinal substances and used for its demulcent, expectorant or sedative proper-


Gelatin capsules


Soft gelatin capsules


Infusion and decoction


Lozenges

Instant tea

Juices

Linctus

ties. They are sipped and swallowed slowly without the addition of water.

Liniment: a liquid or semi-liquid preparation intended for external application. It may contain substances with analgesic, rubefacient, soothing or stimulating activities.

Lotion: an aqueous or alcoholic solution or watery suspension intended for application to the skin.

Lozenge (pastille): neatly shaped lumps of moulded and solidified sugar containing medicinal extracts and intended for sucking or chewing, so that the active ingredients are slowly released in the mouth. They often contain smaller quantities of gums, colourants and flavourants.

Maceration (*maceratio*): an extract prepared by adding cold water to the crude drug and allowing it to soak at room temperature for 6–8 hours.

Medicinal oil: a medicinal extract dissolved in fatty oil or liquid wax and intended for internal or external use (e.g. garlic oil). Oils used in aromatherapy comprise an essential oil (or mixture of oils) dissolved in a carrier oil (often almond oil) or liquid wax (jojoba).

Medicinal spirits or medicinal essence: volatile compounds (usually essentials oils) dissolved in alcohol or alcohol–water mixtures. It may be produced by mixing aromatic herbs with alcohol and then recovering a mixture of the volatile compounds and the alcohol by steam distillation.

Mixture: two or more medicinal herbs that are used in a fixed combination. Mixtures are typical in Traditional Chinese Medicine and African Traditional Medicine, where the individual components may act individually and additively or even synergistically to restore or maintain health.

Monopreparation: a medicinal product that contains only a single herb (or extract) as active ingredient.

Nasal drops: liquid preparations instilled into the nostrils by means of a pipette.

Ointment, paste and gel: semi-solid preparations of medicinal substances dissolved in watery and/or oily solvents or emulsions and intended for external application.

Pill: a neatly shaped, small solidified lump made from a semisolid mixture of medicinal substances with a suitable bulking agent such as gum arabic. The material is cut into small portions of equal size and weight, rolled or shaped and then allowed to solidify. Pill-making was once part of the practical training of a pharmacist but the process is nowadays fully mechanised.

Snuff: dried and finely powdered plant material that can be drawn up into the nostrils through inhalation. Sneezing is traditionally thought of as a way to expel an ailment.

Special extract: a mixture of desirable chemical compounds, obtained by modifying and manipulating the extraction solvents (e.g. liquid carbon dioxide) in such a way that unwanted substances are reduced or eliminated.

Suppository: an oblong, tablet-like product that is inserted into the rectum, vagina or urethra and left to dissolve there. Herbs are more commonly used as enemas (liquid or semisolid preparations).

Syrup (*sirupus*): a viscous sugar solution used as flavouring or taste-masking agent or as cough medicine. It is usually a saturated solution of sucrose (66%) but should not contain less than 50%. Syrups are sterile because there is no free water available for microbial growth. When used as a cough remedy (*linctus*), the syrup is sipped slowly to ensure maximum contact with the inflamed mucous membranes.

Tablet: a neatly shaped, small lump made by compressing a mixture of powdered active ingredient and an excipient (inert binder and bulking agent). A colourant, flavourant and disintegrator may be added (the last-mentioned to ensure that the tablet rapidly dissolves when placed in water). Coated tablets are covered in a thin layer of sugar, colouring agent, fat, wax or special film-forming agents to improve their appearance, to mask an unpleasant taste, to make them smooth for easier swallowing, to prevent them from dissolving too rapidly and to improve shelf life. Film-coated tablets have a surface layer of cellulose acetate phthalate or other substances that resist gastric juices. This is to protect the stomach lining or to ensure that the active substances are only released when the tablet has reached the bowel.

Tea bag: a small porous paper container with a fixed quantity (dose) of finely chopped plant material. They are convenient to use but have a relatively short shelf life because the large surface area promotes not only rapid extraction but also the disadvantages of oxidation by air and evaporation of volatile compounds.

Tea mixture (*species*): a fixed mixture of herbs used for a specific indication (usually four to seven, included for specific purposes). There are active herbs (containing chemical compounds known to be of pharmaceutical benefit for the specific indication), supplementary herbs (supportive of the indication) and adjunct herbs (added to improve the taste, smell or colour of the mixture). Examples are *species amaricantes* (= bitter tea), *species anticystiticae* (= bladder tea), *species carminativae* (= carminative tea), *species laxantes* (= laxative tea) and *species sedativae* (= sedative tea or nerve tea).

Tea: an infusion made covering the herb in boiling water and allowing it to steep for several minutes while the water cools down. The word “tea” when used alone usually refers to black tea (*Camellia sinensis*), known in many parts of the world as *chai* (after the Cantonese and Mandarin name). In

Pills

Tablets

Tea bags

Tea mixture

African teas

African tinctures

the case of other "teas" the raw material has to be specified, e.g. hibiscus tea (*Hibiscus sabdariffa*) or rooibos tea (*Aspalathus linearis*). Sometimes the word "tea" may be ambiguous. Ginger tea or mint tea, for example, may refer to tea made from ginger or mint or to black tea flavoured with ginger or mint. Teas may be taken as pleasant hot drinks or for their therapeutic benefits and the distinction is not always clear.

Tincture (*tinctura*): an extract prepared by soaking the crude herb in an alcoholic solution (usually 70% alcohol) for a specified period, after which it is pressed and strained. The original extract (mother tincture) may then be diluted with pure water to a predetermined herb to extract ratio. No preservatives are necessary because the alcohol prevents microbial growth. To avoid alcohol, glycerides may be prepared by using glycerol as the solvent instead of alcohol.

Methods and routes of administration

The application of a medicinal substance may be topical (local) if it is applied on a localised part of the body, enteral when it is given via the digestive tract and parenteral when it is directly injected into the body. Topical may also refer to epicutaneous (applied on the skin), inhalational (applied into the lungs, through inhaling or smoking), enematic (applied into the rectum, as suppository), conjunctival (applied to the eye), otic (applied into the ear) and mucosal (applied to mucous membranes of the nose (through insufflation – snuffing, snorting); tongue (sublingual); between the lips and gums (sublabial); vaginal or rectal routes of administration. Enteral is application by mouth (or gastric feeding tube). Parenteral application includes intravenous, intra-arterial, intramuscular and subcutaneous. The route of administration is critical because some substances may be highly toxic when injected but harmless when ingested.

Bathing: herbs and herbal mixtures may be added to bath water to alleviate pain, to treat skin conditions and to simply maintain good health.

Conjunctival and otic application: medicinal substances are applied in the form of eye drops and ear drops. These preparations usually have anti-inflammatory, analgesic and antiseptic activities.

Ingestion: infusions (teas), decoctions, syrups and tinctures are usually taken orally (by mouth) and swallowed. The medicinal substances are subjected to acid hydrolysis in the stomach; some compounds may be lost, while others may be converted to the active form. In many cases, the compounds taken by mouth are merely the prodrugs. They may be converted into the active drugs in the stomach (through acid hydrolysis) or in the colon (through the action of bacterial enzymes). Some compounds may be inactivated in the stomach or may be metabolised in the liver.

Injection (parenteral application): suitable preparations are introduced directly into the bloodstream, usually with hypodermic needles and syringes. There are various other methods used in traditional societies, such as rubbing substances into small breaks or cuts in the skin (e.g., the Zulu practice of *umgaba*). Injection is a highly effective but also potentially lethal method. Many substances that are harmless when ingested can be deadly when injected (oral toxicity is often an order of magnitude less than parenteral toxicity).

Mastication: some herbs are typically used as masticatories and are held in various parts of the mouth (sublingual, sublabial), sometimes for extended periods. Active compounds are directly absorbed into the rich supply of blood vessels below the mucous membranes of the mouth and may rapidly reach the brain, unaltered by stomach acids or the liver. It is likely that humans once took all or most of their medicine in this way. Examples include chewing tobacco, betel nut, hoodia and sceletium. In traditional medicine systems, many herbs are used as snuff, not only to treat headache but also for the belief that the induction of sneezing will help to expel the disease. Powdered tobacco (snuff) and cocaine are typically used in this way.

Rectal or vaginal application: infusions and decoctions may be administered as enemas, using modern enema syringes or tubes. Specially prepared suppositories can also be used, so that the active ingredients are slowly released and absorbed over an extended period of time. The popularity of enemas varies greatly among healing cultures and different societies.

Rinsing and gargling: mouth rinses and gargles are usually aimed at antimicrobial (antiseptic) activity and to soothe infected and inflamed mucous membranes of the mouth and throat. They are also used for oral hygiene and the prevention of plaque and dental decay (or simply to freshen the breath). The products used are typically not swallowed, as they are often potentially toxic if ingested.

Smoking: smoking is a popular method to treat asthma and other respiratory conditions but is better known as the most popular method for inducing mind-altering and sedative effects. Many plant products have been used in this way, the most famous being tobacco, cannabis, opium and thorn apple (*Datura*). Smoking is sometimes used in traditional medicine to induce coughing, which is considered to be a way of expelling the perceived cause of the ailment. Various parts of the body may be subjected to smoke treatment or fumigation, for pain relief and to soothe the skin.

Herbal soaps for bathing

Eye drops for conjunctival application

Betel nut, a well-known masticatory

Plasters for wound care

Ointments and oils for topical application

Volatile oils for inhalation

Snuffing and snorting: powdered material is drawn up into the nasal passage, where the active substances are absorbed through the mucous membranes and rapidly reach the brain. This is a highly effective way of introducing soluble substances directly into the cerebral circulation.

Steaming: herbal steaming is a method used to maintain general health, to improve the complexion by opening pores in the skin and stimulating cutaneous circulation, and to induce sweating. Steaming may be used to introduce volatile compounds into the lungs (for chest complaints and asthma), the nose (for headache) and the genitalia (for relief of post-partum pain).

Topical/epicutaneous application: oily and semi-liquid preparations (dressings, ointments and creams) are applied directly on the skin. The use of poultices and plasters has become less common but is still commonly practised in traditional medicine. Leaves containing alkaloids (e.g. *Datura*) and plant materials containing essential oils (e.g. *Artemisia*) may be applied (often with some petroleum jelly or oil) to the chest area (for respiratory ailments and asthma), stomach area (for digestive problems), head (for relief of headache) and knees, elbows and other joints (for treating pain and arthritis). Skin patches can be used, typically to administer alkaloids through the skin. Examples include atropine (for pain relief and to treat motion sickness) and nicotine (for smoking cessation treatments, to break the physical habit of smoking and to gradually decrease physical and psychological dependency).

Extraction and analysis of compounds

The active and toxic ingredients in plants often occur in complex mixtures that may be highly variable, even within a single species. Plants from different populations and different geographical areas may show large quantitative differences and even some qualitative differences that are often genetically fixed. Only a small part of the variation can usually be ascribed to environmental factors and growing conditions. An important reason for studying the chemistry of medicinal plants is therefore not only to identify the main active phytochemicals but also to understand the complexity, in order to explain the rationale behind traditional uses from a scientific perspective. In order to study the chemical structure and biological activities of a chemical compound, it must first be extracted from the plant materials (mostly by using a suitable polar or non-polar solvent) after which it must be separated from other compounds in the crude extract by chromatographic methods. Chromatography is also used for analysis: to study extracts and pure compounds with the aim of separating all the constituents in a mixture so that they can be detected and their relative amounts determined. By determining the chromatographic behaviour of each compound and by comparing this behaviour with those of pure compounds of known chemical structure (authentic reference standards), the individual constituents can be identified and quantified.

Solvent extraction is done by soaking the chopped or milled plant material in a solvent such as water, methanol or acetone for several hours (often 24 hours). A special glass percolator, known as a soxhlet apparatus, can be used to extract and concentrate soluble substances at elevated temperatures. If the compounds of interest are non-polar (such as many terpenoids), methanol is often used as solvent. For polar compounds such as sugars, glycosides, proteins and lectins, water can be used.

Different compounds in a plant can be partly separated by using different solvents. Hexane, for example, can first be used to remove fats and terpenoids (e.g. essential oil), followed by water (to remove polar compounds) and then methanol (to remove non-polar constituents). Specialised methods of extraction can also be used, including supercritical fluid extraction (SFE), using liquid carbon dioxide as solvent.

Alkaloids can be selectively extracted because they form water-soluble salts under acidic conditions, while other non-polar compounds will not dissolve in the acidic water (e.g. 0.1 N H_2SO_4) that is typically used for extraction. After filtration, the watery extract is made alkaline (pH raised above 7) by adding a base such as ammonia. The alkaloids are converted to their free base forms in the alkaline medium and can now be extracted with a non-polar solvent such as chloroform or dichloromethane, leaving behind all non-alkaloidal compounds that remain water-soluble.

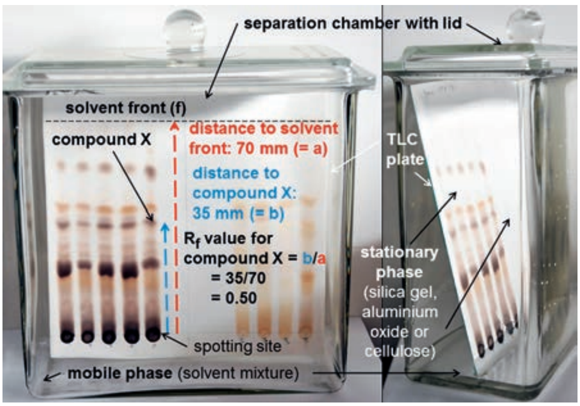
Volatile compounds can be selectively extracted using **distillation**. The plant material is boiled in water (hydrodistillation) or placed above boiling water so that the steam passes through the material (steam distillation). The process is done in a special still (or in the laboratory in a clevenger apparatus) fitted with a condensation cooler. Volatile substances are carried up with the steam and both condense in the cooler. The volatile substances (essential oil) are non-polar and float on top of the water as a separate layer that can easily be recovered.

The next step is to separate the compound of interest (e.g. the main compound) from all other compounds and to get a desired quantity of the pure compound for chemical and pharmacological analyses. **Column chromatography** is often used. A glass tube (column) is filled with a solid material (usually silica gel), which is called the stationary phase. The extract is applied to the top of the column, and a special solvent mixture of predetermined composition, called the mobile phase, is allowed to wash through the extract and the column. Different compounds will move at different rates through the column, depending on the polarity of the compound. More polar compounds absorb stronger on the polar silica and will move slower, emerging later at the end of the column. Fractions are collected in separate test tubes at the bottom of the column at regular intervals (e.g. every 30 seconds). The different test tubes (fractions) will now contain different compounds and those with the same (desired) constituent can be pooled. For larger compounds such as polysaccharides, proteins and lectins, size-exclusion chromatography can be used. In this case the stationary phase

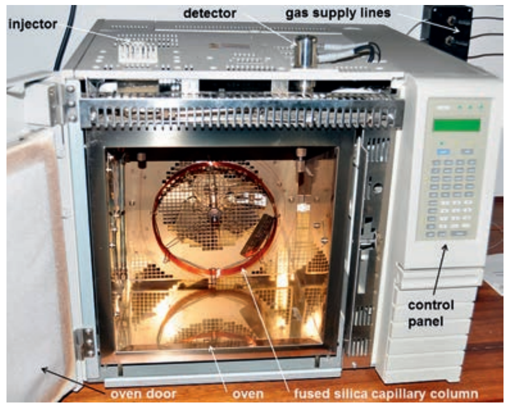

Solvent extraction


Solid phase extraction


Hydrodistillation



Thin layer chromatography (TLC)



Gas chromatography (GC) system

has small pores that trap smaller molecules and slow them down, while the larger ones move more freely through the column.

The pure compound can sometimes be recovered from a semi-pure mixed extract or fraction through crystallisation. By adding different solvents, it is may be possible to get the main compound to form crystals, which can then easily be filtered off from the rest of the mixture. Various other chromatographic methods can also be used; they are called preparative if the aim is to recover pure compounds, or analytical if the aim is to simply visualise and observe the various compounds in the mixture. Preparative paper chromatography (prep-PC), preparative thin-layer chromatography (prep-TLC) and preparative high-performance liquid chromatography (prep-HPLC) can all be used to isolate pure compounds.

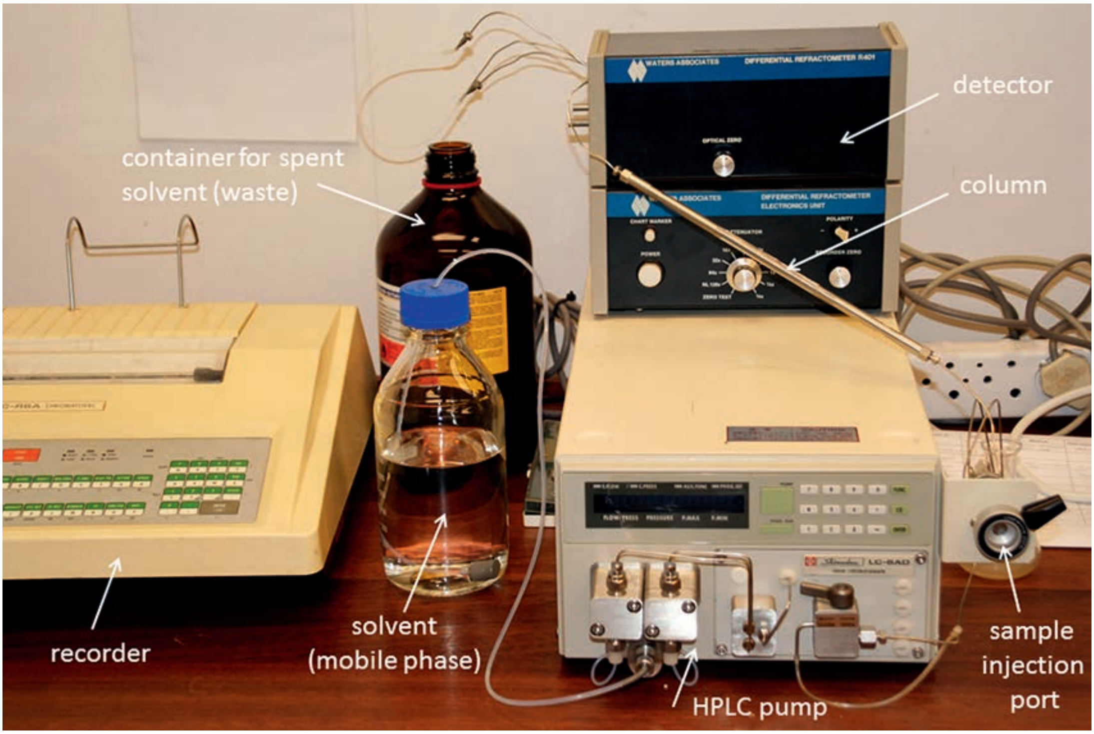
The chromatographic methods listed above are the same that are used for the analysis, identification and quantification of phytochemicals and mixtures of compounds. In analytical work, however, the stationary phase is reduced to a minimum (i.e., thinner layers and thinner columns are used) because they are better in separating the individual compounds and give a better resolution. They also require only minute quantities of the samples to be analysed.

Paper chromatography is the oldest and simplest chromatographic technique and is therefore described here in detail to explain the basic principles. The stationary phase in this case is a strip of paper (e.g. Whatman no. 1 filter paper), suspended in a trough with a suitable solvent mixture (the mobile phase). Spots of the extract are applied to the paper (just above the solvent, using a capillary tube) and the mobile phase is allowed to move through the paper by capillary action. Different compounds within the spots are separated, depending on their polarity. Once the mobile phase has reached the top of the paper, it can be removed and dried. The various compounds are now visible as coloured spots, or invisible constituents can be sprayed with (or dipped in) various detecting reagents to make them visible. The paper can also be studied under ultraviolet light. Short wavelength light (UV 254 nm) or long wavelength (UV 366 nm) will often allow a distinction in the appearance of the spots (substances) which can contribute to their identification. It is also possible to apply spots of known pure compounds (reference standards) alongside the spots of the extract mixtures. If a component in the mixture travels to the same height as the reference standard, then they may be the same compound. This is called the R_f value, i.e. the distance that the spot moved relative to the final position of the solvent front, expressed as a fraction. An R_f value of 0.5, for example, means that the spot moved half the distance from the position where it was applied to the final position of the solvent front. If it also has the same appearance as the authentic reference standard under normal and UV light, then it is even more likely to be the same compound. Paper chromatography is now an old and somewhat outdated method but it is inexpensive and still useful for separating and tentatively identifying flavonoids and especially anthocyanins. It is also a convenient way to isolate these pigments. The mixture is applied as a continuous line rather than as a spot. After the paper is developed, the bands containing the pure compounds can be cut out with scissors and the individual pigments washed out with methanol or other suitable solvents.

Thin-layer chromatography is done in the same way as paper chromatography, except that the stationary phase is a thin layer of cellulose, silica gel or aluminium oxide, coated onto a glass or aluminium plate. The procedure is usually performed in a chromatography tank with a tight-fitting lid to ensure that the air above the paper or plate remains saturated with vapours of the mobile phase until the separation has been completed and the paper or plate is removed and dried. A paper towel soaked in the mobile phase is often placed in the tank to saturate the atmosphere with solvent vapours. The best solvent systems for the various classes of compound have to be determined empirically but many standard recipes are available.

Gas chromatography (GC) [or more precisely called gas-liquid chromatography (GLC)] is used for volatile substances such as essential oils (but other compounds such as alkaloids may become volatile at high temperatures and can also be analysed). In this case the stationary phase is a narrow column (e.g. 0.25 mm in diameter), made from glass or fused silica. A thin special coating inside the column helps to slow down or accelerate the movement of compounds through the column, depending on their chemical interactions with the coating. A gas (often nitrogen) is used as the mobile phase. It flows through the column and carries along the injected compounds, with the more volatile fractions moving faster than the less volatile ones. When they reach the end of the column they are detected and recorded by a special detector. The compounds can be identified by their retention times (R_t values), i.e. the time it took for them to move from the point of injection to the point of detection under a given (carefully controlled) set of conditions. Various electronic detectors are used, some non-selective (e.g. flame ionisation detection) and some selective, such as PND or phosphorus-nitrogen detection, relatively insensitive but highly selective for compounds containing phosphorus and/or nitrogen) or the highly selective and sensitive ECD or electron capture detection (commonly used for detecting trace amounts of organophosphates and other pesticides in food items). The result of a GC analysis is a chromatograph showing all the different compounds as peaks, each with a specific retention time. The size of the area under the peak can be used to determine the relative quantity of each compound in the mixture, expressed as a percentage of the total.

High-performance liquid chromatography (HPLC) is similar to gas chromatography except that it is suitable for non-volatile compounds. In this case the column is much shorter and thicker, and it is filled with a suitable stationary phase (e.g. C18 reverse phase silica). The mobile phase is a predetermined solvent mixture that is pumped at high pressure through the column. After the sample is injected into the system, it is washed through the column, with the more polar fractions moving faster, as in column chromatography. The detector mostly uses the optical spectrum of the compounds to detect them, as in GLC, shown as separate peaks on a chromatogram. Both GLC and HPLC are controlled by computers that allow post-run analyses and comparisons between individual compounds detected in different samples. In preparative GLC and HPLC, the compounds are collected as they emerge from the column outlet, in the same way as in column chromatography. Both GLC and HPLC may be used in combination with a mass spectrometer, which can accurately record the mass spectrum of each component as it reaches the detector. GC-MS and HPLC-MS (often simply called LC-MS) have become powerful tools when linked to large databases of known chemical compounds that can be used to identify compounds.



High-performance liquid chromatography (HPLC) system

Identification and structural determination is the main routine task performed by phytochemists. The identity of isolated (pure) compounds can be determined using a combination of chromatography and other methods such as UV-vis spectroscopy, infrared spectroscopy (IR), mass spectrometry (MS) and nuclear magnetic resonance spectroscopy (NMR). In spectroscopy, the absorption and reflection of visible, UV and infrared light is measured and compared to the values or patterns for known compounds and reference standards. Mass spectrometry is a method in which the compound is broken down in a highly controlled way and the fragments are measured and compared. Each compound has a characteristic fragmentation pattern that serves as a "fingerprint", unique for all except stereoisomers. The ultimate method to determine the absolute configuration of a molecule is by NMR, a sophisticated technique in which the pure compound is placed within a strong magnet and the unique pattern of interactions (couplings) between atoms within the molecule is measured and analysed by organic chemists to determine the structure. In addition, the optical rotation of the compound can be measured (useful in case of optical isomers). When crystals are available, the absolute configuration can be determined by crystallographical methods. The melting point of crystals can provide further confirmation of identity.

A modern approach to studying the chemical compositions of plant extracts is known as metabolomics. It uses LC-MS and NMR techniques with sophisticated computer software to study the total metabolome of an organism (animals or plants). All of the thousands of primary and secondary metabolites are analysed at the same time in an attempt to understand the biology and physiology of the organism. The method is often used in diagnostics and toxicology. For example, blood samples taken before and after a compound or medicine was administered can be used in comparative studies of pharmacodynamics and to see what main effects the test compound had on the metabolism of the animal or person. Principal components analysis (PCA) is a popular statistical method in this type of work and is often performed to determine the main phytochemicals responsible for a change in the metabolome. Another modern development is the use of DNA fingerprinting in the authentication of herbal medicines.

Although highly sophisticated methods such as GC-MS, LC-MS and metabolomics are now available for routine work, there remains a need for "old-fashioned" chromatography such as TLC, GLC and HPLC. These methods are still being used as part of the daily routine in the food, cosmetics and pharmaceutical industries for quality control purposes and in research and forensic laboratories.

Quality control and safety

The safety and efficacy of phytomedicines and natural substances are ensured through the process of quality control. This is done by double-checking not only the correct identity of the crude herb or extract, but also the required concentration (dose) of active ingredients and the purity of the product (to confirm the absence of adulterants, undesirable chemicals or biological contaminants such as bacteria). All procedures are carefully documented so that every step in the production process can later be verified in case side effects or other unexpected outcomes are reported. The focus of quality control procedures is more on safety and quality than on efficacy. The latter is based on traditional evidence and experience and in some cases also on controlled clinical trials.

Pharmacognosy is the science that deals with the identification of medicinal plants and drugs. It is very important to ensure that toxic plants are not mistaken for the required species. The process requires botanical knowledge (to identify the correct plant or its parts), anatomical knowledge (to identify characteristic tissues or cells, such as glands) and phytochemical knowledge (to identify the main chemical compounds or to compare a chromatographic fingerprint with that of an authentic reference sample). Species identification can also be achieved by DNA barcoding.

Purity and hygiene are essential requirements for both the raw materials and the finished products. They have to be free from adulterants, because the adulterant may either be toxic or it may dilute the product so that it is no longer effective. Foreign organic matter may include bits of unwanted plant materials from the same species (e.g. leaf material when only flowers are harvested) but more often material from related or even unrelated species that were intentionally or inadvertently included in the product. In the latter case it may not exceed 2%. Soil and inorganic contaminants can be introduced when herbs are air-dried in the open under windy and dusty conditions, or soil may adhere to rhizomes and roots if they are not carefully washed before drying and milling. This form of contamination can be monitored by the ash value of the material: the % weight of the ash that remains after a sample of the product has been incinerated. The total ash value that is acceptable is often fixed at 3% or 5% of dry weight, and acid-soluble ash at no more than 1%, depending on the product. Other important variables that need to be controlled are bacterial contamination, heavy metals, organic pesticides and radioactive residues.

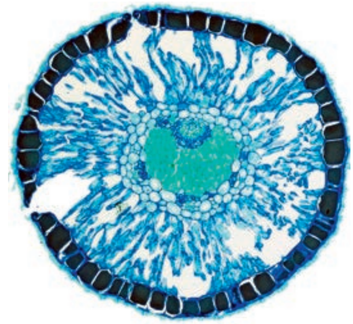
Microbial contaminants are controlled as a matter of routine through standard microbiological tests. The maximum acceptable levels of microorganisms that are allowed depend on the intended use of the product. Material intended to be used for teas and tinctures, for example, will be sterilised by the heat or alcohol when they are prepared for use, so the requirements for them would be less stringent than for an ointment that is applied to open wounds. *Salmonella* species and *Escherichia coli* must usually be negative (not detectable), while the upper limit is usually 10^4 per gram for fungi and 10^5 per gram for aerobic bacteria.

In the final dosage form, heavy metals may not exceed 10 mg/kg (10 parts per million) in the case of lead and 0.3 mg/kg for cadmium. Pesticide residues are monitored according to international guidelines. The upper limit for aldrin and dieldrin is usually set at 0.05 mg/kg. International guidelines also apply to the levels of radioactive residues in plant materials, such as strontium-90, iodine-131, caesium-134, caesium-137 and plutonium-239.

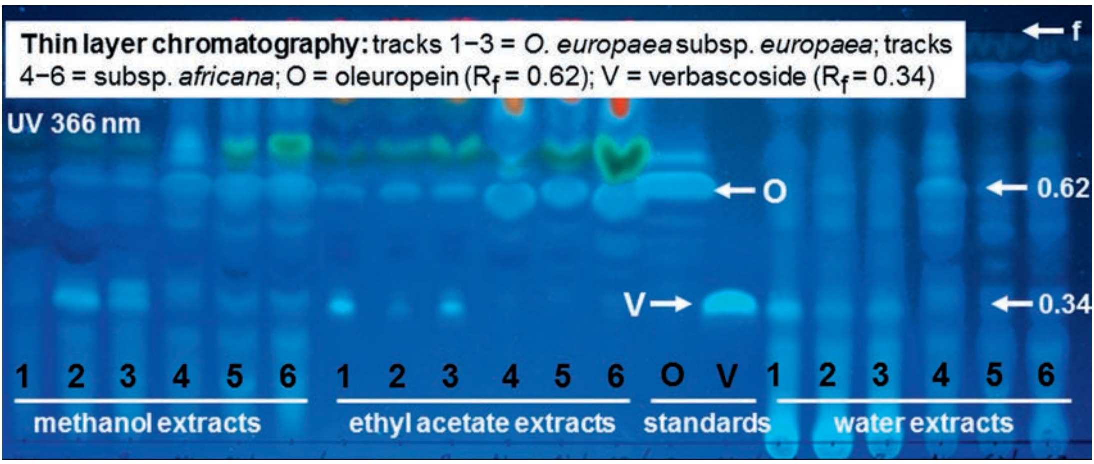
Standardisation is the process through which a finished product (phytomedicine) is manufactured in such a way that all batches contain the same amount of the active chemical compounds (or carefully selected marker compounds). The activity of herbal medicines is often not linked to a single chemical entity, so that a convenient marker is chosen as a standard. It is assumed that the active compound(s) are present at therapeutic levels if the marker compound is above a specified level. The concentration or dosage is very important because the active ingredients may produce serious side effects (if the dose is too high) or have no therapeutic value at all (if the level is too low).

Most medicinal plants have a very wide therapeutic window, meaning that the therapeutic dose is much lower than the toxic dose. For this reason, a minimum dose level is usually specified for medicinal herbs, rather than an upper limit. Plant material is often highly variable, so that it is difficult to set an exact level, as is done with pure chemical substances. An upper limit is, however,

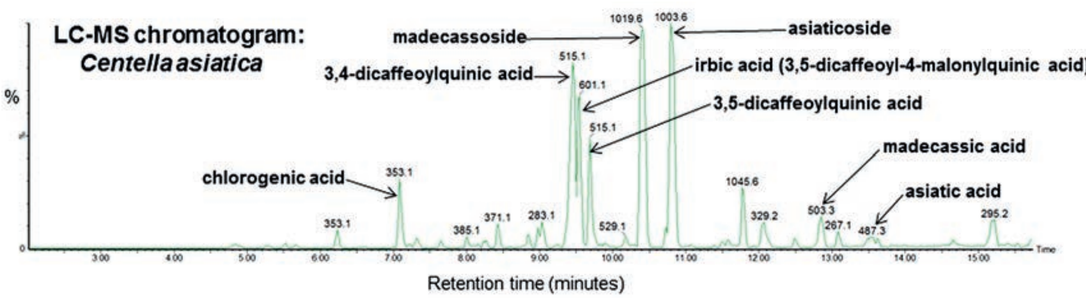
Comparison of rooibos tea samples



Transverse section through the needle-shaped leaf of rooibos tea



Quality control of olive leaf extracts



LC-MS chromatogram of *Centella asiatica* showing the main active compounds

essential for plants containing chemicals with a narrow therapeutic window, such as alkaloids and cardiac glycosides. These products can usually only be taken on prescription and under the supervision of a health care professional.

The safety of herbal medicines is an important consideration. Safety studies, performed according to strict protocols, are required before a new phytomedicine can be registered. Traditional medicines usually have a long history of safe use, so that safety is generally accepted on the basis that no serious side effects have been reported in the literature. It is possible that chronic toxicity may be overlooked (e.g. the cumulative effect of herbs such as comfrey and borage that contain pyrrolizidine alkaloids with an unsaturated necine base). Safety studies often involved test animals but such methods have become less popular. Tissue culture systems can also be used as a first assessment of toxicity. The safety and absence of serious side effects are usually the first parameters that are examined in a formal clinical trial.

Efficacy of herbal medicine

Efficacy is a critical consideration: does the product actually give the desired health benefit that it is intended to do? Many people are still sceptical about traditional medicine despite the fact that it has been used on a daily basis by many cultures all over the world for thousands of years. Furthermore, miracle cures such as aspirin for headache, artemisinin for malaria and vincristine for leukaemia leave no doubt that plants do have definite therapeutic value. However, unrealistic claims on product labels and marketing materials, as well as poor quality products containing little or no active ingredient are the main reasons why there is considerable and justifiable scepticism about efficacy.

The role of the placebo effect is often under-estimated. Many products rely on this powerful force within the human mind and body that regulates health and healing. The uniforms worn by traditional and modern health care workers, the way in which they make a convincing diagnosis and even the way in which medicinal products are formulated and packaged may all contribute towards strengthening the placebo effect. Traditional healers often rely on clever interventions, such as adding powdered aspirin or a mild laxative to the medicine they prescribe, so that there are detectable physical effects in the patient that will serve to enhance the placebo effect (i.e., the belief that "the medicine is working"). The ultimate scientific test is the double-blinded, placebo-controlled clinical trial, aimed at objectively distinguishing between real therapeutic activity and placebo.

There are several ways in which the efficacy of traditional medicine can be assessed, ranging from the traditional use as the first level, to double-blinded placebo-controlled clinical trials and finally the blind testing against an established drug as the ultimate and most sophisticated level. Traditional use may often provide the first hypothesis, especially when a particular medicine has been used for a particular ailment over many years. Studies of the chemical constituents of a plant may provide a scientific rationale for efficacy that has been determined empirically through regular use over many generations.

Plausible anecdotes (clinical observations by health care practitioners) are another source of evidence that may support the claimed efficacy of a traditional medicine. Several anecdotes, reported by independent observers, make the claim even more plausible, especially if it is backed up by physical evidence such as blood tests and pathology reports.

Pharmacological studies are done to demonstrate pharmacological activity using *in vitro, in vivo* and *ex vivo* methods. Such preclinical studies only give a superficial assessment, because isolated cells rarely behave in the same way as they would do when they are part of a complicated organ system that is connected to other systems in the human body. Plants often contain complex mixtures of chemical compounds and these may have unpredictable synergistic effects on various organ systems that cannot be determined by testing the compounds individually. Extracts or compounds may show activity when applied directly to cells in tissue culture but this is far removed from the real situation in the body, where the compound may not be absorbed or may never reach the cells where it is needed. For this reason, a study of pharmacokinetics is important, in order to determine how the compound is absorbed, circulated and eliminated.

Observational studies are performed when many people have already used the medicine out of their own free will for an extended period of time. If sufficient numbers of people are available, statistical methods can be applied to show significant health benefits in those who have used the medicine compared to those who have not (the control group).

Clinical studies (studies in humans) are the most convincing scientific method of proving safety and efficacy. Unfortunately, there are not many clinical studies done on herbal medicine because there is no way to protect the intellectual property, so that those who have funded this often very expensive activity will never get a return on their investment. Plants cannot be patented, and the results of a clinical study will place the competitors who did not fund it at an unfair advantage. One common approach to partly overcome this problem is to develop a patented proprietary extract, and to do the clinical studies on the extract and not the plant. The development of new medicinal products is done in four phases (a preclinical phase and three clinical phases). Phase I

The health benefits of functional foods, an important research focus area

Science-based phytotherapy relies on placebo-controlled clinical studies to test efficacy

clinical studies are done to establish a safe dose and also the best dosage form. It is typically done in a relatively small number of healthy volunteers (as few as 12). Phase II clinical studies are done in a larger number of patients to test the efficacy of the medicine (how well it works) and to obtain additional data on safety. Phase III clinical studies are done on a relatively large number of patients to compare the new drug against the current standard treatment and to determine if there are statistically significant health benefits. A person will be randomly assigned to either the treatment group (new drug) or the control group or the established drug (standard treatment). A placebo (inactive product that closely resembles the treatment) is often used as a control. A double-blind design means that neither the doctor/investigator nor the patients know which persons are receiving the treatment and which ones the placebo. The aim is to quantify the placebo effect and to determine if there are statistically significant differences between the treatment and the control group or established drug. There are many reasons why a carefully planned and executed clinical study may fail even if the medicine is highly effective (under the right circumstances or when administered in the traditional way). A masticatory, for example, could fail as a tablet because the active ingredients may be destroyed by stomach acid. A traditional infusion may show severe and unacceptable side effects when used as a tincture because water will dissolve only polar substances (which may be the beneficial ones) while alcohol will dissolve non-polar and potentially toxic substances.

Pharmacological and toxic effects

The majority of medicinal plants are used on the basis of anecdotal evidence. They have been used by generations of people within the context of traditional medicinal systems and are therefore considered to be safe and effective. However, chronic toxicity may easily be overlooked, and it may be hard to distinguish between real efficacy and the placebo effect. Medicinal plants used for self-medication typically have very wide therapeutic windows (i.e., the therapeutic dose is much less than the toxic dose) so that overdosing is rarely a problem. When relatively poisonous plants are used, the methods of preparation and dosage are much more critical, and the intervention of a healer or health care professional is required to ensure safety. The ultimate test of efficacy is the controlled clinical trial, where extracts or compounds are tested in humans to determine if there is sufficient therapeutic benefit to confidently recommend the plant or extract for a particular disease or indication.

The chemical compounds in the plant interfere with organs, tissues, cells and ultimately a molecular target (such as proteins and enzymes). The same effects that restore balance and improve health may also disrupt the functioning of organs (i.e., lead to poisoning) if the therapeutic dose is exceeded. All phytomedicines must have some pharmacological activity in order to be effective. This also means that they are potentially harmful if used in the wrong way. The mechanisms of action of various classes of chemical compounds are highlighted in the review of secondary metabolites that follows, as well as in the individual species treatments. Substances can be classified by their pharmacological and toxic activities, as listed below. Definitions for the various pharmacological effects that are caused by medicinal and poisonous plants are given in the *Glossary of botanical, chemical, medical, pharmacological and toxicological terms* at the back of this book.

Phytomedicines differ from pure chemical compounds in their chemical complexity. Each plant typically has a diversity of compounds and even different functional groups on the same molecules that may have different pharmacological activities. Furthermore, different organs of the plants (roots, leaves, seeds) may be quite different in their chemical composition. Alkaloids often accumulate in seeds, tannins in bark and anthocyanins in petals, for example. Genetic differences between individual plants (and different populations of the same species) may lead to marked chemical differences. This genetic effect is usually much more pronounced than environmental effects and the way in which the plant has been cultivated often plays only a minor part in the chemical composition and level of the active ingredients. These different "chemical forms" of a species are often referred to as chemotypes, and the identification of suitable or favourable chemotypes is part of the selection and standardisation process that is necessary to ensure the quality and efficacy of phytomedicines. It is also noteworthy that tradition (and traditional healers) often utilises certain fixed mixtures of different plant species, such as the mixtures used in Traditional Chinese Medicine that date back to ancient times. It is sometimes possible to demonstrate that only a particular combination of plants or plant parts have a synergistic effect while other combinations may have merely an additive (or even an antagonistic) effect.

In recent years, pharmacological research has moved in the direction of multiple therapies and synergism, based on the belief that all the various chemical compounds in a plant (or in mixtures of plants) act together, additively or even synergistically, to improve health or prevent disease. Many medicinal plants contain complex mixtures of alkaloids, flavonoids, organic acids, saponins, steroids, tannins and volatile oils. It seems very likely that all of these have a role to play, similar to the music made by an orchestra. The alkaloids or nitrogen-containing compounds typically set the mood and provide the inspiration, by acting on the brain as sedatives or stimulants, according to need (a positive feeling of well-being is already an important step towards recovery and good health, probably enhancing the placebo effect). Their typical bitter taste may ensure regularity and rhythm, by stimulating gastric juices for good digestion and surprisingly even having a positive and stress-reducing effect on the heart. The flavonoids and organic acids may provide the volume and resonance by their anti-inflammatory effects and venotonic properties. The saponins and steroidal compounds may ensure harmony through their antispasmodic activity, influence on enzymes and even corticomimetic effects. The tannins may contribute to clarity and purity by acting as non-specific protein poisons, denaturing the proteins of the unicellular organisms that make us ill (at the same time destroying the upper cell layers of our mucous membranes, but luckily these are rapidly replaced without any harm being done, since we are multicellular). The volatile oil components may similarly contribute to clarity by their antiseptic effects, and by opening up the respiratory tract through their expectorant and secretolytic activities. Sugars and polysaccharides may also provide support for the acoustics of health by their demulcent effects and probably many other surface interactions on skin and mucosa that we do not yet fully understand. Biology is complicated and the human body is complicated; it therefore seems reasonable to expect that at least some of the medicines of the future will also be complicated, not only in their pharmacological activities but also in their chemical compositions.

The following is a list of the pharmacological and toxic activities of medicinal and poisonous plants:

abortifacient
adaptogen
adrenergic
allergenic
amoebicidal
anaesthetic
analeptic
analgesic
anaphrodisiac
anthelmintic
anti-arrhythmic
anti-asthmatic
antibacterial
antibiotic
anticholinergic
anticoagulant
anticonvulsant
antidepressant
antidiabetic
antidiuretic
antidote
anti-emetic
antifungal
antigen
antihistaminic
antihydrotic
antihypertensive
anti-inflammatory
antimetabolite
antimicrobial
antimitotic
antimycotic
anti-oedemic
antioxidant
antiparasitic
antiphlogistic
antipruritic
antipyretic
antirheumatic
antiseptic
antispasmodic
antitumour
antitussive
aphrodisiac
aromatic bitter
asphyxiant
astringent
bactericide
bacteriostatic
bitter tonic (*amarum*)
blood purifier (outdated term)
bronchodilatory
carcinogen
cardiotonic
cardiotoxic
carminative
catalyst
cathartic
cholagogue
cholekinetic
choleretic
cholinesterase inhibitor
cytostatic
cytotoxic
decongestant
demulcent
detergent
diaphoretic
diuretic
emetic
emollient
expectorant
febrifuge
free radical scavenging
galactogogue
haemostatic
haemostyptic
hallucinogen
hepatotoxic
hypnotic
immune stimulant
immunosuppressant
inotropic
intoxicant
irritant
lacrimator
laxative
ligand
lipid-lowering
MAO inhibitor
mucolytic
mutagenic
narcotic
nephrotoxic
neurotoxin
neurotransmitter
nutritive
oxytocic
parasympatholytic
parasympathomimetic
pesticide
piscicide
poison
prophylactic
psychotropic
purgative
pyretic (pyrogen)
relaxant
repellent
re-uptake inhibitor
roborant
rodenticide
rubefacient
saluretic
secretolytic
sedative
soporific
stomachic
styptic
sudorific
sympatholytic
sympathomimetic
teratogenic
tonic
toxicant
tranquilliser
vasoconstrictor
vasodilator
vermifuge
vesicant
virustatic
vulnerary

Regulation and legal aspects

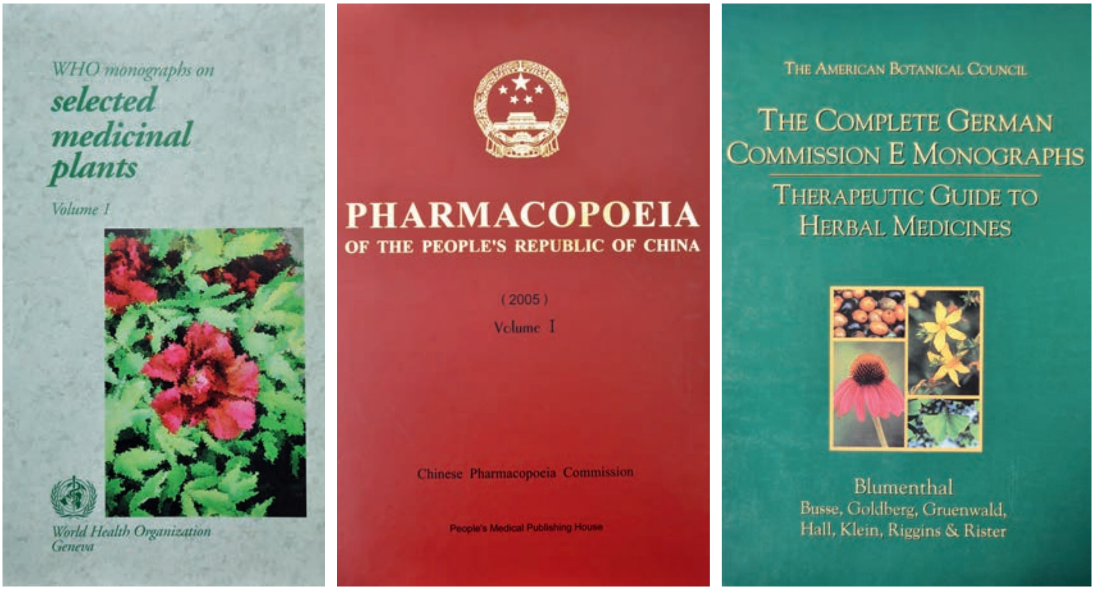
Regulations are necessary to protect the public and to ensure the safety, quality, efficacy (that they actually work) and sometimes also the timely availability of medicinal products. Most countries have an executive agency of the Department of Health that is responsible for regulating all medicines and medical devices. The age-old traditional way of regulating medicine is to compile an official pharmacopoeia of traditional medicinal plants (and other products) that are considered to be safe and effective on the basis of a long history of use. Most countries of the world have an official pharmacopoeia and there are also international and continental pharmacopoeias as highlighted below. The modern trend is that more and more herbal product monographs are included in the official pharmacopoeias. Herbal pharmacopoeias are valuable sources of information but often have no legal status.

In the pharmacopoeia, each product or herb is treated in a formal monograph, describing in detail the plant or plant part to be used, the indications that are allowed (what it can be used for and what claims are allowed on product labels), the dose, methods of preparation and administration, possible side effects and contraindications (e.g. pregnancy). A positive monograph in an official pharmacopoeia therefore represents an "official approval" for the use of the plant or plant part for specified indications. This is why some plants have *officinalis* as the Latin epithet in their names, e.g. *Salvia officinalis* is the official *Salvia* species that is sanctioned for medicinal use. The pharmacopoeia typically also describes quality control procedures and test methods to be used to ensure quality and safety. The minimum level of active ingredient is often specified, as well as possible adulterants. The World Health Organisation is producing a pharmacopoeia in several volumes (WHO Monographs). The WHO also published a global checklist of all pharmacopoeia but the list is now somewhat outdated. In Europe there are three prominent pharmacopoeias (see below).

Most countries require companies wishing to sell medicines to have a product licence. In Britain, for example, herbal medicine is regulated by the Medicines and Healthcare Products Regulatory Agency of the Department of Health. Herbal medicines are regulated according to the European Traditional Herbal Medicinal Products Directive (THMPD) 2004/24 EC that came into effect on 30 April 2011. In line with most other countries, companies need a product licence to sell herbal medicine. This may be either a full marketing authorisation (MA), based on the safety, quality and efficacy of the product (the same as with any regular medicine) or a traditional herbal registration (THR), based on the safety, quality and evidence of traditional use of the product.

In the United States of America, medicinal herbs are called "botanicals" and are sold either as medicines (drugs) or as "dietary supplements". The Food and Drug Administration (FDA) is the regulatory agency. The *Dietary Supplement, Health and Education Act* of 1994 (DSHEA) defines dietary supplements as vitamins, minerals, herbs or botanicals, amino acids and other dietary substances not intended as food but to affect the structure and function of the body. Dietary supplements may not claim to "diagnose, cure, mitigate, treat or prevent illness" but certain "structure/function" claims are allowed (often referred to as "soft claims"; vaguely worded, indirect indications of the health benefits that can be expected). The FDA bears the burden of proof that a dietary supplement is unsafe before it can be withdrawn from the market. Pharmacopoeias in the USA do not automatically give marketing authority and have no legal status.

In Europe, medicinal plant products are regulated and registered as medicine when they fulfil the same requirements which would apply to synthetic drugs. Many plant products can also be registered as traditional medicine, based on a long tradition of safe use as documented in pharmacopoeia and herbal monographs. Limited claims can be made and the plant parts to be used and the allowed indication are specified. Well-known pharmacopoeias include the ESCOP monographs of the European Scientific Cooperative on Phytotherapy, the monographs of the European Committee on Herbal Medicinal Products (HMPC) and the European Pharmacopoeia (now in its 8th edition). These monographs are attempts to work towards unified standards across the European Union. Most European countries also have their own official national pharmacopoeias. In Germany, the Commission E monographs are particularly important because they provided the scientific rationale for the use of many herbal products and also the reasons why some herbs are considered not to have a favourable benefit to risk ratio.



Examples of pharmacopoeias

In Japan, herbal products are classified according to how they are regulated, either as prescription drugs, generics or over-the-counter drugs (*Pharmaceutical Affairs Act*) or as functional foods (*Nutritional Improvement Act*). They are also classified according to how they are marketed. *Kampo* drugs are mixtures of between two and 32 different species, formulated strictly according to ancient Chinese compendia. These are legally considered to be both prescription drugs and generic drugs – 130 such formulas are listed in the National Health Insurance Drug List. Herbs in Japanese pharmacopoeia are excluded because they are used alone and not in mixtures. Over-the-counter herbal drugs are based on traditional family formulas or old Chinese compendia. There are 210 such formulas (dosage and therapeutic claims are limited). The registration route for new drugs is expensive and applies to any new synthetic or plant-derived product. Functional foods are regulated in much the same way as generic drugs, and limited claims are allowed. Health foods are becoming very popular, but no therapeutic claims are allowed. The 16th edition of the Japanese Pharmacopoeia was published online and a new 17th edition is planned for 2016.

In Australia they use a relatively simple procedure, the so-called *listing system*. Herbal medicine is regulated by the *Therapeutic Goods Act* of 1989, which is aimed at controlling the quality, safety, efficacy and timely availability of therapeutic goods. Unless specifically exempted, all therapeutic goods must be entered on the *Australian Register of Therapeutic Goods* (ARTG) before they can be marketed, imported or exported. Herbal medicine may either be registered (as prescription drugs or as over-the-counter drugs) or more often listed in the register. The listing system also has a list of Australian Approved Names (AANs) for all ingredients made from plants or plant-like materials.

In China, safety or clinical data are required for new medicines, while traditional herbal medicines are listed in the *Pharmacopoeia of the People's Republic of China*. The latest English edition was published in two volumes in 2007. Volume 1 contains herbal medicine and Volume 2 Western medicine. It is the ninth edition since the first one was published in 1930.

In India, any herbal medicine can be registered as long as it appears in standard texts, as part of the Ayurvedic or Unani medicine systems. The official Indian Pharmacopoeia was published in four volumes by the Indian Pharmacopoeia Commission late in 2013. It came into effect on 1 January 2014 and features 30 additional new herbal drug monographs in Volume 3.

Aleppo rue (*Ruta chalepensis*): essential oil, flavonoids

Shan shu yu (*Cornus officinalis*): iridoids, triterpenoids

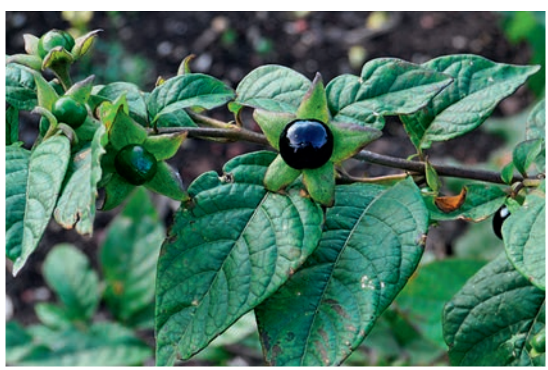
Siberian ginseng (*Eleutherococcus senticosus*): triterpene saponins

Soapbark tree (*Quillaja saponaria*): saponins

Poison rope (*Strophanthus speciosus*): cardiac glycosides

Common fig (*Ficus carica*): furanocoumarins

Raspberry (*Rubus idaeus*): tannins



Deadly nightshade (*Atropa belladonna*): tropane alkaloids

Secondary metabolites

The biological and pharmacological activities of medicinal, poisonous or mind-altering plants can be explained through the presence of mixtures of secondary metabolites often belonging to several structural classes. In many instances, individual compounds not only exert additive but also synergistic interactions. Secondary metabolites have apparently evolved as a means for plants to defend themselves against herbivores and against bacteria, fungi and viruses. They also serve as signal compounds to attract pollinating and seed-dispersing animals, furthermore as antioxidants and UV protectants. It is now generally accepted that it may not always be possible to solve complicated health problems with a single chemical compound or "magic bullet". It is far more likely that the sophisticated medicines of the future will be based on combinations of chemical compounds, targeting different organ systems and enzymes, wherever an imbalance needs to be rectified. From a biosynthetic perspective we can group secondary metabolites into those without nitrogen or those with nitrogen in their structures. Each group is again divided more or less according to their biosynthesis and chemical structure, resulting in eight main groups or classes as shown below.

A. Nitrogen-free compounds

1. Terpenes (p. 50)

Monoterpenes (p. 50)
Iridoid glucosides (p. 52)
Sesquiterpenes and sesquiterpene lactones (p. 52–55)
Diterpenes (p. 56)
Triterpenes and steroids (p. 58)
Saponins (p. 60)
Cardiac glycosides (p. 62)
Tetraterpenes and polyterpenes (p. 63)

2. Phenolics (p. 64)

Phenylpropanoids (p. 64)
Diarylheptanoids (p. 66)
Coumarins and furanocoumarins (p. 66)
Lignans and lignin (p. 67)
Flavonoids, stilbenoids, chalcones and anthocyanins (p. 67)
Catechins and tannins (p. 69)
Small reactive molecules (ranunculin, tuliposide, ethanol) (p. 70)

3. Quinones (p. 72)

Quinones and naphthoquinones (p. 72)
Anthraquinones and other polyketides (p. 72)

4. Polyacetylenes, polyenes, alkamides (p. 73)

5. Carbohydrates (p. 74)

6. Organic acids (p. 76)

B. Nitrogen-containing compounds

7. Alkaloids (including amines) (p. 78)

Amaryllidaceae alkaloids (p. 78)
Bufotenin, tryptamines and tyramines (p. 78)
Colchicine (p. 79)
Diterpene alkaloids (p. 79)
Ergot alkaloids (p. 80)
Indole alkaloids (including monoterpene indole alkaloids) (p. 81)
Indolizidine alkaloids (p. 82)
Isoquinoline alkaloids (including protoberberine, aporphine, morphinane alkaloids) (p. 82)
Phenylpropylamines (p. 84)
Piperidine alkaloids (p. 84)
Purine alkaloids (p. 84)
Pyrrolidine alkaloids (p. 85)
Pyrrolizidine alkaloids (p. 85)
Quinolizidine alkaloids (p. 85)
Quinoline alkaloids (including acridone alkaloids) (p. 85)
Steroidal alkaloids (p. 86)
Tropane alkaloids (p. 86)

8. Amino acids and related compounds (p. 88)

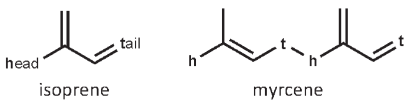
Amino acids (p. 88)
Non-protein amino acids (p. 89)
Cyanogenic glucosides (p. 90)
Glucosinolates and mustard oils (p. 90)
Lectins and peptides (p. 91)

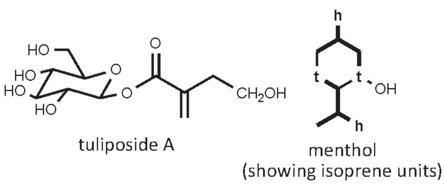
Terpenes

Terpenes are built from C5-units as a building block and can be subdivided into hemiterpenes (C5), monoterpenes (C10), sesquiterpenes (C15), diterpenes (C20), triterpenes (C30), tetraterpenes (C40) and polyterpenes. Steroids (C27) are derived from triterpenes. Hemiterpenes are quite rare. An example is tuliposide A, one of the skin irritant compounds in tulip bulbs (see below). Most of the terpenoids are lipophilic. They readily interact with biomembranes and membrane proteins. They can increase the fluidity and permeability of the membranes, which can lead to uncontrolled efflux of ions and metabolites and even to cell leakage, resulting in cell death. In addition, they can modulate the activity of membrane proteins and receptors or ion channels. This membrane activity is rather non-specific; therefore, terpenes show cytotoxic activities against a wide range of organisms, ranging from bacteria and fungi to insects and vertebrates. Many terpenes are even effective against membrane-enclosed viruses.

Monoterpenes

Monoterpenes are derived from the head-to-tail coupling of two isoprene units (2 × C5). More than 40 skeleton types are known. Monoterpenoids occur in nature as the major components of volatile oils (essential oils), often in combination with sesquiterpenoids. Volatile phenolic compounds may also be present in essential oil, such as the phenylpropanoids eugenol and anethole (see under phenolic compounds). The oil is stored in specialised canals, resin ducts and trichomes (unicellular or more often multicellular glands) and is usually extracted by steam distillation.

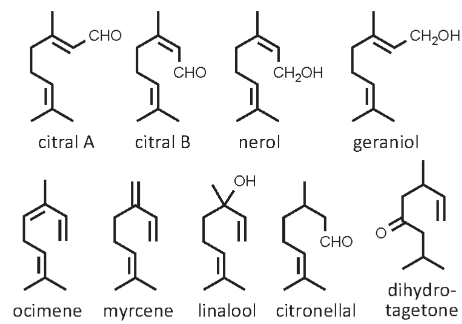




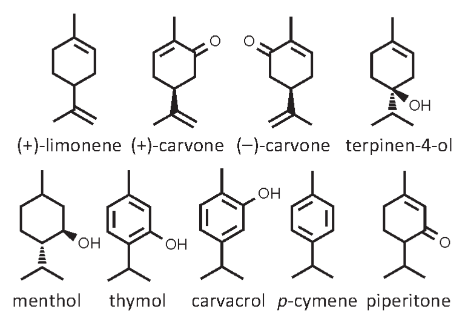
Monoterpenes are widely present in Lamiaceae, Asteraceae, Apiaceae, Rutaceae, Myricaceae, Dipterocarpaceae, Myristicaceae, Verbenaceae, Burseraceae, Poaceae and conifers. Their presence can be detected by smelling crushed leaves (or other plant parts).

Essential oils with monoterpenes are commonly used in aromatherapy and in phytomedicine to treat rheumatism, infections (bacterial, fungal), colds, restlessness, flatulence, intestinal spasms, as stomachicum and to improve taste. Essential oils are ingredients of many perfumes and of some natural insect repellents. Applied to the skin, monoterpenes and aliphatic hydrocarbons can cause hyperaemia; higher doses cause narcotic effects.

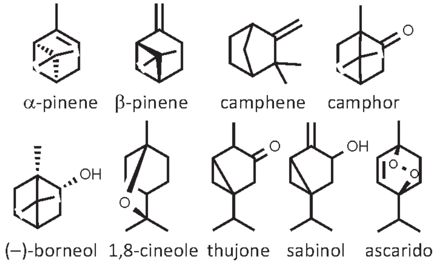
Monoterpenoids can be linear, monocyclic or bicyclic.



Examples of linear monoterpenoids.



Examples of monocyclic monoterpenoids.



Examples of bicyclic monoterpenes.

Myrtle (*Myrtus communis*): essential oil – 1,8 cineole

White peony (*Paeonia lactiflora*): roots – paeoniflorin

Citral is a mixture of two isomers, **citral A** (geranial) and **citral B** (neral). The essential oil of one chemotype of the Australian lemon myrtle tree (*Backhousia citriodora*) is almost pure citral. Citral is partly responsible (with **limonene**) for the strong lemon flavour of lemon verbena (*Aloysia citrodora*). Carvone occurs in nature as two isomers: (+)-carvone smells like caraway (it is the main compound in caraway seed oil from *Carum carvi*), while (–)-carvone has a spearmint smell and is the main constituent (50–80%) in spearmint oil (*Mentha spicata*).

Menthol accumulates in cornmint (*Mentha arvensis*) and peppermint (*M. ×piperita*). It induces a pronounced cooling sensation by triggering cold-sensitive receptors in the skin and mucosa. It also has analgesic effects by selectively activating κ-opioid receptors. **Piperitone** is used as a starting material for the production of synthetic menthol. It is obtained, in very high yield, from the essential oil of the broad-leaved peppermint gum (*Eucalyptus dives*).

Two of the most ubiquitous monoterpenoids are **camphor** and **1,8-cineole** (= eucalyptol). They often co-occur in essential oils and have been shown to exert a powerful synergistic antibacterial activity. The common bluegum (*Eucalyptus globulus*) is a well-known source of 1,8-cineole, while camphor is distilled from the wood of the camphor tree (*Cinnamomum camphora*).

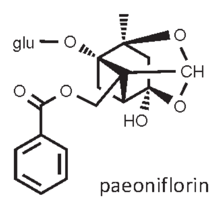
Both enantiomers of **α-pinene** occur in nature; (–)-α-pinene is found in European pine trees. The compound is a bronchodilator and has anti-inflammatory and broad-spectrum antibiotic activities.

Thujone (in *Artemisia absinthium*, *Thuja* species, *Tanacetum vulgare*) contains a cyclopropane ring, which makes the molecule highly reactive. It appears that thujone can alkylate important proteins of the neuronal signal transduction, therefore causing neuronal disorder.

Sabinene (see *Juniperus sabina*) and **sabinol** are reactive monoterpenes with a highly reactive cyclopropane ring and/or with exocyclic or terminal methylene groups, as in **camphene**, pinocarvone or in **linalool**, which can bind to SH-groups of proteins and thus change their conformation.

Monoterpenes with a peroxide bridge, such as **ascaridol**, are reactive compounds, which can alkylate proteins.

Compounds with phenolic hydroxyl groups (such as **thymol** and **carvacrol**) or with an aldehyde function (such as citral, **citronellal**) can bind to proteins and exhibit pronounced antiseptic properties; they are active against bacteria and fungi.

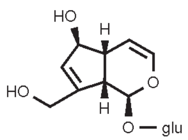


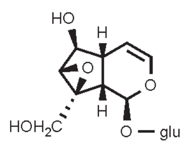
paeoniflorin

Monoterpene glycosides appear to be relatively rare but are found in several members of the Lamiaceae. Peony root (from the Chinese *P. lactiflora*) contains **paeoniflorin**, a monoterpenoid glucoside with antispasmodic, sedative and anti-inflammatory activities. It has been used as a dietary supplement.

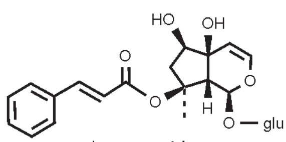
Iridoids

Iridoids are related to monoterpenoids but they usually occur in plants as non-volatile glucosides. They were named for a genus of ants (*Iridomyrmex*) because they were first isolated from these ants, where they serve as defence compounds. Iridoids typically have a cyclopentane ring fused to a six-membered oxygen heterocycle. The biosynthesis proceeds from 10-oxogeranial, through reduction and cyclisation by the enzyme iridoid synthase. The two most common iridoids in plants are **aucubin** and **catalpol**. Iridoids often have a bitter taste and show a wide range of pharmaceutical activities, including analgesic, antihepatotoxic, anti-inflammatory, antimutagenic, antispasmodic, antitumour, antiviral, cardiovascular, choleretic, hypoglycaemic, immunomodulatory and laxative activities.


aucubin

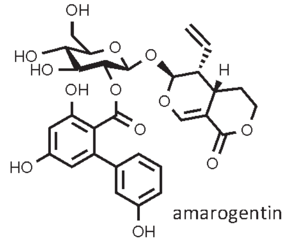

catalpol

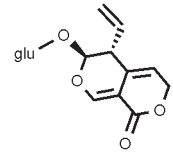
Secoiridoids are formed when a bond in the cyclopentane ring is cleaved. Secologanin derivatives (involved in ipecac alkaloid synthesis) are also formed in this way. More than 200 structures are known, distributed in the families Apocynaceae, Gentianaceae, Lamiaceae, Loganiaceae, Menyanthaceae, Plantaginaceae, Rubiaceae, Scrophulariaceae, Valerianaceae and Verbenaceae. Some of them, such as the gentiopicrosides, present in Gentianaceae and Menyanthaceae, exhibit an extremely bitter taste; they are used to improve digestion and to raise appetite in patients.


harpagoside

Iridoid glucosides, such as aucubin and **harpagoside**, are hydrolysed by β-glucosidase into an unstable aglycone. The lactol ring can open and produce a functional dialdehyde. Catalpol has a reactive epoxide ring in addition.

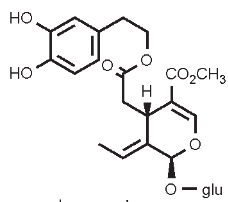
Several medicinal plants rich in iridoid glucosides have been used to treat infections, rheumatism and inflammations (*Plantago* species, *Harpagophytum procumbens*, *Scrophularia nodosa*, *Warburgia salutaris*).

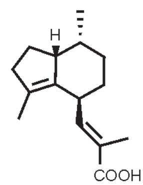

amarogentin


gentiopicrin

Gentiana lutea is well known for its extremely bitter taste, resulting from the presence of **amarogentin** and **gentiopicrin**. These compounds are used as standard to determine bitter values.

The bitter taste of olives is due to **oleuropein**, a secoiridoid with demonstrated hypotensive activity. It occurs in all parts of the plant, including the fruits and leaves.

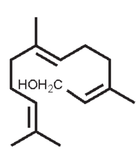

oleuropein

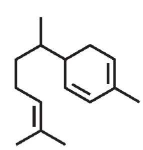

valerenic acid

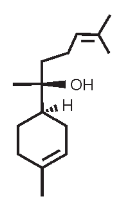
The secoiridoids in *Valeriana officinalis* contribute to the sedating properties of the medicinally used drug. **Valerenic acid** is the main compound.

Sesquiterpenes

Sesquiterpenes are derived from the coupling of three isoprene units (3 × C5). More than 100 skeleton types are known, which can be acyclic, monocyclic, bicyclic or tricyclic. They often co-occur with monoterpenoids as the major components of essential oils, but are typically less volatile, resulting in longer retention times when analysed by gas-liquid chromatography. Sesquiterpenes are therefore found in the same plant families as the monoterpenoids, e.g. Apiaceae, Asteraceae, Burseraceae, Cupressaceae, Dipterocarpaceae, Lamiaceae, Myricaceae, Myristicaceae, Pinaceae, Poaceae, Rutaceae and Verbenaceae.


farnesol


zingiberene


α-bisabolol

An example of an acyclic sesquiterpenoid is **farnesol**, present in many essential oils (e.g. Tolu

Gardenia (*Gardenia jasminoides*): gardenoside (iridoids)

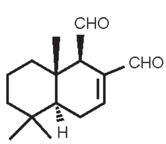
Figwort (*Scrophularia nodosa*): harpagoside (iridoids)

Valerian (*Valeriana officinalis*): valerenic acid (iridoids)

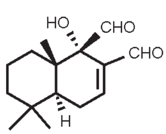
Cotton (*Gossypium hirsutum*): gossypol (sesquiterpene)

balsam, lemongrass and citronella). It is used in perfumery and to flavour cigarettes. **Zingiberene**, a component of ginger oil, is an example of a monocyclic sesquiterpenoid.

The dialdehydes **polygodial** and **warburganal** belong to the "drimane" group of sesquiterpenoids. They have a peppery taste and are recognised as the active principle in *Polygonum hydropiper*, *Drimys aromatica* and *Warburgia salutaris*. The dialdehyde can bind to proteins and form Schiff's bases with free amino groups, which appears to be the base for their pharmacological properties.

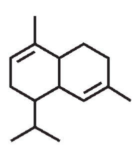


polygodial

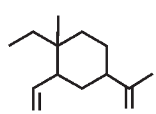


warburganal

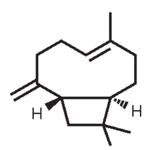
Bicyclic compounds also include the well-known **α-cadinene** (in oil of the cade juniper, *Juniperus oxycedrus*), **β-selinene** (celery seed oil), **(–)-β-caryophyllene** (clove oil) and **carotol** (carrot seed oil). Some sesquiterpenoids are highly aromatic, such as guaiazulene, a main compound in the bright blue oils of guaiac (see *Guaiacum officinale*) and the anti-inflammatory chamazulene from chamomile (*Matricaria chamomilla*) and wormwood (*Artemisia absinthium*). Chamomile has the monocyclic **α-(–)-bisabolol** as main compound in the oil (shown on page 52).



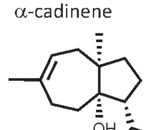
α-cadinene



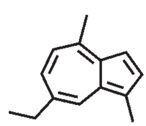
β-selinene



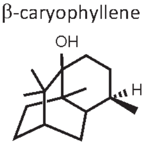
β-caryophyllene



carotol



chamazulene



patchoulol

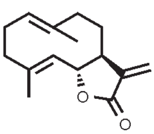
A wide diversity of tricyclic types occurs in nature. An example is the alcohol **patchoulol**, responsible for the typical scent of patchouli oil (*Pogostemon cablin*).

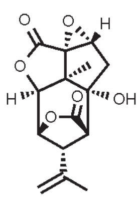
Sesquiterpene lactones

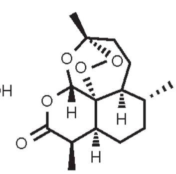
Sesquiterpene lactones are also formed from three isoprene units but they characteristically have a lactone ring. It is an exceptionally common and diverse group (more than 3 000 structures are known) that occurs mostly in Asteraceae and a few other families (Apiaceae, Magnoliaceae, Menispermaceae, Lauraceae) and ferns. The bitterness of many herbs can be ascribed to lactones.

These sesquiterpene lactones can bind to SH-groups of proteins via one or two exocyclic methylene groups and the enone configuration in the furan ring and are therefore pharmacologically active, often as anti-inflammatory agents. Some carry additional 1 or 2 epoxide functions, which make them even more reactive. Alkylated proteins can change their conformation and are no longer able to properly interact with substrates, ligands or other proteins. Also DNA can be alkylated, leading to mutations. Sesquiterpene lactones also bind glutathion (via SH-groups) and can deplete its content in the liver. As a consequence, these sesquiterpene lactones exhibit broad biological activities, including cytotoxic, antibiotic, anthelminthic, anti-inflammatory, phytotoxic, insecticidal and antifungal properties.

Several plants with sesquiterpene lactones have been used in traditional medicine or phytotherapy (*Achillea*, *Arnica*, *Matricaria*, *Parthenium*) because they have anti-inflammatory, expectorant, antibacterial, antifungal and antiparasitic properties. Many are structurally related to **costunolide** (first isolated from *Saussurea costus*, hence the name). It is a prototypical germacranolide.


(+)-costunolide

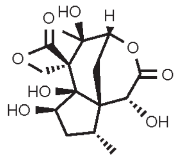

picrotoxinin

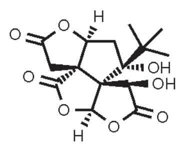

artemisinin

The **picrotoxinin**-producing *Anamirta cocculus* has been used to treat vertigo.

Artemisinin from *Artemisia annua* has a reactive peroxide bridge. It has recently been developed into a potent antimalaria drug (artesunate), which is active against the dangerous *Plasmodium falciparum* that causes cerebral malaria. This compound is not part of the classical "sesquiterpene lactone" group.

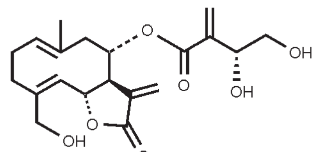
Several examples of sesquiterpene lactones are presented here in alphabetical order.


anisatin

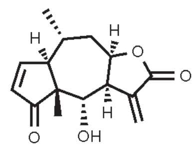

bilobalide

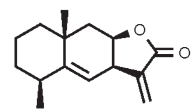
Anisatin is a lethal poison and insecticidal compound isolated from the shikimi plant (*Illicium anisatum*).

Bilobalide is a biologically active trilactone found in *Ginkgo biloba* leaves.

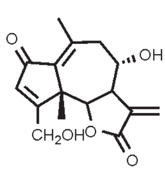

cnicin

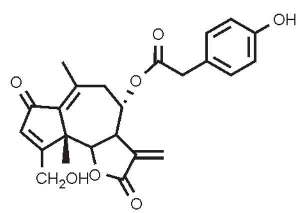
Cnicin is the active compound in *Centaurea benedicta* (formerly known as *Cnicus benedictus*).


helenalin


alantolactone

Helenalin occurs in *Arnica montana* and *A. chamissonis* and is believed to be responsible for the anti-inflammatory, but also skin-irritant and toxic effects. Several other sesquiterpene lactones are also known for their toxic effects. Elfdock (*Inula helenium)* has **alantolactone** as main active compound.


lactucin


lactucopicrin

Lactucin and **lactucopicrin** occur in the milky latex of lettuce, chicory and dandelion. They are the main ingredients of lactucarium (lettuce opium), the dried latex that was once used as an official sedative and mild laxative in the USA and Britain. It was made from the latex of opium lettuce (*Lactuca virosa*) and included in throat lozenges and cough syrups. It was later found to be ineffective and lost its popularity. Since the hippie move-

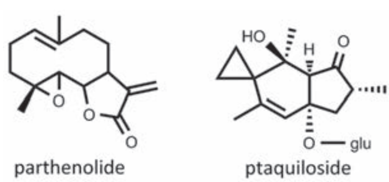
Motherwort (*Artemisia vulgaris*): sesquiterpene lactones

Opium lettuce (*Lactuca virosa*): lactucin and lactucopicrin

Germander (*Teucrium chamaedrys*): diterpene lactones

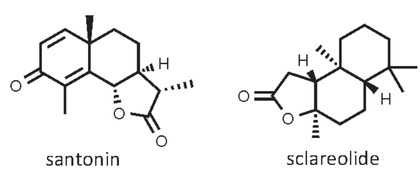
Hyssop (*Hyssopus officinalis*): diterpene lactones

ment, however, it has sometimes been promoted as a safer and weaker alternative to opium, that can be smoked as a legal psychotropic and euphorant. At least one death has been recorded as a result of this practice.



Parthenolide occurs in feverfew (*Tanacetum parthenium*), hence the name. It is believed to be the main active compound responsible for the activity of the herb in preventing migraines.

Young shoots of *Pteridium aquilinum* (containing **ptaquiloside**) have been eaten as vegetable in Japan, but ptaquiloside can cause cancer and should therefore be avoided. Milk and other dairy products may be contaminated when cattle feed on pastures where this fern is abundant.

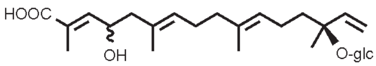


Santonin, known from *Artemisia* species, was once an important commercial anthelmintic but its use has been replaced by safer alternatives. The main sources are santonica or Levant wormseed (*A. cina*) and sea wormwood (*A. maritima*).

Sclareolide is known from *Salvia sclarea* and other species. It is a fragrant compound used in cosmetics and has recently been sold as a dietary supplement with putative weight loss effects.

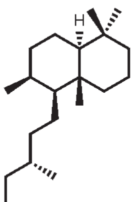
Diterpenes

Diterpenes have a C20 skeleton, based on four isoprene units. They represent a very large and diverse group of compounds that can be classified into more than 50 structural groups. Diterpenes are typically non-volatile and odourless, but they often have very strong flavours. Some are acyclic (e.g. various glycosides of **capsianoside**, found in sweet peppers) but most of them are bicyclic or tricyclic.

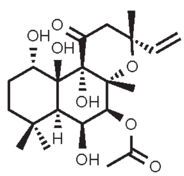


capsianoside

Among the largest and best-known groups are the labdanes, based on the structure of **labdane**.

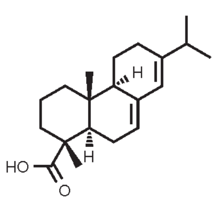


labdane structure

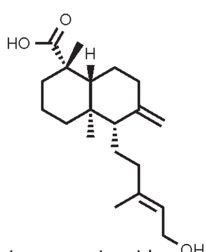


forskolin

Labdane diterpenoids were first isolated from ladanum, a resin obtained from rockroses (*Cistus ladanifer* in the western Mediterranean and *C. creticus* in the eastern Mediterranean). Ladanum has been used since ancient times in herbal medicine and is still used in perfumery. Another example of a labdane diterpenoid with medicinal properties is **forskolin** (found in *Plectranthus barbatus*) which stimulates adenynylcyclase and thus stimulates the cAMP signal pathway.

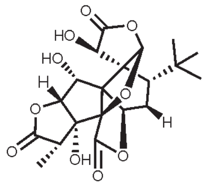


abietic acid

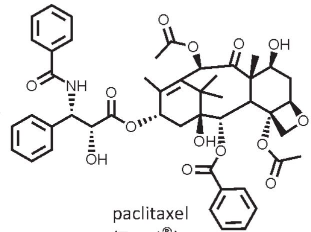


isocupressic acid

The abietane diterpenes represent another large group, of which **abietic acid** is a typical example. It is found in the oleoresins of coniferous trees (e.g. *Abies* and *Pinus* species) and is commercially used in varnishes, lacquers and soaps. It shows potent testosterone 5α-reductase inhibitory activity. Another diterpene in conifers is **isocupressic acid**, an abortifacient in cattle.

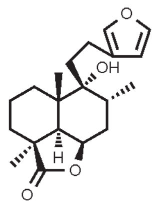


ginkgolide B

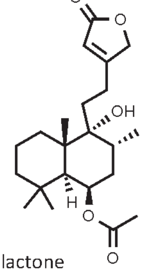


paclitaxel (Taxol®)

The ginkgolides found in *Ginkgo biloba* (e.g. **ginkgolide B**) are also diterpenes, as is taxadiene, a precursor of **paclitaxel** in *Taxus* (**Taxol**® is the trade name.).

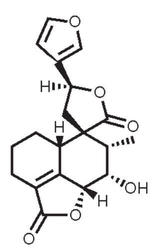


marrubiin

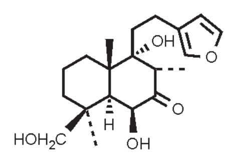


vitexilactone

White horehound (*Marrubium vulgare*) and related plants of the Lamiaceae (e.g. *Leonurus* and *Leonotis* species) have diterpenes as some of the main active compounds. An example is **marrubiin**. Monk's pepper fruit (*Vitex agnus-castus*) has diterpenes such as **vitexilactone** and rotundifoline that contribute to the pharmacological activities of the herb.

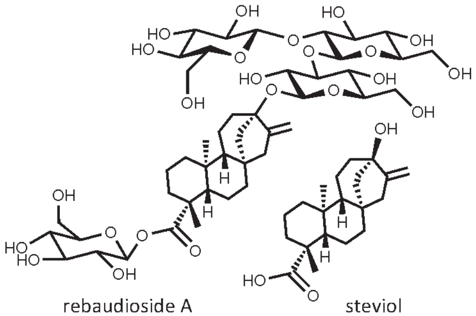


teucrin A



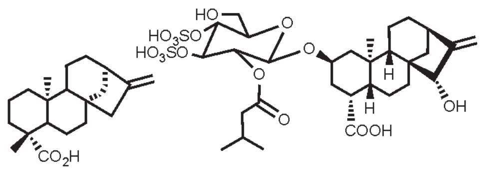
ballotenol

Several furan-containing diterpene lactones of the *ent*-clerodane type occur in wild germander (*Teucrium chamaedrys*). **Teucrin A** is the main diterpene (ca. 70% of the total) in extracts that are used to flavour wines, bitters and liqueurs. Because of its proven hepatotoxic activity, *Teucrium* has been banned in some countries, while others (e.g. the USA) allow low levels of the compound, but in beverages only. Similar furane compounds occur in black horehound (*Ballota nigra*) such as **ballotenol**.



rebaudioside A steviol

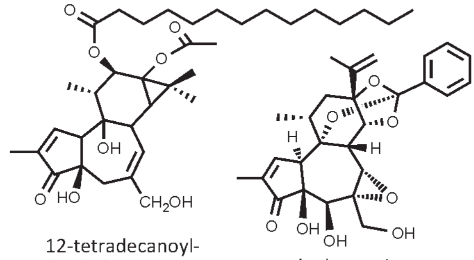
Another large group is the kaurene-type diterpenes. A well-known example is **steviol**. It occurs in *Stevia rebaudiana* as glycosides and includes the well-known natural sweeteners steovioside and **rebaudioside A** (it is sold as rebiana).



ent-16-kauren-19-oic acid atractyloside

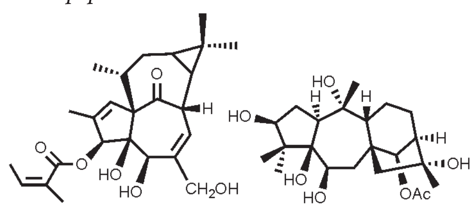
Other examples of kaurene diterpenoids are ***ent*-16-kauren-19-oic acid**, the main compound in two South African medicinal plants of the Apiaceae (*Alepidea* and *Arctopus*). **Atractyloside** from *Atractylis gummifera* and *Callilepis laureola* (Asteraceae) is a specific inhibitor of ATP/ADP transport across mitochondrial membranes and thus blocks energy supply of cells and organisms.

Several diterpenes are quite toxic, such as phorbol esters (present in Euphorbiaceae and Thymelaeaceae), which can be divided into those with a tigliane moiety and others with a daphnane or ingenane moiety. The **phorbol** moiety carries one or two long-chained esters so that the phorbol esters resemble diacyl glycerol, a substrate of protein kinase C (PKC). The most common phorbol ester is **12-*O*-tetradecanoylphorbol-13-acetate** (TPA), which is used in carcinogenesis studies.



12-tetradecanoyl-
phorbol 13-acetate daphnetoxin

Phorbol esters activate PKC and therefore cause severe inflammation; they can also function as tumour promoters. Plants with phorbol esters are strong purgatives; they induce drastic diarrhoea as soon as 5–10 minutes after ingestion. They are also potent skin irritants and lead to painful inflammation, especially of mucosal tissue and of the eye. *Croton flavens* is an ingredient of Welensali tea, which has been consumed in Curacao. There, a high incidence of oesophagus cancer has been recorded, caused by welensalifactor F1. Some plants (such as *Daphne mezereum*) have been used in traditional medicine as laxative and blister-forming drug. The main toxic substance is a daphnane ester, **daphnetoxin**. An example of an ingenane-type diterpenoid is **ingenol mebutate** (see below), the active compound in *Euphorbia peplus* used to treat skin keratoses.



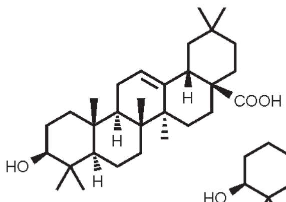
ingenol mebutate andromedotoxin

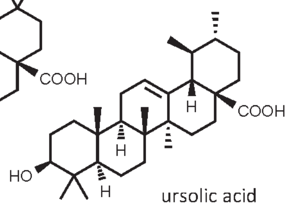
Another group of toxic diterpenes includes **andromedotoxin** (synonyms: acetylandromedol, grayanotoxin-I, rhodotoxin). The neurotoxic andromedotoxin and related compounds are common in Ericaceae, especially in the genera *Gaultheria*, *Pieris*, *Ledum*, *Rhododendron* and *Kalmia*. The toxins can be transferred to honey, rendering it toxic. Andromedotoxins inhibit Na^+-channels; they bind to receptor site II and block the transmission of action potentials. This causes bradycardia, hypotension and even death.

Triterpenes and steroids

Triterpenes are C30 compounds, representing six isoprene units. They are biosynthetically derived from squalene, a simple triterpene originally obtained from shark liver oil.

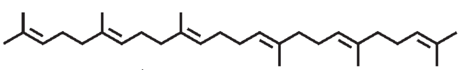
An example of a typical triterpene is **oleanolic acid**, present in many food plants and medicinal plants (such as olives). It is hepatoprotective and shows antitumour and antiviral effects. Another example is **ursolic acid**, a natural substance in many types of food (high levels in apple peels, for example) with a wide range of biological activities.

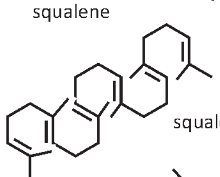

oleanolic acid

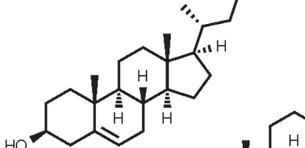

ursolic acid

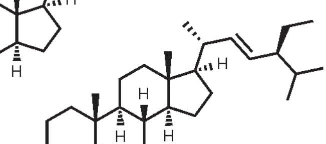
Squalene is abundant in nature (e.g. in amaranth seed oil and olive oil) and is commonly used in cosmetics and as dietary supplement, believed to have chemopreventative activity to protect people against cancer (high levels are found in the Mediterranean diet). It plays a vital role in the synthesis of all animal and human sterols, including **cholesterol**, steroid hormones and vitamin D. In plants it is a precursor to **stigmasterol**. Phytosterols are structurally similar to cholesterol.

The shared use of squalene as a precursor leads to the fact that some triterpenes and steroids from plants show structural similarity with hormones, including steroidal hormones, sex hormones, cortisone, ecdysone and juvenile hormone.

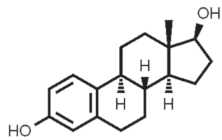

squalene

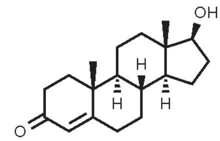

squalene

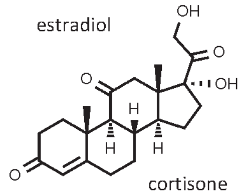

cholesterol


stigmasterol

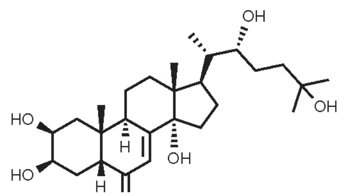
The main sex hormones in humans are **estradiol** (female) and **testosterone** (male). **Cortisone** is a hormone released by the adrenalin gland in response to stress and as an anti-inflammatory agent.

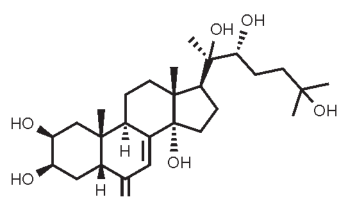

estradiol


testosterone


cortisone

Prominent examples of bioactive steroids are the phytoecdysones. An example is **polypodine B**, found in *Polypodium vulgare* rhizomes. Phytoecdysones have also been isolated from other ferns (*Pteridium aquilinum*) and several gymnosperms and angiosperms (*Achyranthes*, *Ajuga*, *Rhaponticum*, *Vitex*, *Silene*, *Podocarpus*). They mimic the insect moulting hormone **ecdysone**, stressing the role of terpenes in anti-herbivore defence.


ecdysone


polypodine B

Mammalian steroidal sex hormones can also be produced by plants. Examples of oestrogen-producing plants are *Phaseolus vulgaris*, *Salix*, *Phoenix dactylifera*, *Punica granatum* and for androgens the pollen of *Pinus sylvestris*.

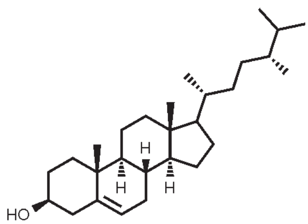
Foods and dietary supplements enriched with phytosterols have become popular in recent years.

Red stinkwood (*Prunus africana*): bark – β-sitosterol

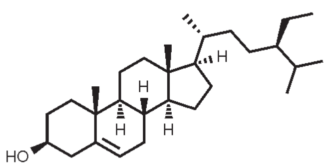
Rapeseed [*Brassica rapa* (= *B. campestris*)]: seeds – campesterol

Pleurisy root (*Asclepias tuberosa*): cardiac glycosides

Red bryony (*Bryonia dioica*): roots – cucurbitacins



campesterol

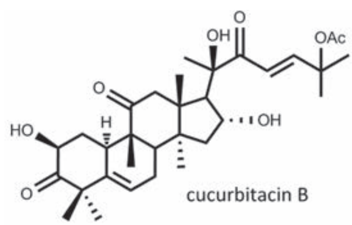


β-sitosterol

The best-known example of a dietary phytosterol is **β-sitosterol**, which occurs in pumpkin seeds (*Cucurbita pepo*) and many other plants (*Hypoxis hemerocallidea*, *Nigella sativa*, *Prunus africana*, *Serenoa repens*, *Urtica dioica*). These plants are traditionally used to treat benign prostate hyperplasia because the phytosterols are believed to inhibit the activity of the enzyme 5α-reductase and/or to decrease binding of dihydrotestosterone in the prostate. Another common phytosterol is **campesterol**, first found in rape seeds (*Brassica campestris*), hence the name. High levels (up to 100 mg/100 g) are found in canola oil and corn oil. It is thought that sitosterol and campesterol compete with cholesterol and therefore reduce the absorption of cholesterol in the human intestine.

Stigmasterol is used as a starting material in the semi-synthesis of cholesterol and cortisone. The latter has anti-inflammatory and painkilling activities and is used to treat many ailments. It is speculated that some plant steroids may mimic the effects of cortisone.

Among steroidal glycosides, the cucurbitacins (occurring in members of the Cucurbitaceae and a few other families) express substantial cytotoxic activities; they inhibit tumour growth *in vitro* and *in vivo*. Cucurbitacins have been used to treat nasopharyngeal carcinoma. They are highly cytotoxic as some of them block mitosis in metaphase by inhibiting microtubule formation.

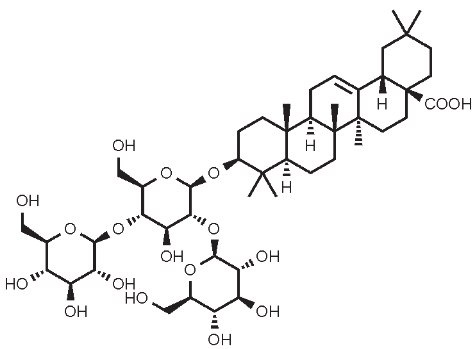


cucurbitacin B

A typical example is **cucurbitacin B**, present in *Citrullus colocynthis* and other members of the Cucurbitaceae. Drugs with cucurbitacins have been used to treat malaria, as emetic or anaesthetic (now obsolete), and in traditional medicine as diuretic, abortifacient and importantly as drastic laxative. Cucurbitacins irritate intestinal mucosa and cause release of water into the gut lumen. This in turn activates gut peristalsis and promotes diarrhoea. For topical use, *Bryonia* cucurbitacins have been applied to treat rheumatism and muscle pain.

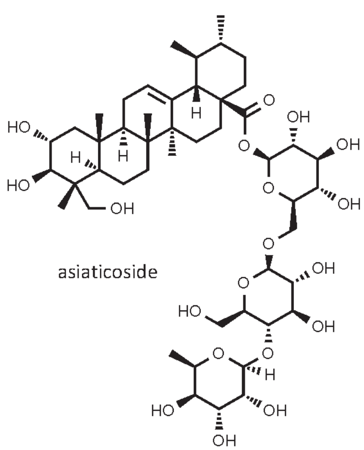
Saponins

Saponins are the glycosides of triterpenes or steroids and include the group of cardiac glycosides and steroidal alkaloids. They are amphipathic glycosides, meaning that they have both hydrophilic (polar, "water-loving") and lipophilic (non-polar, "fat-loving") properties. The sugar part(s) of the saponin is hydrophilic, while the terpene part is lipophilic. Saponins are easily detected by the soap-like foaming that occurs when they are shaken in water. This has led to the so-called foam test (froth test), positive for saponins when the froth exceeds 20 mm in height and persists for 10 minutes or more. Monodesmosidic saponins have a single sugar chain, usually at C-3, while bidesmosidic saponins have two sugar chains, at C-3 and C-28.



oleanoglycotoxin A

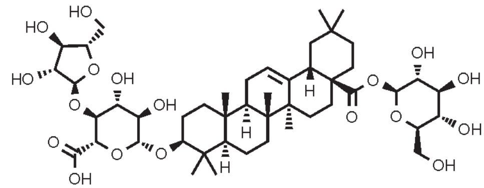
An example of a monodesmosidic saponin with the sugar chain at C-3 is **oleanoglycotoxin A**, the active compound in endod (*Phytolacca dodecandra*).



asiaticoside

Asiaticoside (the main active compound in *Centella asiatica*) is also a monodesmosidic saponin but has the sugar chain attached at C-28.

Araloside, the main saponin of the Japanese angelica tree (*Aralia japonica*) is an example of a bidesmosidic saponin with sugar chains at both C-3 and C-28. It has anti-ulcer activity.



araloside A

When the sugars are removed (e.g. through acid hydrolysis), the aglycones are known as sapogenins.

Saponins are found in many plants but their name is derived from the well-known soapwort plant (*Saponaria officinalis*), the roots of which were traditionally used as a soap substitute and detergent for washing clothes. Another practical use of saponins is in the production of Turkish halva, where they are responsible for the unique texture that is so distinctive of these delicious sweets. Turkish soaproot and soaproot extracts are obtained from *Gypsophila graminifolia*, *G. bicolor*, *G. arrostii* and the closely related *Ankyropetalum gypsophiloides*.

The compounds are highly toxic for fish because they inhibit their respiration; therefore they have been traditionally used as fishing poisons. Saponins also kill water snails and have been employed to eliminate snails in tropical waters that transmit human parasites, such as *Schistosoma* (causing schistosomiasis, also known as bilharzia). An example of an African plant that is traditionally used as a soap substitute and as fish and snail poison in Ethiopia is endod (*Phytolacca dodecandra*).

Steroidal saponins are typical for several families of monocots, and are less frequent in dicots (Fabaceae, Scrophulariaceae, Plantaginaceae, Solanaceae, Araliaceae). Triterpene saponins are abundant in several dicot families, such as Caryophyllaceae, Ranunculaceae, Phytolaccaceae, Amaranthaceae, Primulaceae, Poaceae and Sapotaceae. They are absent in gymnosperms.

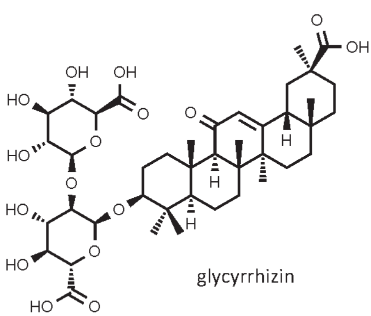
Some saponins are stored as bidesmosidic compounds in the vacuole, which are cleaved to the active monodesmosidic compounds by a β-glucosidase or an esterase upon wounding-induced decompartmentation. Monodesmosidic saponins are amphiphilic compounds, which can complex cholesterol in biomembranes with

Endod (*Phytolacca dodecandra*): saponins (soap substitute)

Elephant's foot (*Dioscorea elephantipes*): tuber – steroidal saponins

their lipophilic terpenoid moiety and bind to surface glycoproteins and glycolipids with their sugar side chain. This leads to a severe tension of the biomembrane and leakage. This activity can easily be demonstrated with erythrocytes, which lose their haemoglobin (haemolysis) when in contact with monodesmosidic saponins. This membrane activity is rather unspecific and affects a wide set of organisms, from microbes to animals. Therefore, saponins have been used in traditional medicine as anti-infecting agents.

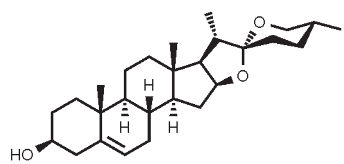
Because saponins irritate the *nervus vagus* in the stomach, which induces the secretion of water in the bronchia, saponin-containing drugs are widely employed as secretolytic agents in phytomedicine (see *Hedera helix* and *Primula veris*, for example).



glycyrrhizin

In some cases, steroids, triterpenes and saponins structurally resemble endogenous anti-inflammatory hormones, e.g., glucocorticoids. The anti-inflammatory effects known from many medicinal plants could be due to a corticomimetic effect. A pronounced anti-inflammatory activity has been reported for **glycyrrhizin** (also known as glycyrrhizic acid) from liquorice (G*lycyrrhiza glabra*). This triterpene saponin is the main sweet-tasting substance in the rhizomes.

Steroidal saponins are important for the synthesis of steroid hormones that are used in the oral contraceptive pill, commonly known as "the pill". It has become a popular form of birth control in almost all countries since 1961 (except Japan) and is used by more than 100 million women worldwide.

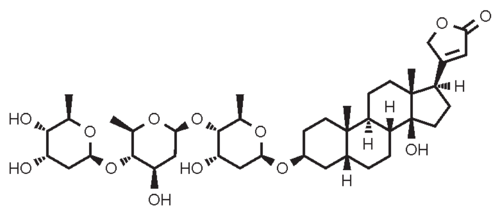


diosgenin

Diosgenin, obtained by hydrolysis of dioscin (the main saponin in *Dioscorea villosa* and other species) is an example of a starting material for the commercial synthesis of steroids such as cortisone, pregnenolone and progesterone. Progesterone, for example, was used in early combined oral contraceptive pills. These steroids are nowadays semi-synthesised from phytosterols extracted from common sources such as soybeans.

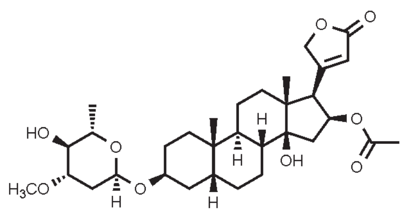
Cardiac glycosides

Some saponins have additional functional groups, such as the **cardiac glycosides**. They can either be cardenolides (when they carry a five-membered cardenolide ring) or bufadienolides (with a six-membered bufadienolide ring). Cardenolides have been found in Plantaginaceae (formerly Scrophulariaceae; *Digitalis*), Apocynaceae (*Apocynum*, *Nerium*, *Strophanthus*, *Thevetia*, *Periploca*, *Xysmalobium*), Brassicaceae (*Erysimum*, *Cheiranthus*), Celastraceae (*Euonymus*), Convallariaceae (*Convallaria*) and Ranunculaceae (*Adonis*). Bufadienolides occur in Crassulaceae (*Cotyledon*, *Kalanchoe*), Hyacinthaceae (*Drimia*, formerly *Urginea*) and Ranunculaceae (*Helleborus*). Examples of cardenolides are shown below.



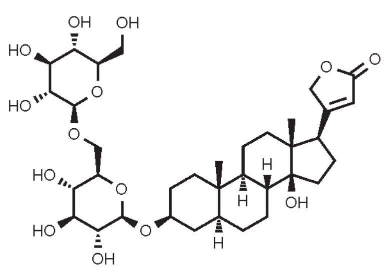
digitoxin

Digitoxin is the main poisonous cardenolide in the common purple foxglove (*Digitalis purpurea*).



oleandrin

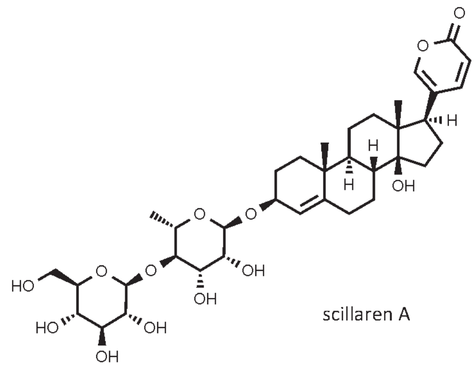
Oleandrin is the main poisonous cardenolide in oleander (*Nerium oleander*).



uzarin

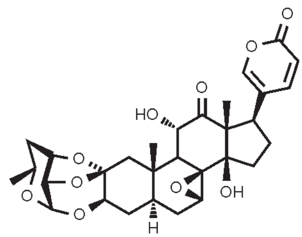
Uzarin is the active (non-toxic) cardenolide in the roots of uzara (*Xysmalobium undulatum*).

Two examples of bufadienolides are given below to show the typical six-membered bufadienolide ring in these compounds.



scillaren A

Scillaren A is the main toxic and active bufadienolide in the bulbs of the European squill (*Drimia maritima*).



orbicuside A

Orbicuside A is a major poisonous bufadienolide from pig's ears or *plakkie* (*Cotyledon orbiculata*), a popular garden succulent. The compound causes a condition known as *krimpsiekte* in stock animals.

Although structurally different, all cardiac glycosides inhibit one of the most important molecular targets of animal cells, the Na^+, K^+-ATPase which builds up Na^+ and K^+ gradients, which are essential for transport activities of cells and neuronal signalling. Therefore, cardiac glycosides are strong neurotoxins, which cause death through cardiac and respiratory arrest. Cardiac glycosides are used in medicine to treat patients with cardiac insufficiency. They slow down the heartbeat and exhibit positive inotropic, positive bathmotropic, weakly negative chronotropic and dromotropic heart activity. Isolated cardiac glycosides are still used to treat patients with cardiac insufficiency; in phytomedicine standardised extracts of cardiac glycoside-producing plants are employed.

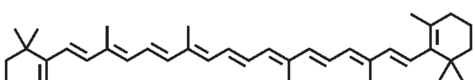
Uzara (*Xysmalobium undulatum*): roots – uzarin

Pig's ears (*Cotyledon orbiculata*): leaves – bufadienolides

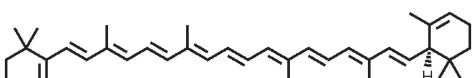
Tetraterpenes

Carotenoids are formed from eight isoprene units (40 carbons) and represent the most important members of the tetraterpene group (more than 600 are known). They are organic pigments found in the chloroplasts and chromoplasts of plants. Carotenoids are highly lipophilic compounds and are always associated with biomembranes. In chloroplasts they serve as accessory pigments important for photosynthesis. They also protect against UV light. Carotenoids in food and medicinal drugs are employed as powerful antioxidants. Carotenoids (mainly β-carotene, α-carotene and cryptoxanthin) are the precursors for vitamin A in animals. Vitamin A is a group of unsaturated compounds (retinal, retinol and retinoic acid) along with several provitamin A carotenoids, among which β-carotene is the most important.

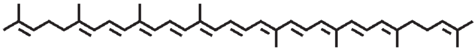
Carotenoids are divided into two groups: those with oxygen (**xanthophylls**) and those without (**carotenes**).



β-carotene (carotene)

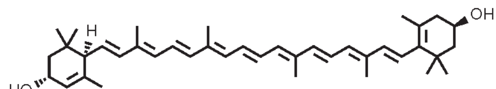


α-carotene

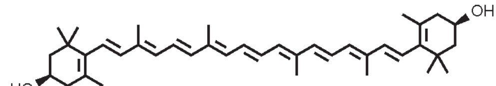


lycopene

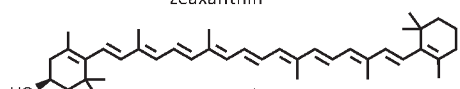
The main dietary carotenes are **β-carotene** (often referred to simply as carotene, because it is the major carotenoid), **α-carotene** and **lycopene**. Carrot (*Daucus carota*) is a major source of dietary carotene. Lycopene is the major red pigment in tomatoes (*Lycopersicon esculentum* or *Solanum lycopersicum*).



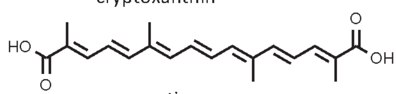
lutein



zeaxanthin

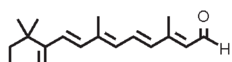


cryptoxanthin

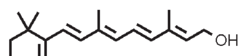


crocetin

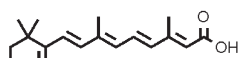
Examples of xanthophylls include **lutein**, **zeaxanthin** and **cryptoxanthin**. The flavour of saffron (*Crocus sativus*) is due to crocin, a digentiobioside ester of the carotenoid **crocetin**.



all-trans-retinal



retinol



all-trans-retinoic acid

The carotenoids are used to produce **retinal** (a light sensor in the rhodopsin complex) and **retinoic acid** (retinoids bind to nuclear receptors and are local mediators of vertebrate development).

Polyterpenes

Polyterpenes, consisting of 100 to 10 000 isoprene units, are prominent in latex of Euphorbiaceae, Moraceae, Apocynaceae, Sapotaceae and Asteraceae. Some polyterpenes are used commercially, such as rubber (from *Hevea brasiliensis*, Euphorbiaceae) or gutta-percha.

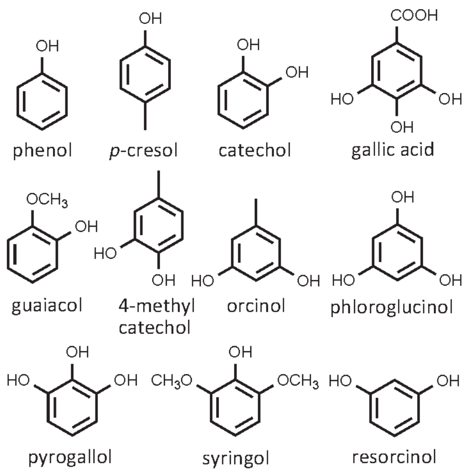
Phenolics

A large group of secondary metabolites, which are produced by most plants, are phenolics. They contain one or several aromatic rings carrying phenolic hydroxy groups. Phenolic substances often occur as glycosides and tend to be water soluble. They are all aromatic and therefore show intense absorption of light in the UV region of the spectrum. This is a useful means of detecting, identifying and quantifying phenolic compounds. The group includes simple phenols, phenylpropanoids, flavonoids and phenolic quinones, as well as polymeric materials such as tannins and lignins.

The phenolic hydroxy groups of these compounds can dissociate in negatively charged phenolate ions under physiological conditions. Phenolic hydroxy groups can thus form both hydrogen and ionic bonds with many proteins and peptides involved in health disorders. The higher the number of hydroxy groups, the stronger the astringent and denaturing effect. A common chemical property is the scavenging of oxygen radicals and therefore many phenolics exert antioxidant activity. Polyphenols (with several phenolic rings) are present in most drugs used in phytotherapy and apparently are responsible for a wide array of pharmacological properties, including antioxidant, anti-inflammatory, sedating, wound-healing, antimicrobial and antiviral activities.

Phenylpropanoids

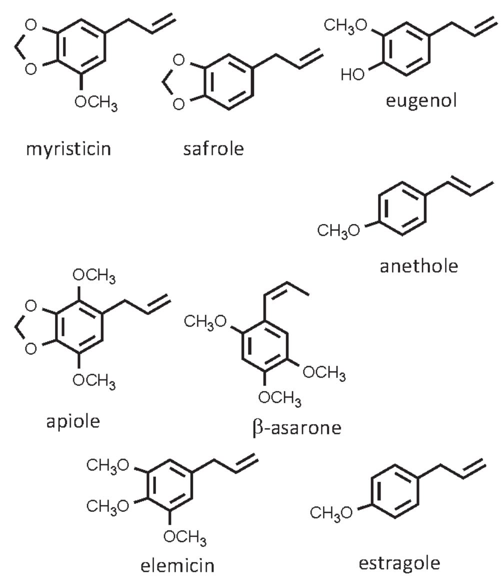
Simple phenols with pronounced antioxidant activity include **phenol** itself, ***p*-cresol**, **catechol**, **gallic acid**, **guaiacol**, **orcinol**, **4-methylcatechol**, **phloroglucinol**, **pyrogallol**, **syringol** (2,6-dimethoxyphenol) and **resorcinol**. They carry two or three phenolic hydroxy groups, which are either free or methylated.



Medicinally important phenylpropanoids with a shortened side chain include **salicylic acid**, saligenin and the corresponding glucoside **salicin**.

Because they inhibit a key enzyme of prostaglandin biosynthesis, i.e. cyclooxygenase, they have been used in the treatment of inflammation, fever and chronic pain. These compounds are known from willows (*Salix purpurea*), *Populus*, *Filipendula ulmaria*, *Primula veris* and *Viola tricolor*.

Some lipophilic and aromatic **phenylpropanoids** include **myristicin**, **safrole**, **eugenol**, **apiole**, **ß-asarone**, **elemicin** and **estragole**, which can be found in essential oils.

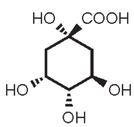


Phenylpropanoids with a terminal methylene group as shown here can react with SH-groups of proteins. In the liver, these compounds are converted to epoxides, which can alkylate proteins and

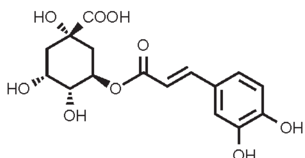
Sassafras (*Sassafras albidum*): leaves – safrole

Sweet woodruff (*Galium odoratum*): leaves – coumarin

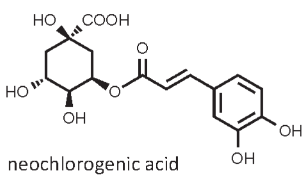
DNA. Therefore, they are potentially mutagenic and tumours have been observed in animal experiments. In particular, myristicin inhibits MAO, which induces an increase of biogenic amine neurotransmitters, such as dopamine, serotonin and noradrenaline. Psychotropic effects resemble those of amphetamine. Eugenol is antiseptic and analgesic and has been widely used in dentistry. Another well-known phenylpropanoid is **anethole** (see *Pimpinella anisum*).



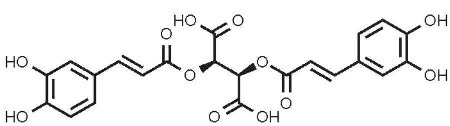
quinic acid



chlorogenic acid

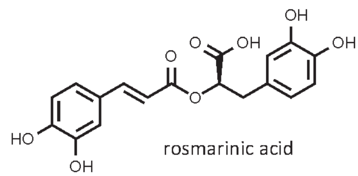


neochlorogenic acid

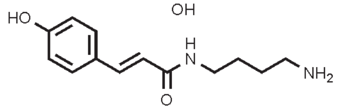


cichoric acid

Chlorogenic acid and related **quinic acid** esters of caffeic acid occur in some medicinal plants that are used as general tonics, including *Centella asiatica* and *Echinacea* species. **Neochlorogenic acid** occurs in dried fruits and is believed to be responsible for their mild laxative effect. The structurally related **cichoric acid** occurs in *Cichorium intybus* and in *Echinacea purpurea* (but not any of the other *Echinacea* species). Phenolic acids are treated in more detail in the section on organic acids.

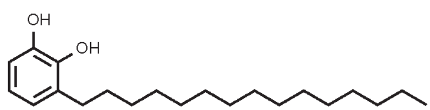


rosmarinic acid



coumaroylputrescine

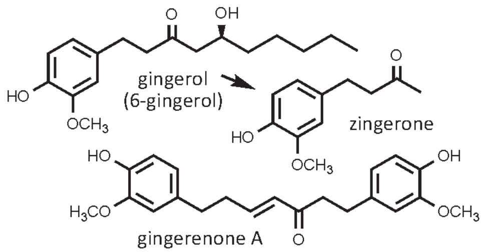
Phenylpropanoids can also be conjugated with a second phenylpropanoid, such as in **rosmarinic acid** or with amines, such as **coumaroylputrescine**. Rosmarinic acid (common in Lamiaceae) bears a number of phenolic hydroxy groups with tannin-like activity (anti-inflammatory, antiviral).



urushiol I

Some phenols carry long alkyl and alkenyl side chains. Alkyl and alkenyl phenols such as urushiol are abundant in Anacardiaceae, Hydrophyllaceae, Proteaceae, *Ginkgo* and *Philodendron*. The example shown here is **urushiol I**, found as one of a mixture of urushiols in poison ivy (*Rhus toxicodendron*). Alkyl phenols are extremely allergenic compounds that are responsible for over a million poisoning cases (*Rhus* dermatitis) reported in the USA. Contact with the eye is extremely hazardous and can lead to blindness.

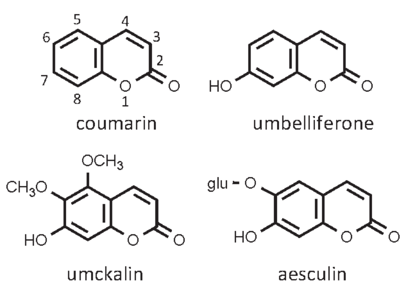
Phenylpropanoids occur in abundance in the ginger family (Zingiberaceae). The pungent taste (and medicinal value) of ginger (*Zingiber officinale*) is due to gingerols (such as **6-gingerol**) in the intact rhizome and derivatives (shogaols and **zingerone**) that form when ginger is dried or cooked.



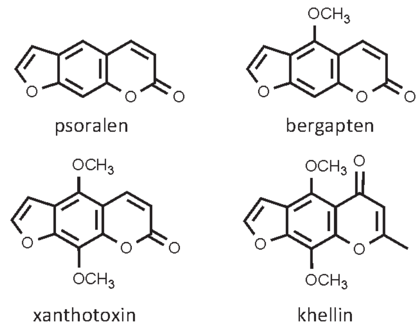
Diarylheptanoids occur in large numbers in ginger and related plants. These compounds comprise two aromatic rings connected by a chain of seven carbons (heptane). An example is **gingerenone A**, a major compound in ginger. The related turmeric (*Curcuma longa*) has curcumin, a major food colouring with demonstrated medicinal activities.

Coumarins and furanocoumarins

Phenylpropanoids serve as building blocks for coumarins and furanocoumarins of which over 700 structures have been determined. These compounds are named after *coumarou*, the French name for the tonka bean (*Dipteryx odorata*) from which coumarin was first isolated. Coumarins can reach concentrations of up to 2% in plants and are common in the Apiaceae (most genera), Fabaceae (e.g., *Dipteryx odorata*, *Melilotus officinalis*), Poaceae (e.g., *Anthoxanthum odoratum*), Rubiaceae (e.g., *Galium odoratum*). In phytomedicine they are used because of anti-inflammatory and antimicrobial properties (*Melilotus*). Coumarins are aromatic and therefore used in cosmetics and in beverages. They are often components of essential oils.

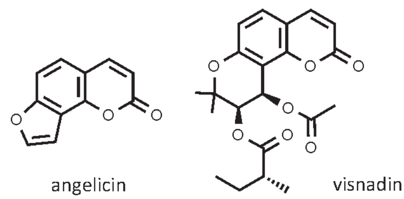


Simple coumarins include **coumarin** itself, present in tonka bean, sweet clover (*Melilotus officinalis*); **umbelliferone**, in many members of the Apiaceae (Umbelliferae) such as angelica, coriander and carrot, but also in mouse-ear hawkweed (*Hieracium pilosella*, Asteraceae) and hydrangea (*Hydrangea macrophylla*, Hydrangeaceae); **umckalin**, present in *Pelargonium sidoides* (the additional presence of coumarin sulfates distinguishes this species from *P. reniforme*). These coumarins also occur as glycosides, e.g. **aesculin** in horse chestnut (*Aesculus hippocastanum*).



Furanocoumarins usually have a third furane ring that derives from active isoprene. Linear (psoralen-type) or angular (angelicin-type) furanocoumarins are distinguished.

Linear furanocoumarins include the widely distributed **psoralen**, **bergapten** and **xanthotoxin**, as well as **khellin** (in *Visnaga daucoides*).

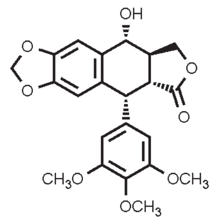


Examples of the angular type include **angelicin** (from *Angelica archangelica*) and **visnadin** (from *Visnaga daucoides*).

The furanocoumarins occur in aerial parts such as leaves and fruits but also in roots and rhizomes. They are abundant in Apiaceae (contents up to 4%), but also present in certain genera of the Fabaceae (e.g., *Psoralea bituminosa*) and Rutaceae. The lipophilic and planar furanocoumarins can intercalate DNA and upon illumination with UV light can form cross-links with DNA bases, but also with proteins. They are therefore mutagenic and possibly carcinogenic. In medicine, furanocoumarins (such as 8-methoxypsoralen, 8-MOP) are employed for the treatment of psoriasis and vitiligo because they can kill proliferating keratocytes in the skin upon UV exposure. This treatment brings some relief for psoriasis patients.

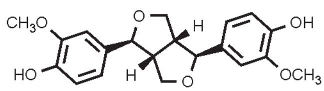
Lignans and lignin

Phenylpropanoids can form complex dimeric structures, so-called lignans.



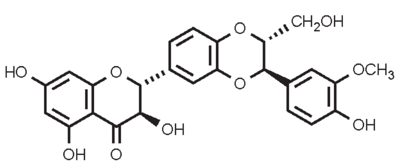
podophyllotoxin

Podophyllotoxin, which occurs in members of the genera *Podophyllum* (Berberidaceae), *Linum* (Linaceae) and *Anthriscus* (Apiaceae), is a potent inhibitor of microtubule formation and thus prevents cell division.



pinoresinol

Pinoresinol and related compounds are inhibitors of cAMP phosphodiesterase, cytotoxic, insecticidal and immune modulating.



silybin

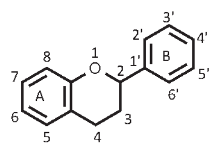
The lignans from *Silybum marianum* (**silybinin**, silandrin, silychristin) have antihepatotoxic properties and the product is used to treat *Amanita* poisoning and liver cirrhosis.

Condensation of phenylpropanoids generates the complex lignin macromolecules that are important for the mechanical stability of plants, but also show some antimicrobial effects.

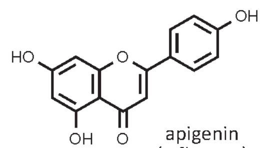
Flavonoids and anthocyanins

Phenylpropanoids can condense with a polyketide moiety to form flavonoids, stilbenes, chalcones, catechins and anthocyanins. These compounds are characterised by two aromatic rings that carry several phenolic hydroxy or methoxy groups. In addition, they often occur as glycosides and are stored in vacuoles. Flavonoids are active ingredients of many phytopharmaceuticals.

Flavonoids have a typical **C15 nucleus** with three rings. The flavonoid nucleus is usually attached to a sugar and the compounds occur mostly as glycosides in the vacuoles of cells. The main classes of flavonoids are flavones, flavanones, flavonols, chalcones and aurones, and isoflavones and isoflavonoids.

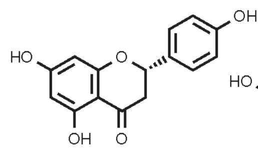


The flavonoid nucleus

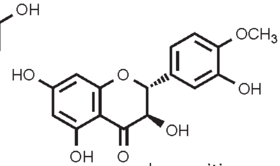


apigenin
(a flavone)

Flavones are the most basic type of flavonoid and occur in many angiosperms. **Apigenin** and luteolin are well-known examples.



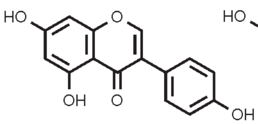
naringenin
(a flavanone)



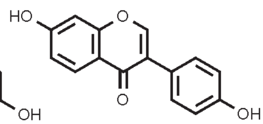
hesperitin
(a flavanone)

Flavanones are similar to flavones but differ in the absence of a double bond in the 2,3-position. They are common in many plant families (Asteraceae, Fabaceae, Rosaceae and Rutaceae). **Naringenin** is an example – it is the dominant flavanone in grapefruits (an aglycone of naringin). Another is **hesperitin**, the aglycone of hesperidin. It is released through acid hydrolysis when citrus fruits are ingested.

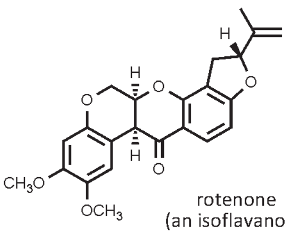
Isoflavones and isoflavonoids are typical secondary metabolites of the legumes (subfamily Papilionoideae). They resemble the female sex hormone estradiol. Isoflavones can exhibit oestrogenic properties and inhibit tyrosine kinases. Because of these properties they are often regarded as useful compounds that might play a role in the prevention of certain cancers, and for women with menopause or osteoporosis problems.



genistein
(an isoflavone)

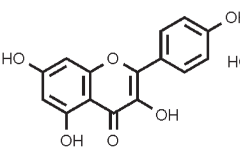


daidzein
(an isoflavone)

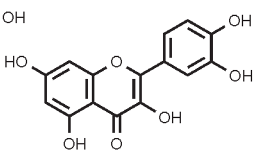


rotenone
(an isoflavanoid)

Isoflavones from soy bean (*Glycine max*) and red clover (*Trifolium pratense*) are marketed as nutraceuticals. The two main compounds in these preparations are **genistein** and **daidzein**. **Rotenone** is an isoflavonoid that inhibits the mitochondrial respiratory chain and is therefore highly toxic and used as an insecticide (traditionally as a fish poison).

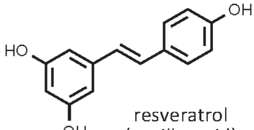


kaempferol
(a flavonol)



quercetin
(a flavonol)

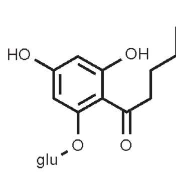
Flavonols are very common in plants. They are characterised by a hydroxy group in the 3-position. Glycosides of **kaempferol** and **quercetin** are frequently found in many medicinal plants.



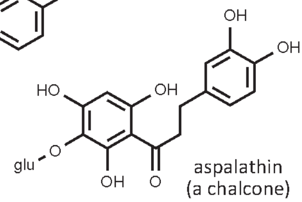
resveratrol
(a stilbenoid)

Stilbenoids are hydroxylated derivatives of stilbene with a C6-C2-C6 structure that are biogenetically related to the chalcones. Stilbenes such as **resveratrol** (present in red wine) have antioxidant, antibacterial and antifungal activities, and are present in several drugs and nutraceuticals.

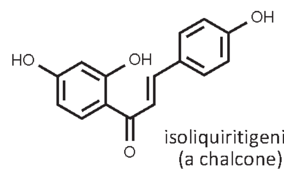
Chalcones are characterised by an open C3 heterocyclic ring.



phlorizin
(a chalcone)

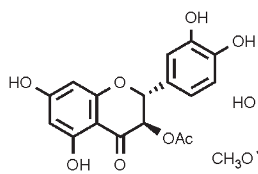


aspalathin
(a chalcone)

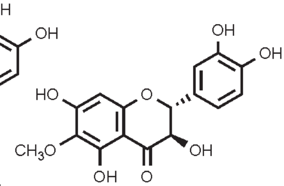


isoliquiritigenin
(a chalcone)

Examples include **aspalathin**, the main phenolic compound in rooibos tea (*Aspalathus linearis*), the *O*-glycoside **phlorizin** from *Acorus*, *Pieris* and *Rhododendron* (it inhibits glucose transport at biomembranes) and **isoliquiritigenin** (it inhibits mitochondrial monoamine oxidase and uncouples mitochondrial oxidative phosphorylation). Glyceollin II, a prenylated pterocarpan and phytoalexin with anti-oestrogenic activity, has the same activity.



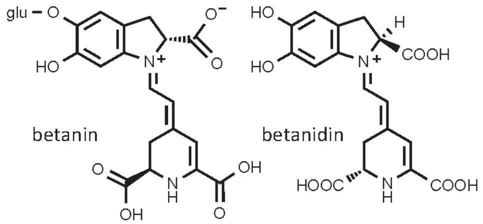
taxifolin-3-O-acetate
(a dihydroflavonol)



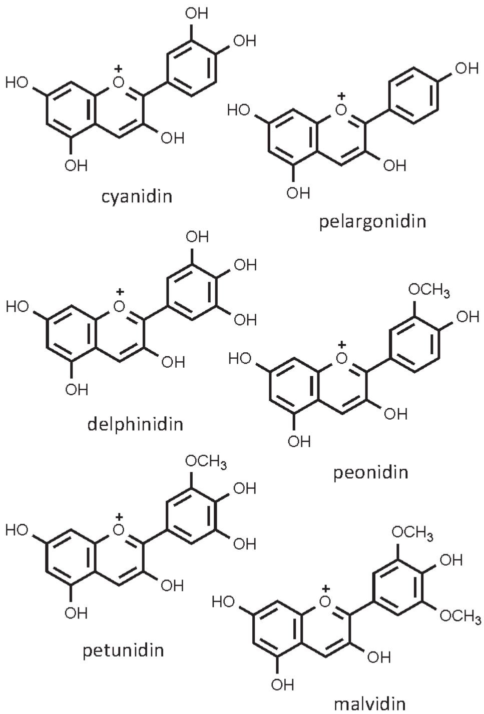
6-methoxytaxifoline
(a dihydroflavonol)

Dihydroflavonols such as **taxifolin 3-*O*-acetate**, **6-methoxytaxifolin** and 6-methoxyaromadendrin 3-*O*-acetate have a sweet taste. This is unlike many flavanones such as naringin, neoeriocitrin and neohesperidin that are typically very bitter.

Anthocyanins are the dominant flower and leaf pigments in plants that give red, pink, blue and purple colours, including autumn colours. The only exception is certain plant families of the order Caryophyllales, where the bright colours are due to betacyanins or betalains (indole-derived pigments) that contain nitrogen.



The bright red colour of beetroot, for example, is due to **betanin** (beetroot red). It is used as a food additive. The aglycone is called betanidin.

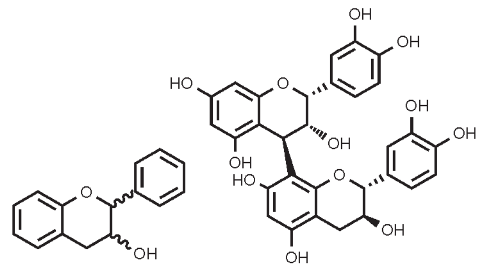


There are six very common anthocyanin aglycones (called anthocyanidins) in nature, three with hydroxy groups on the B-ring and three with methoxy groups. These are **cyanidin**, **pelargonidin** and **delphinidin** (hydroxylated) or **peonidin**, **petunidin** and **malvidin** (methoxylated).

The colour of anthocyanins depends on the degree of glycosylation, hydrogen ion concentration and the presence of certain metals [e.g., aluminium (aluminum) ions] in the vacuole. Parallel to a change in pH of the vacuole in developing flowers, a colour change from pink to dark blue can be observed in several species of the Boraginaceae (e.g., *Symphytum*, *Echium*). Anthocyanins are active antioxidants and are therefore used in phytomedicine or nutraceuticals to prevent ROS-related health disorders (anthocyanin-rich fruits and fruit juices from *Aronia*, *Vaccinium*, *Punica*, *Vitis* and others). ROS refers to reactive oxygen species that cause damage to cells and DNA.

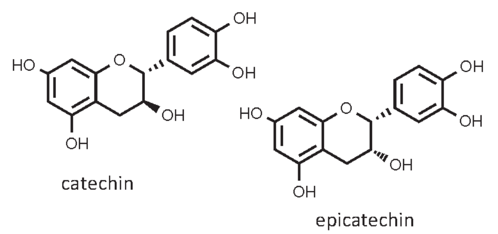
Catechins and tannins

Catechins form a special class of flavonoids, which often dimerise or even polymerise to form procyanidins and oligomeric procyanidins.



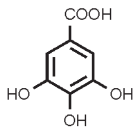
flavan-3-ol procyanidin B-2

The basic structure is a **flavan-3-ol**. **Procyanidin B-2** is an example of a dimeric catechin found in *Crataegus* flowers and in grape leaves.



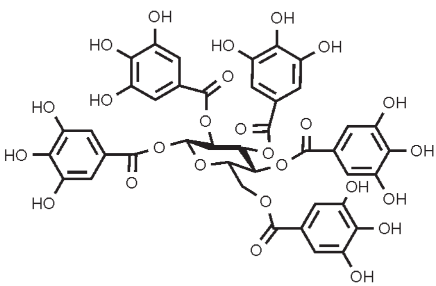
catechin epicatechin

Common catechins include **catechin** and **epicatechin**, both found in tea and cacao. The conjugates (which cannot be hydrolysed; "non-hydrolysable or condensed tannins") are characterised by a large number of hydroxy groups. The phenolic hydroxy groups can interact with proteins to form hydrogen and ionic bonds and possibly even covalent bonds. If more than 10 hydroxy groups are present these compounds act as "tannins". Non-hydrolysable tannins are also called condensed tannins (or proanthocyanidins, polyflavonoid tannins, catechol-type tannins, pyrocatecholic type tannins or flavolans). They are polymers formed by the condensation of flavans but they have no sugar residues. The term proanthocyanidin is appropriate because these polymers yield anthocyanidins when they are depolymerised. The different types are called procyanidins, propelargonidins, prodelphinidins, and so on, depending on the units. The tannin-protein interactions are a base for the utilisation of plants with catechins in phytotherapy (e.g., *Crataegus monogyna* in patients with heart problems).



gallic acid

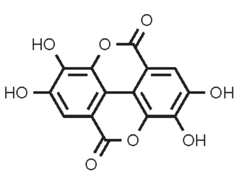
Another important group of tannins is hydrolysable. They represent esters of **gallic acid** and sugars; in addition several moieties of gallic acid can be present that are also linked by ester bonds. These gallotannins are widely distributed in plants, often in bark, leaves and fruits. Gallotannins, which can additionally be condensed with catechins, contain a large number of phenolic hydroxy groups so that they can form stable protein-tannin complexes and thus interact with a wide variety of protein targets in microbes and animals.



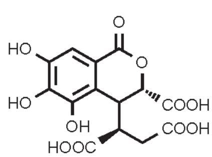
pentagalloylglucose

An example of a hydrolysable tannin is **pentagalloylglucose**, found in pomegranate (*Punica granatum*) and several other plants.

Ellagitannins differ from gallotannins because their galloyl groups are linked through C-C bonds. In this case the acid component is **chebulic acid** or **ellagic acid**.

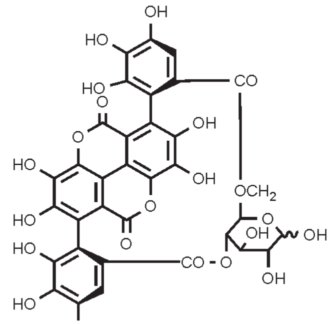


ellagic acid

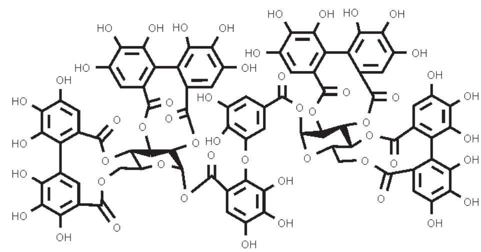


chebulic acid

Examples include **punicalin** from pomegranate (*Punica granatum*) and **agrimoniin** from agrimony (*Agrimonia eupatoria*) and wild strawberry (*Fragaria vesca*).



punicalin

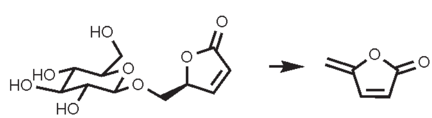


agrimoniin

Tannins are known for their tanning properties (i.e. to turn raw hide into leather by forming a resistant layer on the collagen fibres). They are also traditionally used as antidiarrhoeals and externally as vasoconstrictors. Tannins are strong antioxidants, with anti-inflammatory, antidiarrhoeal, cytotoxic, antiparasitic, antibacterial, antifungal and antiviral activities. Several medicinal plants (*Quercus*, *Krameria*, *Alchemilla*, *Agrimonia*, *Potentilla*) are used internally and externally to treat inflammation and infection.

Small reactive molecules

This short section accommodates some important small molecules that do not fit comfortably elsewhere. They have no direct relation to phenolics. Included here are ranunculin, tuliposide and ethanol (alcohol).



ranunculin protoanemonin

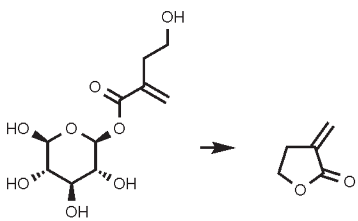
Ranunculin is a characteristic secondary metabolite of Ranunculaceae. When plant tissue is damaged, ranunculin is converted to **protoanemonin**.

Lungwort (*Pulmonaria officinalis*): leaves – flavonol glycosides

Wood avens (*Geum urbanum*): tannins

Herb Robert (*Geranium robertianum*): tannins and terpenoids

Pasque flower (*Pulsatilla vulgaris*): ranunculin



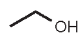
tuliposide A tulipalin A

Tuliposide (up to 0.1%) has been found in the genera *Tulipa*, *Alstroemeria*, *Bornarea*, *Erythronium*, *Fritillaria*, *Gagea*, *Notholirion* and *Lilium*. Any damage to plant material caused by handling, bruising (or eating, in the case of herbivores) leads to the enzymatic conversion of tuliposide A to **tulipalin A**.

Tulipalin and protoanemonin have a highly reactive extracyclic methylene group that can form covalent bonds with free SH-groups of proteins or glutathione. Therefore, cytotoxic and allergenic effects can occur. Protoanemonin can also alkylate DNA and is therefore mutagenic. It exhibits antibacterial and antifungal properties.

Tuliposide and tulipalin both have cytotoxic and fungitoxic properties.

Some plants with protoanemonin are used in traditional medicine (*Pulsatilla*, *Anemone*) to treat infections and cold.



ethanol

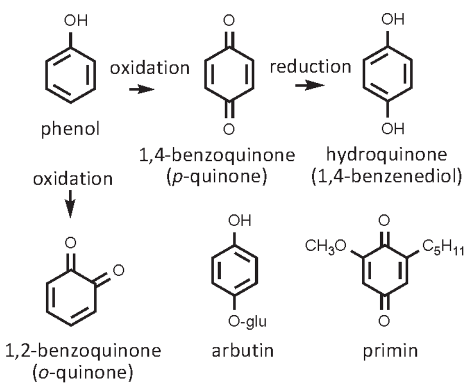
Ethanol is produced by yeasts, such as *Saccharomyces cerevisiae*, when growing on a sugar-rich food source, such as juices from grapes (*Vitis vinifera*), apples (*Malus domesticus*), sugar cane (*Saccharum officinarum*), sugar beet (*Beta vulgaris*), agave (*Agave tequilana*), phloem sap of palms (e.g. *Cocos nucifera*) or on a starch source that has been digested with amylase (rice, barley, corn, potato). Ethanol has depressant activity in the CNS. Since ethanol is soluble in lipids, it is likely that it dissolves in the cell membrane. If it accumulates in the neighbourhood of ion channels or other membrane proteins it can change their conformation and thus their activities (similar to the activity of some lipophilic anaesthetics). This activity interferes with inhibiting systems first, and later with excitable ones. A more important target seems to be the GABA receptor. As an agonist, ethanol can enforce synaptic inactivation and chloride influx that are mediated by GABA. This activity antagonises agonistic reactions of acetylcholine, glutamate and serotonin that are mediated by sodium and potassium channels. Thus ethanol has a similar sedating activity as barbiturates.

Quinones

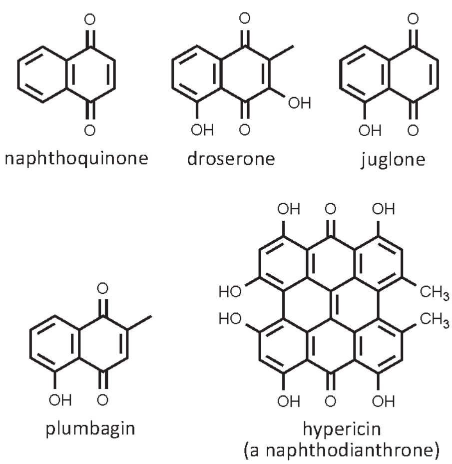
Phenolic compounds can be oxidised to quinones – they are oxidised homologues of aromatic compounds. They differ from phenolics in having a one or more carbonyl groups rather than hydroxyl groups within the ring structure. The carbonyl groups are often opposite each other (*para*-quinones, as in 1,4-benzoquinone) or they may be together (*ortho*-quinones, as in 1,2-benzoquinone). Quinones can be divided into four groups: benzoquinones, naphthoquinones, anthraquinones and isoprenoid quinones. They are often used as natural dyes and many of them have antimicrobial activity. Their best-known use is as laxative medicines (*Aloe*, *Rheum*, *Rhamnus*, *Senna*).

Quinones and naphthoquinones

Examples of hydroquinones are presented below.



Hydroquinones (derived from 1,4-benzoquinone) such as **arbutin** are typical for Ericaceae and are considered to be urinary tract antiseptics. **Hydroquinone** has been used as a skin lightener but is no longer considered safe. **Primin** (present in leaves of *Primula* species) and other quinones are known to cause dermatitis and severe rashes.

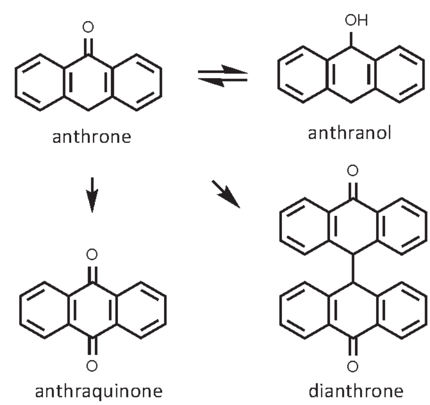


Naphthoquinones such as **droserone**, **juglone** and **plumbagin** are typical for Droseraceae, Iridaceae, Bignoniaceae, Juglandaceae, and Balsaminaceae. Quinones and naphthoquinones are redox reagents that can bind to enzymes or interact with proteins containing Fe^{2+}/Fe^{3+}, such as cytochromes and haemoglobin. Alkylated quinones can form novel antigens when bound to proteins and cause dermatitis.

Drugs containing the antimicrobial arbutin are used in traditional medicine to treat bacterial infections of the urinary tract. A tea from *Tabebuia impetiginosa* ("Lapacho tea" or "Inka tea"), used by native South American people, has been introduced in Europe as a general health tea and even for the treatment of cancer. Extracts from *Drosera* have been used in medicine as antitussive agents.

Anthraquinones

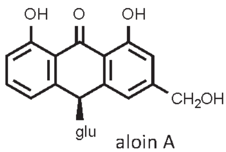
Secondary metabolites with an anthracene skeleton can be present as anthrones, anthraquinones, anthranols, dianthrones, naphthodianthrones and dianthranoles.

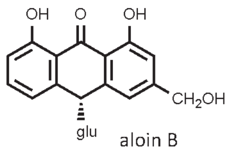


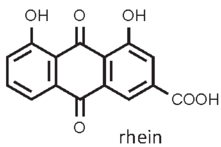
Anthraquinones are characteristic for Polygonaceae, Rhamnaceae, Fabaceae, Rubiaceae, Hypericaceae, Scrophulariaceae, Asphodelaceae and Liliaceae.

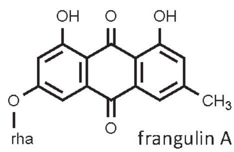
Anthrones are the active drugs in several traditional laxative medicines, including **aloin** in *Aloe* species, **rhein** in *Polygonum* and *Rheum*, **frangulin A** in *Rhamnus frangula* and **sennosides** in

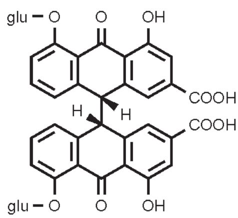
Senna alexandrina. Aloin occurs as two isomers, **aloin A** and **aloin B**, almost invariably as an equal mixture of the two (then often referred to simply as aloin). The glycosides are converted to the corresponding active aglycones by bacterial enzymes in the colon. Sennosides occur as a mixture of four isomers, depending on the econfiguration at C-10.

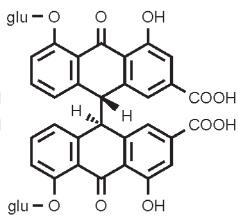

aloin A


aloin B

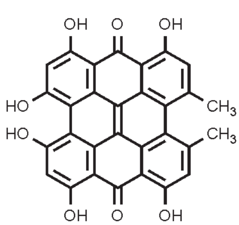

rhein


frangulin A


sennoside A


sennoside B

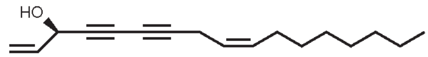
Glycosylated monomeric anthrones target chloride channels, and Na^+, K^+-ATPase. In addition, the synthesis of a prostaglandin PGE2, histamine, and serotonin is stimulated and gastrointestinal hormones are released. Anthrones enhance peristalsis and the secretion of water and inhibit its absorption in the colon. Several anthraquinone-containing drugs have been used for a long time (and are still employed) as purgatives. However, anthraquinones can intercalate DNA and appear to be mutagenic and should therefore not be taken regularly as therapeutic agents.


hypericin

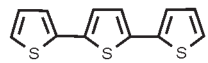
Hypericin from *Hypericum perforatum* is stored in the skin by herbivores; upon exposure to UV light, severe photodermatosis can occur. Special extracts from *Hypericum*, which contain hyperforin, flavonoids and/or hypericin, serve as a powerful remedy against mild depression.

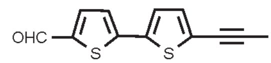
Polyacetylenes, polyenes, alkamides

Polyacetylenes or polyenes are aliphatic hydrocarbons with C-C triple and double bonds, such as in **falcarinol**.

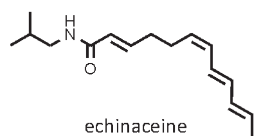

falcarinol

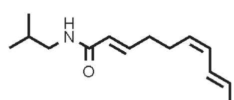
Polyenes are common in Asteraceae, Apiaceae, Araliaceae, Campanulaceae, Oleaceae and Santalaceae. They are reactive molecules that can interfere with membrane proteins (receptors, ion channels, transporters) and other proteins. They are active against bacteria, fungi, insects and nematodes.


α-tertienyl


arctinal

In *Tagetes*, special polyenes are produced in which oxygen or sulfur have been added to the triple bonds and secondary ring formations have occurred. Typical examples are thiophenes from *Tagetes* (e.g. **α-tertienyl**) that exhibit a wide range of antimicrobial and antiherbivore activities, some of which can be increased by light (phototoxicity). Roots of burdock (*Arctium lappa*) contain several polyenes, including **arctinal**.


echinaceine

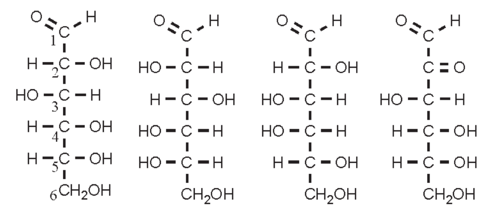

spilanthol

Alkamides (150 structures have been reported) can be regarded as polyenes with nitrogen-containing substituents. They occur in Piperaceae, Aristolochiaceae, Rutaceae and Asteraceae and appear to be antimicrobial, insecticidal and molluscicidal. Several alkylamides (mainly isobutylamides) occur in roots and aerial parts of *Echinacea* species. They contribute to the immunostimulant activity. One of the main compounds in *Echinacea angustifolia* is **echinaceine**. Alkamides often cause a tingling, itchy or burning sensation in the mouth when chewed. An example is **spilanthol**, the main active constituent in *Spilanthes acmella*.

Carbohydrates

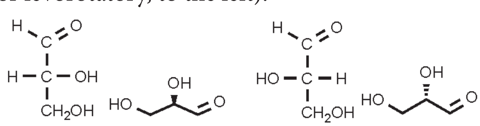
Carbohydrates are organic molecules with several hydroxy groups and one or more carbonyl groups, present either as aldehydes or ketones (respectively giving aldoses or ketoses). Carbohydrates are directly or indirectly the precursors of all other natural metabolites. They are not only the main sources of energy (mainly glucose) and energy reserves (starch, inulin) but also have a structural function, as part of cell walls (cellulose and polysaccharides). Plants produce and store several carbohydrates, most of which must be regarded as primary metabolites. Glucose, galactose, fructose and other sugars may form glycosides with many other secondary metabolites and are thus participants of both primary and secondary metabolism. The sugar moiety can be attached via a hydroxy group, giving an *O*-glycoside, or directly attached to a carbon, giving a *C*-glycoside. In the case of *O*-glycosides, the sugar can be easily removed by acid hydrolysis (or enzymatic hydrolysis), while in *C*-glycosides the sugar is not easily removed. Some carbohydrates appear to be allelochemicals in their own right: an example is phytic acid (a myo-inositol esterified with up to six phosphate groups) that can complex Ca^{2+}- and Mg^{2+}-ions and thus function as an antinutritive substance. Hexoses and pentoses are also building blocks for prominent polysaccharides of plants, i.e. starch, cellulose, hemicellulose and pectin. In addition, a number of plants produce mucilage and specific storage products, such as inulin in Asteraceae and Campanulaceae which can be used medicinally for patients with diabetes. Plants rich in mucilage (*Verbascum*, *Malva*, *Alcea*, *Plantago*) are used in medicine to treat coughs and to improve digestion. A typical cough syrup (*linctus*) is based on sugar as the primary emollient that forms a protective and soothing layer on inflamed mucosa.

Monosaccharides are simple sugars (from the Greek *monos*, single and *sacchar,* sugar) named according to the number of carbon atoms: tetroses, pentoses, hexoses, heptoses and so on. The three most common sugars in the human diet are **glucose** (both isomers), **galactose** and **fructose**.



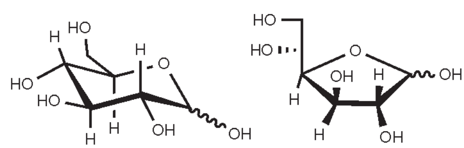
D-glucose (a D-aldose) | L-glucose (an L-aldose) | D-galactose (a D-aldose) | D-fructose (a D-ketose)

The simplest of all monosaccharides is **glyceraldehyde** (an aldose). It has one asymmetrical carbon and therefore exists as two enantiomers: (*R*) and (*S*) (from the Latin *rectus*, right and *sinister*, left). The optical rotation (+) and (–) cannot be deduced from the chemical structure and has to be determined empirically. Glyceraldehyde is used as the configurational standard for carbohydrates in the D/L system (D for dextrorotatory, to the right; L for levorotatory, to the left).



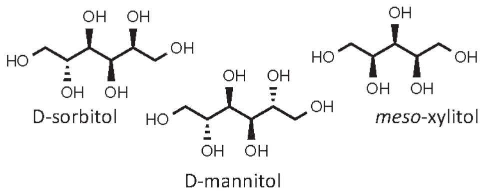
D-glyceraldehyde = (*R*)-glyceraldehyde = (+)-glyceraldehyde | L-glyceraldehyde = (*S*)-glyceraldehyde = (–)-glyceraldehyde

Monosaccharides with an absolute configuration identical to (*R*)-glyceraldehyde at the last stereocentre (see C5 in D-glucose, for example) are assigned the stereo-descriptor D; those identical to (*S*)-glyceraldehyde are assigned an L. Only D-glucose is found in nature. Sugars can occur in different forms and are often present as cyclic molecules (furanose and pyranose forms, as shown here in the Haworth projection).



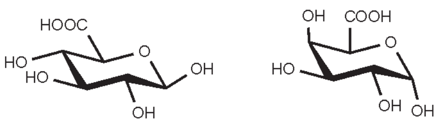
D-glucose (pyranose form) | D-glucose (furanose form)

Polyalcohols are compounds formed when the carbonyl or aldehyde functions of monosaccharides are converted to hydroxy groups. The best-known examples are **D-sorbitol**, formed from glucose (present in the fruits of mountain ash, *Sorbus aucuparia*) and used as a sweetener for diabetics and for its cholagogue properties; **D-mannitol**, formed from mannose (present in manna ash, *Fraxinus ornus*) and used as mild laxative; ***meso*-xylitol**, formed from D-xylose and used as sweetener, especially in chewing gums (reduces calories and suppresses the formation of dental caries). Various other biologically important derivatives of monosaccharides occur in nature, such as ascorbic acid, oxalic acid and tartaric acid (see group 6, Organic acids, page 76). These acids arise in plants directly from D-glucose.



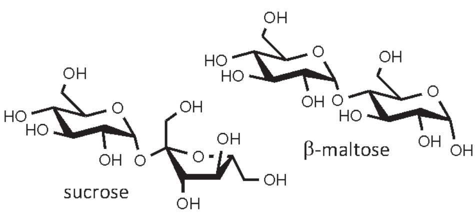
D-sorbitol D-mannitol *meso*-xylitol

Hexose sugars may also be converted to uronic acids, where the primary alcohol function is oxidised to a carboxylic acid. **D-glucuronic acid** and **D-galacturonic acid** are constituents of many polysaccharides and pectins, such as the mucilage of marshmallow (*Althaea officinalis*).



D-glucuronic acid D-galacturonic acid

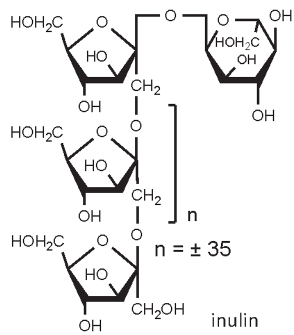
Oligosaccharides are formed by two to 10 monosaccharides that are bonded together by glycosidic linkage. The best-known examples are **sucrose** (table sugar; α-glucose and fructose, linked via an α-glycosidic bond), **maltose** (malt sugar; two α-glucoses linked via an α-glycosidic bond) and lactose (milk sugar; galactose and β-glucose linked via a β-glycosidic bond).



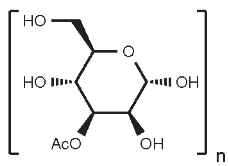
sucrose β-maltose

Several di-, tri- and oligosaccharides, such as stachyose and raffinose (which are typical for seeds and roots), produce substantial flatulence and thus come closer to typical secondary metabolites, as they can be regarded as defence compounds against herbivores. Similar to the situation of nitrogen-containing defence chemicals in seeds, these oligosaccharides are additionally used as carbon source by the growing seedling.

Polysaccharides (glycans) are high molecular weight polymers formed by condensation of numerous monosaccharides. Links are formed between the C1 hydroxy group of one sugar and any hydroxy groups of other sugar molecules. Many polysaccharides form gels and have many industrial and pharmaceutical uses as emulsifiers, solid excipients, stabilisers and gelling agents. Examples include the carrageenans in Irish moss (see *Chondrus crispus*), the starches of various cereals and potatoes, cellulose from the seed hairs of cotton and dietary fibres from a wide range of medicinal plants and dietary supplements. The term dietary fibre is used by dieticians and nutritionists and is not really a category of chemical compounds. It may include polysaccharides, pectins, hemicelluloses, lignin and glycoproteins. Of special interest are fructans such as **inulin**, e.g. in chicory (*Cichorium intybus*) and dandelion (*Taraxacum officinale*) and phlein (Poaceae, e.g. *Elymus repens*).



inulin



acemannan

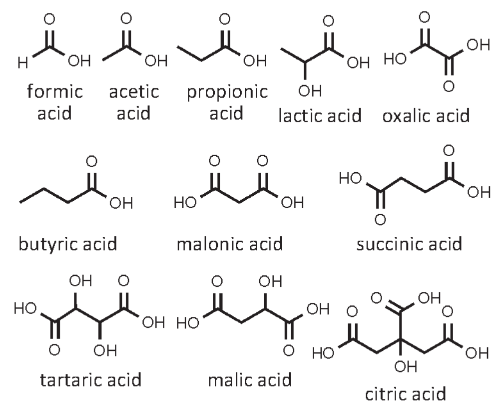
Polysaccharides also include gums and mucilages (those that readily dissolve in water to form colloidal solutions). Examples include karya gum (*Sterculia* spp.), gum arabic (*Acacia* spp.) and tragacanth gum (*Astragalus gummiferum*). Of interest are polysaccharides derived from mannose, such as glucomannans (*Amorphophallus konjac* tubers), galactomannans (carob seed gum, *Ceratonia siliqua*) and acetylated mannans – **acemannan** (see *Aloe vera* gel). Apart from industrial uses, the gums are bulking agents used in diets to restrict caloric intake, treat obesity and reduce blood cholesterol. They also have demulcent and wound-healing activities. Other medicinal and dietary gums or mucilages include guar gum (*Cyamopsis tetragonolobus*), fenugreek (*Trigonella foenum-graecum*), psyllium husk (*Plantago* spp.), ispaghula (*Plantago ovata*), plantain (*Plantago lanceolata*), mallow (*Malva sylvestris*), marshmallow (*Alcea officinalis*), lime tree (*Tilia cordata*) and flax seeds (*Linum usitatissimum*).

Organic acids

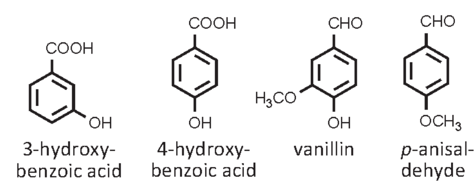
Organic acids can be aliphatic, as in the common carboxylic acids, where the acidity is associated with a carbonyl group (–COOH) or aromatic, as in phenolic acids, hydroxycinnamic acids (and some amino acids). Most organic acids, such as acetic acid, fumaric acid, malic acid or citric acid, have a prominent role in primary metabolism (Krebs cycle). In addition, fruits of many plants are rich in organic acids, which include those important in energy metabolism but also derivatives of them. In fruits they appear to carry ecological functions in preventing microbial infections or the feeding of immature fruits by herbivores. A number of organic acids derive from amino acids, such as senecic acid, angelic acid or tiglic acid, which are part of many secondary metabolites in the form of esters.

Carboxylic acids include **formic acid** (present in ant venom), **acetic acid** (the main acid in vinegar), **propionic acid** (from the Greek *protos*, first and *pion*, fat; because it is the smallest acid that shows the typical properties of fatty acids), **lactic acid** (produced from glucose and sucrose by lactic acid bacteria; the bacteria also occur in the mouth and the acid causes tooth decay/caries), **oxalic acid** (present in many plants and vegetables and a component of kidney stones), **butyric acid** (in milk and butter, and body odour), **malonic acid** (occurs in beetroot and often forms esters, known as malonyl esters), **succinic acid** (originally obtained from amber – *succinum* in Latin, hence the name; it is used in the food and beverage industry as an acidity regulator), **tartaric acid** (in grapes, wine, baobab and tamarind) and **citric acid** (it occurs naturally in citrus fruits and is an important flavouring agent and preservative of food and especially soft drinks).

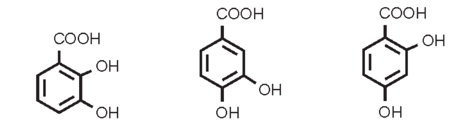
Oxalic acid is a simple dicarboxylic acid, which can be present as a free acid or as a salt (e.g. water-soluble potassium oxalate). In Araceae and Liliaceae oxalic acid is often deposited as hardly soluble calcium oxalate crystals that can form sharp needles (raphides), which make such plants potentially toxic. Oxalic acid is a strong acid and powerful reducing agent. The sharp oxalate crystals of Araceae are potent irritants of the skin and mucosal tissues; they can penetrate cells and cause necrosis. The release of histamine causes itching, burning, salivation and severe inflammation. Oxalic acid forms insoluble salts with calcium. If calcium oxalate is deposited in kidney tubules, kidney tissue becomes damaged. By depletion of calcium in the heart, the heart muscles can be damaged and its contractibility reduced. In the blood, blood coagulation is also hampered by Ca^{2+}-depletion. Plants with oxalic acid have a sour taste and some are consumed as vegetables, such as rhubarb or sorrel.



Aromatic acids include phenolic acids, hydroxycinnamic acids and aromatic amino acids. The phenolic acids can either be monohydroxybenzoic acids or dihydroxybenzoic acids. The former includes **3-hydroxybenzoic acid** and **4-hydroxybenzoic acid** (= *p*-hydroxybenzoic acid). The last-mentioned is found in several medicinal plants (e.g. *Vitex agnus-castus* and *Hypericum perforatum*) and may occur as the 4-glucoside or as the ester component of other secondary metabolites. Benzoic acid derivatives also include gallic acid, its dimer, hexahydroxydiphenic acid, as well as ellagic acid (see under tannins). Aldehydes derived from benzoic acid include **vanillin** and ***p*-anisaldehyde**.

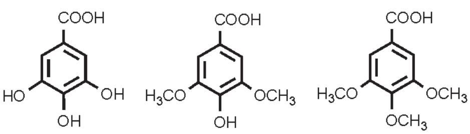


An example of a dihydroxybenzoic acid is **2,3-dihydroxybenzoic acid** (a natural phenol found in the fruits of *Phyllanthus acidus*). Another example is **protocatechuic acid**, found naturally in açaí oil (*Euterpe oleracea*), in roselle (*Hibiscus sabdariffa*) and as a major metabolite of the polyphenols of green tea (*Camellia sinensis*). Experiments showed that it can both enhance and suppress tumour growth. Another example is **2,4-dihydroxybenzoic acid** (β-resorcylic acid), a degradation product of cyanidin glycosides that can be found in human blood plasma after eating cranberries.



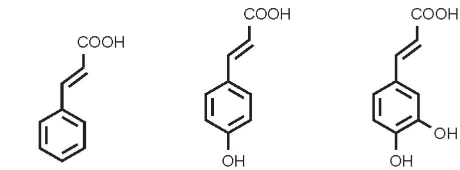
2,3-dihydroxy-benzoic acid   protocatechuic acid   2,4-dihydroxy-benzoic acid

Perhaps the best-known example of a trihydroxybenzoic acid is **gallic acid** (= 3,4,5-trihydroxybenzoic acid). It is found in witch hazel, black tea, oak bark and many other plants and may occur either in its free form or as part of hydrolysable tannins. Trihydroxybenoic acids commonly occur in fruits and as breakdown products of anthocyanins. **Syringic acid**, for example, is released when malvidin is metabolised. It also occurs in wine and vinegar. These acids may be methylated to form more complex molecules. An example is **eudesmic acid**, found in *Eucalyptus* species.

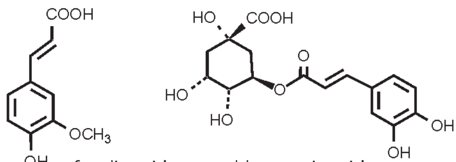


gallic acid   syringic acid   eudesmic acid

Hydroxycinnamic acids occur widely in nature. **Cinnamic acid** is a well-known example, present in cinnamon oil. Not only does it contribute a honey-like smell, but its derivatives (ethyl cinnamate and cinnamaldehyde) are important flavour compounds. Of the three isomers of coumaric acid, ***p*-coumaric acid** is the most abundant in nature and occurs in many food plants. C**affeic acid** is found in practically all plants because it is an intermediate in lignin biosynthesis. **Ferulic acid** occurs in cell walls of plants but also as major compound in the resin of giant fennel, *Ferula communis* (hence the name). It contributes to the antibacterial and antioxidant activities of sour figs (*Carpobrotus edulis*). Hydroxycinnamic acids may be esterified with quinic acid (a cyclitol or cyclic polyol), as in **chlorogenic acid** (an ester of caffeic acid). High levels of chlorogenic acid occur in green coffee beans and is the main active ingredient in green coffee extracts that have become popular as dietary supplements.

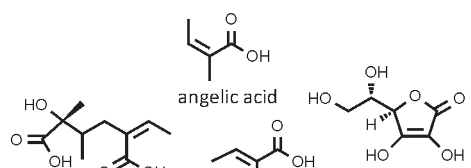


cinnamic acid   *p*-coumaric acid   caffeic acid



ferulic acid   chlorogenic acid

Organic acids such as carboxylic acids, **senecic acid**, **angelic acid** or **tiglic acid** can form ester bonds with alcohols. Fats and oils, for example, are fatty acid esters of glycerol. Low molecular weight esters are highly fragrant and are often found in essential oils, pheromones and perfumes. Angelic acid occurs widely in members of the Apiaceae and was first isolated from the roots of the garden angelica (*Angelica archangelica*), hence its name. It readily converts to its *cis* isomer, tiglic acid, when heated or exposed to inorganic acids. Angelate and tigliate esters are the major compounds in the oil of roman chamomile (*Chamaemelum nobile*). Petasin; the analgesic and spasmolytic compound in butterbur (see *Petasites hybridus*) is an angelic acid ester of a sesquiterpene alcohol. Tiglic acid occurs in croton oil (*Croton tiglium*).



angelic acid   senecic acid   tiglic acid   ascorbic acid (vitamin C)

Humans and some animals lack the ability to convert glucose to vitamin C, resulting in a deficiency disease known as scurvy or *scorbutus*, hence the name **ascorbic acid** (*a*- means "not"). Many fruits, including rose hips, are rich in vitamin C.

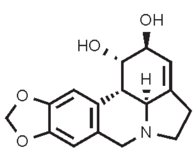
Alkaloids

Alkaloids are among the most active secondary metabolites and widely distributed in the plant kingdom (especially in angiosperms). Their structures contain one or several nitrogen atoms either in a ring structure (true alkaloids) or in a side chain (pseudoalkaloids). Depending on the ring structures, alkaloids are subdivided into several subgroups. Tropane alkaloids have a tropane ring system, indole alkaloids have an indole ring system, and so on.

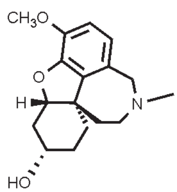
Alkaloids are infamous as animal toxins and certainly serve mainly as defence chemicals against predators (herbivores, carnivores) and to a lesser degree against bacteria, fungi and viruses. The molecular targets of alkaloids and amines are often neuroreceptors, or they modulate other steps in neuronal signal transduction, including ion channels or enzymes, which take up or metabolise neurotransmitters or second messengers. Other alkaloids are mutagenic in that they intercalate or alkylate DNA, induce apoptosis or inhibit carbohydrate processing enzymes.

Amaryllidaceae alkaloids

Typical alkaloids in this group are ambelline, **lycorine**, narciclasine, **galanthamine** and haemanthamine which are produced by several genera of the Amaryllidaceae. They are sometimes classified as isoquinoline alkaloids.



lycorine



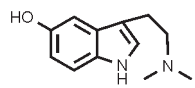
galanthamine

Lycorine and narciclasine inhibit ribosomal protein biosynthesis by binding to the 60S subunit. Galanthamine, which is isolated from *Galanthus woronowii*, *Leucojum aestivum*, *Narcissus pseudonarcissus* and *N. nivalis*, has been introduced as a therapeutic agent to treat Alzheimer's disease because it inhibits cholinesterase (parasympathomimetic). In addition, it shows analgesic properties.

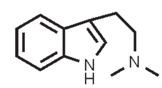
Bufotenin, tryptamines, tyramines

Bufotenin occurs in the legumes *Anadenanthera peregrina* and *Mucuna pruriens*, and in *Banisteriopsis rusbyana* (Malpighiaceae) but also in the skins of toads. ***N,N*-Dimethyltryptamine** is produced by some mimosoid legumes, *Virola peruviana* (Myristicaceae) and *Banisteriopsis argentea* (Malpighiaceae). **Psilocin** and its phosphate ester **psilocybin** are common ingredients of the sacred and hallucinogenic mushroom of Mexico called "teonanacatl" (*Psilocybe mexicana;* Strophariaceae).

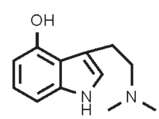
The methylated tryptamines are analogues of the neurotransmitter **serotonin** (5-hydroxytryptamine) and thus work as 5-HT agonists. They stimulate 5-HT receptors, which evoke psychedelic hallucinations and euphoric feelings. Extracts from plants and mushrooms with these psychoactive amines have been used as mind-altering drugs.



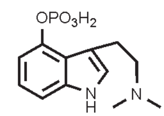
bufotenin



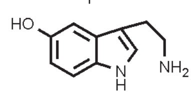
N,N dimethyltryptamine



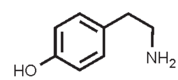
psilocin



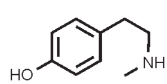
psilocybin



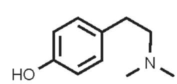
serotonin



tyramine



N-methyltyramine



hordenine

Tyramine and structurally related alkaloids such as ***N*-methyltyramine** and ***N,N*-dimethyltyramine** (= **hordenine**) occur in many plants [e.g. Cactaceae and Poaceae (*Hordeum*, *Phalaris*)] and food items, especially aged and fermented products such as hams and cheeses. In foods it is often a product of the enzymatic decarboxylation of the amino acid **tyrosine**. Tyramine may displace dopamine and other stored monoamines from the pre-synaptic vesicles.

Orange lily (*Clivia miniata*): lycorine

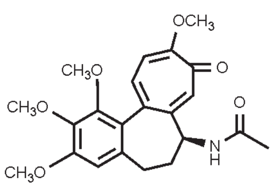
Autumn crocus (*Colchicum autumnale*): colchicine

Australian chestnut (*Castanospermum australe*): seeds – castanospermine

Californian poppy (*Eschscholzia californica*): roots – isoquinoline alkaloids

Colchicine

Colchicine and related alkaloids are typical secondary metabolites of plants in the genera *Colchicum*, *Gloriosa* and a few other members of the family Colchicaceae (formerly associated with Liliaceae).

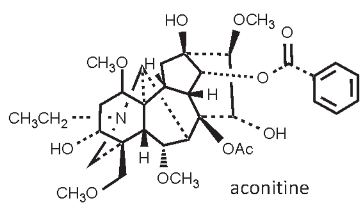


colchicine

The molecular target of colchicine is tubulin; it inhibits the polymerisation and depolymerisation of microtubules which are necessary for cell division and intracellular transport of vesicles. Colchicine inhibits the synthesis of collagen and activates collagenase. Colchicine has been used against fast-dividing cancer cells, but its toxicity prevents a general application. In modern medicine, colchicine is prescribed in cases of acute gout as it prevents macrophages from migrating to inflamed joints.

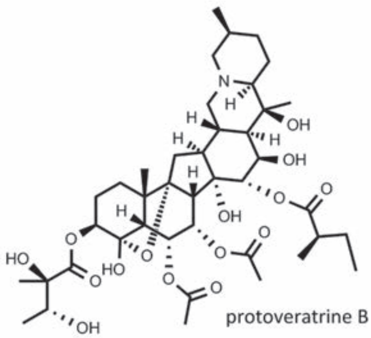
Diterpene alkaloids

Aconitine from *Aconitum* species and **protoveratrine B** from *Veratrum* species are potent activators of Na^+-channels that are essential for neuronal signalling. If these ion channels are completely activated, the action potential from nerves to muscles is no longer transmitted, leading to a complete arrest of cardiac and skeletal muscles.



aconitine

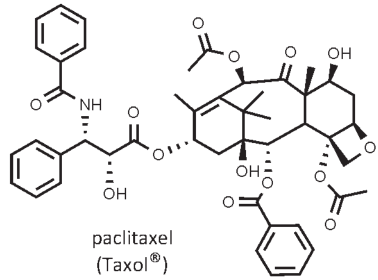
Aconitine and protoveratrine B first activate and then paralyse the sensible nerve endings and neuromuscular plates. Aconitine also exerts analgesic properties and has been used to treat neuronal pain, such as caused from irritation of the trigeminus nerve. Extracts from *Aconitum* have been widely used as arrow poison, deadly poison and in witch ointments for thousands of years in Europe and Asia.



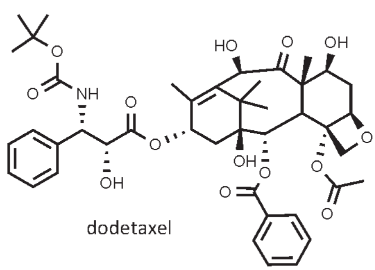
protoveratrine B

Another diterpene alkaloid is **paclitaxel**, (Taxol®) which can be isolated from several yew species (including the North American *Taxus brevifolia* and the European *T. baccata*). Taxol® stabilises microtubules and thus blocks cell division in the late G2 phase; because of these properties, Taxol® has been used for almost 20 years with great success in the chemotherapy of various tumours.

Docetaxel (trade name Taxotere or Docecad) is a semi-synthetic analogue of paclitaxel, developed because of the scarcity of the latter. It is an esterified product of 10-deacetyl baccatin III, a starting material which can be extracted from the leaves of the common and readily available European yew (*Taxus baccata*).



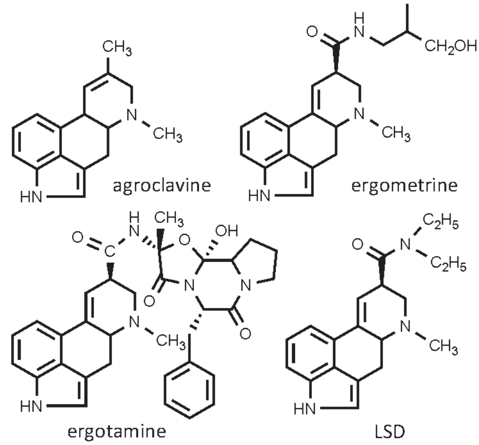
paclitaxel (Taxol®)



dodetaxel

Ergot alkaloids

Included here are the clavine alkaloids (**agroclavine** and elymoclavine), lysergic acid amides (ergine, **ergometrine** and more complex peptide alkaloids, such as **ergotamine** and ergocristine).



agroclavine, ergometrine, ergotamine, LSD

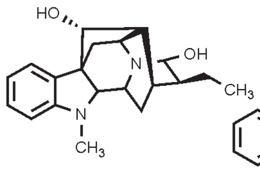
Ergot alkaloids are produced by a symbiotic fungus *Claviceps purpurea*, and more than 40 other species which are symbionts on grasses (tribes Festucaceae, Hordeae, Avenae, Agrosteae). Rye is especially affected. Ergot alkaloids are also found in some Convolvulaceae (*Argyreia*, *Ipomoea*, *Rivea corymbosa*, *Stictocardia tiliafolia*) which carry the fungi as endophytes.

These alkaloids modulate the activity of noradrenaline, serotonin and dopamine receptors as agonists, partial agonists but also antagonists. Consequences are contraction of smooth muscles of peripheral blood vessels (causing gangrene), or permanent contraction of uterine muscles (causing abortion). By blocking alpha-adrenergic receptors, the alkaloids can induce spasmolysis (relaxation of smooth muscles). They inhibit serotonin receptors but stimulate dopamine receptors. Ergometrine (an α-receptor agonist) is used in obstetrics to stop bleeding after birth or abortion. Ergotamine (antagonist at noradrenaline and 5-HT receptor; agonist at dopamine receptor) is used to treat migraine. Ergocornine reduces the secretion of prolactin and inhibits nidation as well as lactation. **LSD** (*N,N*-diallyllysergic acid amide), which is a synthetic derivate of ergot alkaloids, is one of the strongest hallucinogens.

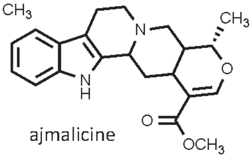
Poisoning with ergot alkaloid-contaminated cereals and flour causes the dramatic and cruel effects of ergotism which has been documented in many paintings of the Old Masters. The hallucinogenic Mexican drug "ololiuqui" is composed of ergot alkaloids of *Rivea corymbosa*, *Ipomoea argyrophylla*, *I. violacea* and other *Ipomoea* species.

Indole alkaloids

Indole alkaloids (including monoterpene indole alkaloids) occur mainly in four plant families – the Apocynaceae, Loganiaceae, Gelsemiaceae and Rubiaceae.

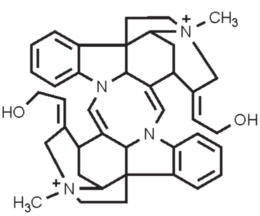


ajmaline



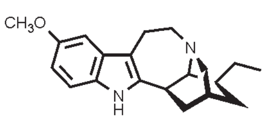
ajmalicine

Ajmaline from *Rauvolfia serpentina* blocks sodium channels and has therefore antiarrhythmic properties because it lowers cardiac excitability. It has negative inotropic properties and is used medicinally to treat tachycardial arrhythmia, extra systoles, fibrillation and *angina pectoris*. **Ajmalicine** (also from *Rauvolfia serpentina*) has a pronounced dilatatoric activity in blood vessels, which causes hypotension. Ajmalicine is used as a tranquilliser and as an antihypertensive to improve cerebral blood circulation.



C-toxiferine I

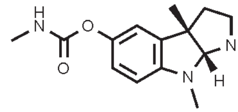
***C*-Toxiferine I** and II from *Strychnos* are neuromuscular blocking agents, thus highly toxic and used as an arrow poison. They are strong inhibitors of nicotinic AChR at the neuromuscular plate and cause paralysis of muscle cells.



ibogaine

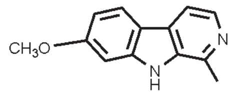
Ibogaine from *Tabernanthe iboga* is a CNS stimulant with anticonvulsant and hallucinogenic properties.

Physostigmine, eseridine and related compounds from *Physostigma venenosum* (calabar beans) are strong inhibitors of cholinesterase with wide-ranging parasympathetic activities.



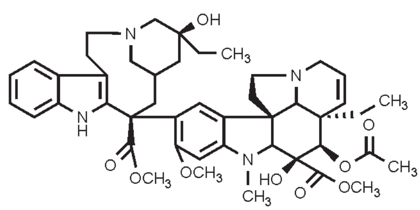
physostigmine

Physostigmine is used as a miotic in eye treatments and in the therapy of Alzheimer's disease. It is highly toxic and calabar beans were used as an ordeal poison in West Africa.



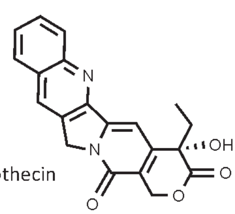
harmine

Harman or β-carboline alkaloids occur, among others, in Malpighiaceae (*Banisteriopsis*), Zygophyllaceae (*Peganum*, *Zygophyllum*) and Rutaceae (*Clausena*, *Murraya*). β-Carboline alkaloids are inhibitors of MAO and agonists at serotonin receptors. Since they enhance serotonin activity, they exhibit substantial hallucinogenic activities and might be useful to treat patients with depression. An example is **harmine**, the main compound in *Peganum harmala*.



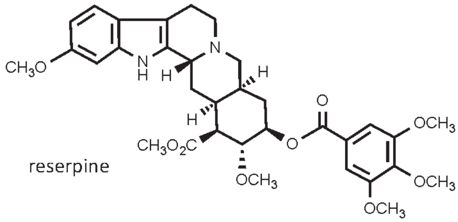
vinblastine

Dimeric *Vinca* alkaloids (vincristine, **vinblastine**, leurosine) from *Catharanthus roseus* inhibit tubulin polymerisation and intercalate DNA. As a consequence they effectively block cell division and are therefore important drugs used in cancer therapy.



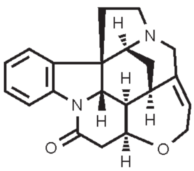
camptothecin

Camptothecin, an inhibitor of DNA topoisomerase used in cancer therapy, is mainly produced from *Camptotheca acuminata* (but is also found in some genera of Icacinaceae, Rubiaceae, Apocynaceae and Gelsemiaceae).



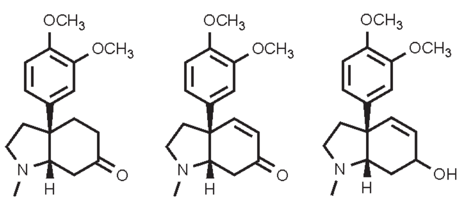
reserpine

Reserpine and related alkaloids from *Rauvolfia serpentina* inhibit transporters for neurotransmitters at vesicle membranes and thus act as an antihypertensive and tranquilliser.



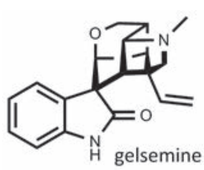
strychnine

Strychnine from *Strychnos nux-vomica* is an antagonist at the glycine-gated chloride channel. It is a CNS stimulant and extremely toxic.



mesembrine mesembrenone mesembrenol

Mesembrine, a simple indole alkaloid from *Sceletium tortuosum* (= *Mesembryanthemum tortuosum*), is a narcotic with cocaine-like activities and has been used as an antidepressant. Extracts rich in **mesembrenone** and **mesembrenol** enhance cognitive function.



gelsemine

Gelsemine and gelsemicine are CNS active and highly toxic. They are the main alkaloids of *Gelsemium sempervirens*.

Indolizidine alkaloids

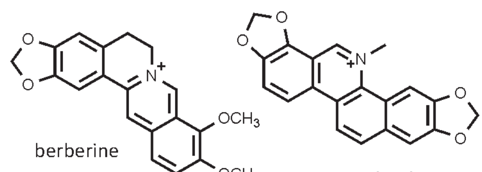
Indolizidine is an isomer of indole. It forms the base of several alkaloids, mainly found in the legume family (Fabaceae). The compounds are also called polyhydroxy alkaloids or sugar-shaped alkaloids because they mimic sugar in structure (but with nitrogen in the place of oxygen). They also behave like sugars in solution and are therefore missed with the usual method of alkaloid extraction (cation exchange resin is therefore used).

castanospermine swainsonine

Castanospermine is the main alkaloid in seeds of the Australian chestnut tree, *Castanospermum australe*. It is an inhibitor of glucosidase enzymes and has been studied for its antiviral activity (also against the HIV virus). **Swainsonine** is the poisonous compound in locoweed, responsible for severe stock losses in North America (mainly the western parts of the USA). Locoweed refers to pasture plants that contain swainsonine, which include several species of the legume genera *Astragalus* and *Oxytropis* (and *Swainsonia* in Australia). Animals develop a condition called "locoism" in North America (and "pea struck" in Australia).

Isoquinoline alkaloids

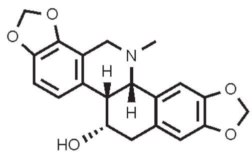
Isoquinoline alkaloids include protoberberine, aporphine and morphinane alkaloids. Isoquinoline alkaloids are common in genera of the Papaveraceae, Annonaceae, Ranunculaceae, Berberidaceae, Monimiaceae, Menispermaceae, Lauraceae, Rutaceae and Magnoliaceae.

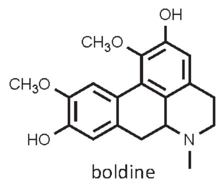


berberine sanguinarine

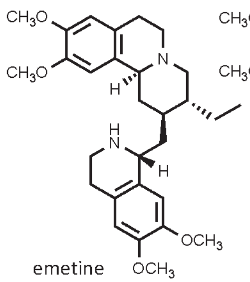
Many protoberberine and benzophenanthridine alkaloids interfere with neuroreceptors and DNA (several are strong intercalators). The intercalating alkaloids (e.g. **berberine**, **sanguinarine**) show pronounced antibacterial, antiviral and cytotoxic properties. Extracts of *Sanguinaria canadensis*, which are rich in the benzophenanthridine alkaloid sanguinarine, have been included in mouthwashes and toothpaste.

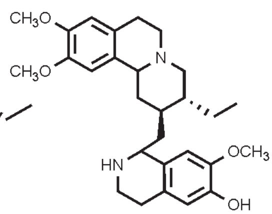
Chelidonium majus has been used in traditional medicine and phytomedicine as cholagogue, spasmolytic, diuretic and analgesic drug or to treat warts. **Chelidonine** has been employed as a painkiller to treat abdominal pain, and to treat spasms and asthma. Extracts of *Eschscholzia californica*, which are rich in aporphine, protoberberine and benzophenanthridine alkaloids, have been employed as a mild psychoactive drug to induce euphoria.


chelidonine

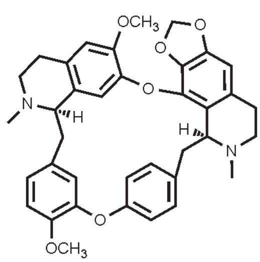

boldine

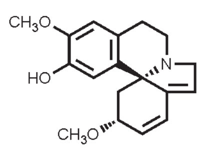
The aporphine **boldine** (from *Peumus boldus*) is used to treat hepatic dysfunction and cholelithiasis.


emetine


cephaeline

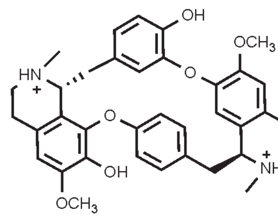
Emetine and **cephaeline** from (*Psychotria ipecacuanha*) are potent inhibitors of ribosomal protein synthesis; they have been used as emetics, expectorants and anti-amoebics.


cepharanthine

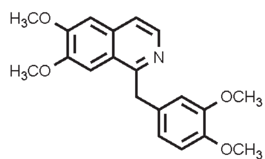

erysovine

Cepharanthine, a bisbenzylisoquinoline from *Stephania*, has been used to treat tuberculosis and leprosy. *Erythrina* alkaloids block signal transduction at the neuromuscular plate and have been used as curare substitute. An example is **erysovine**, a major alkaloid of *E. lysistemon* and *E. caffra*.

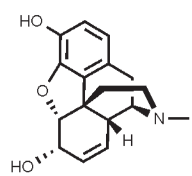
Tubocurarine and other bisbenzylisoquinolines from *Chondrodendron* and *Ocotea* have been used traditionally as arrow poison but also in surgery as muscle relaxant (inhibition of nAChR).

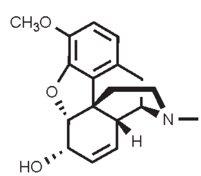

tubocurarine

These alkaloids have the advantage that the prey animal (monkey or parrot) relaxes its grip when it dies, so that it can be easily retrieved. Furthermore, the alkaloids are only poisonous when injected and are quite harmless when ingested.


papaverine

Papaverine (from several *Papaver* species) inhibits phosphodiesterase and thus acts as smooth muscle relaxant, vasodilator and spasmolytic.

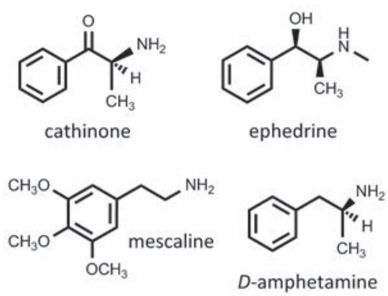

morphine


codeine

Morphinane alkaloids are typical for members of *Papaver somniferum* and *P. bracteatum*. Morphine causes central analgesia, euphoria and sedation. **Morphine** is an agonist of endorphine receptors in the brain and other organs and promotes powerful sleep-inducing, analgesic and hallucinogenic effects. It is used in standardised modern medicines intended for oral and parenteral use – mainly to treat intense pain (e.g. in cancer patients). **Codeine** is an effective painkiller (though less active than morphine, but also less addictive); it sedates the cough centre and is widely used as antitussive agent. Morphine and other morphinane alkaloids show addictive properties.

Phenylpropylamines

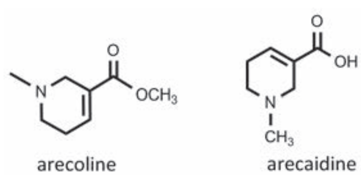
This group of bioactive amines with pronounced pharmacological activity includes **cathinone** (from *Catha edulis*), **ephedrine** (from several *Ephedra* species) and **mescaline** (*Lophophora williamsii* and other cacti).



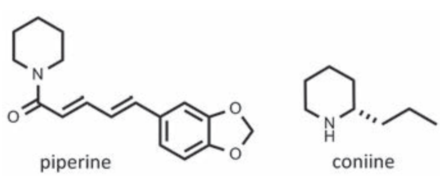
Cathinone and ephedrine structurally resemble **amphetamine** and act in a similar way as sympathomimetics. These alkaloids stimulate α- and β-adrenergic dopaminergic receptors by stimulating the release of noradrenaline and dopamine from catecholic synapses and inhibiting their re-uptake. Ephedrine causes vasoconstriction, hypertension, bronchial dilatation and heart stimulation. Plants with ephedrine or cathinone reduce hunger sensation and have been used as appetite depressant and stimulant. Ephedrine has been used medicinally to treat asthma, sinusitis and rhinitis. Mescaline is a psychomimetic; it is a CNS depressant and hallucinogenic in high doses.

Piperidine alkaloids

Arecoline and **arecaidine** from betel nut (*Areca catechu*) exhibit parasympathetic activities and act as a central stimulant. Betel is widely used in Southeast Asia as a masticatory.

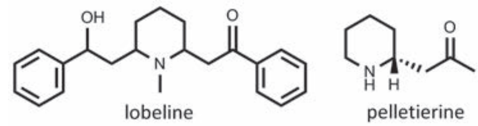


Piperine is the pungent principle of *Piper nigrum* and other species. *Piper* fruits are widely used as hot spice and sometimes as insecticide.

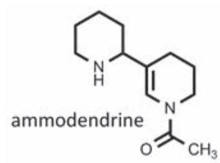


Coniine is a famous toxin from *Conium maculatum* which acts as a muscarinergic agonist. It causes ascending paralysis, which starts at the extremities of the arms and legs and ends with respiratory failure and death. *Conium* alkaloids are extremely toxic and teratogenic in livestock.

Lobeline occurs in *Lobelia* species and has been used in the treatment of asthma and as anti-smoking drug.



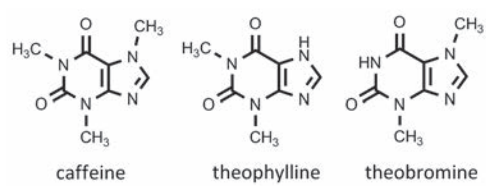
Pelletierine from *Punica granatum* has been used against intestinal tapeworms.



Ammodendrine often co-occurs with quinolizidine alkaloids in members of the Fabaceae. It can cause malformation in cattle if pregnant cows feed on plants which contain this alkaloid.

Purine alkaloids

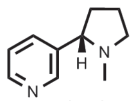
Caffeine, **theophylline** and **theobromine** are produced by *Coffea arabica*, *Cola acuminata*, *Cola nitida*, *Theobroma cacao*, *Paullinia cupana*, *Ilex paraguariensis* and *Camellia sinensis*.



The purine alkaloids function as central nervous system stimulants, conferring wakefulness and enhanced mental activity. Caffeine inhibits cAMP phosphodiesterase and adenosine receptors. As a consequence dopamine is released and many brain parts become activated. These alkaloids are cardiac stimulants, vasodilators and smooth muscle relaxants. Extracts with purine alkaloids are widely used by humans as stimulants; caffeine is incorporated into numerous formulations employed against fever, pain and flu symptoms.

Pyrrolidine alkaloids

Nicotine (from *Nicotiana tabacum*) is an agonist at nACh-receptors and functions as a CNS stimulant with addictive and tranquillising properties. Today it is also used in electronic cigarettes ("e-cigarettes"). Before the availability of synthetic insecticides, nicotine was widely used as a natural insecticide in agriculture.

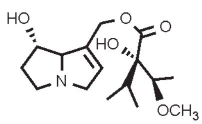


nicotine

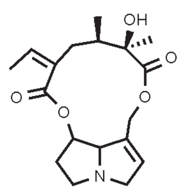
Pyrrolizidine alkaloids

Pyrrolizidine alkaloids are produced from nearly all members of the Boraginaceae, several Asteraceae (subfamily Senecioninae) and Fabaceae (tribe Crotalarieae).

Examples of well-known compounds include **senecionine** (produced by many *Senecio* species and also Fabaceae – *Crotalaria* and *Lotononis* species) and **heliotrine**, a typical product from Boraginaceae genera such as *Amsinckia* and *Heliotropium.*



heliotrine



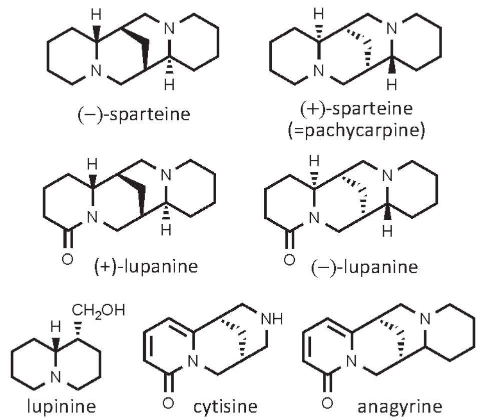
senecionine

Pyrrolizidine alkaloids are activated in the liver of humans or animals to reactive pyrroles (dehydropyrrolizidines) that can alkylate DNA bases. These alkylations can lead to mutation and cell death (especially in the liver). Furthermore, mutations can lead to malformations in pregnant animals and humans, and to cancer of liver, kidneys and lungs.

Several pyrrolizidine alkaloid-containing plants are used in traditional phytomedicine to treat bleeding or diabetes or as general herbal teas (*Senecio*, *Petasites*, *Heliotropium*, *Crotalaria*); *Symphytum officinale* and other Boraginaceae are used to treat wounds, broken or injured bones. Others, such as comfrey (*Symphytum ×uplandicum*) are regularly supplied on local markets as "healthy" salad ingredients. Drugs containing pyrrolizidines are usually banned as medicines.

Quinolizidine alkaloids

Quinolizidine alkaloids such as **sparteine**, **lupanine**, **lupinine**, **cytisine** and **anagyrine** are common secondary metabolites in genistoid legumes (Fabaceae). They affect acetylcholine receptors and ion channels; they are poisonous neurotoxins for animals.



(−)-sparteine (+)-sparteine (=pachycarpine)

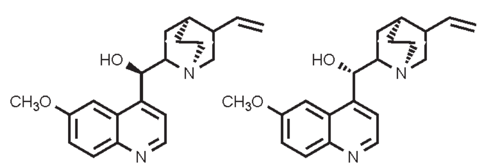
(+)-lupanine (−)-lupanine

lupinine cytisine anagyrine

Sparteine from *Cytisus scoparius* has been employed medicinally to treat heart arrhythmia (Na^+-channel blocker) and during childbirth (inducing uterus contraction). Plants with anagyrine can cause malformations ("crooked calf disease") if pregnant animals feed on plants (such as lupins) containing it.

Quinoline alkaloids

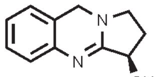
Quinoline alkaloids are here considered to include acridone alkaloids. Medically important quinolone alkaloids occur in Rutaceae, Acanthaceae and Rubiaceae.



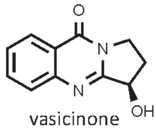
quinine quinidine

They include **quinine**, **quinidine** and cinchonidine which have been used as antimalarial drugs. Quinidine inhibits Na^+-channels and has antiarrhythmic properties. Quinine is very bitter and is employed as a bittering agent in the food industry. It also gives the bitter taste to tonic water, in concentrations of ca. 70 mg per litre.

Peganine (= vasicine) and **vasicinone** (and related compounds) show cholinergic activity. They occur as major alkaloids in *Justicia adhatoda* (an important traditional Ayurvedic medicine) and other members of the Acanthaceae.

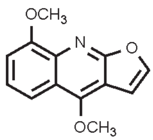


peganine (=vasicine)

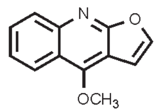


vasicinone

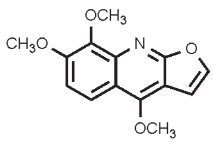
Most quinoline alkaloids intercalate DNA and thus cause frame shift mutations. Furanoquinolines can be activated by light and can form covalent bonds with DNA bases. This explains their cytotoxicity, antibacterial and antifungal properties.



γ-fagarine

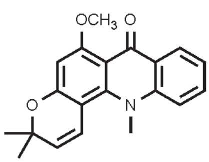


dictamnine

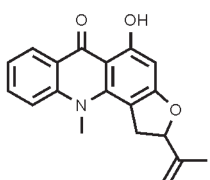


skimmianine

When human skin that has been in contact with furanoquinolines, such as **fagarine**, **dictamnine** or **skimmianine**, is exposed to sunlight, severe burns can occur with blister formation, inflammation and necrosis.



acronine (=acronycine)

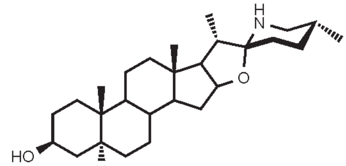


rutacridone

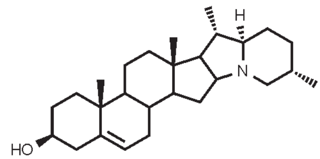
Acridone alkaloids have been found in many genera of the Rutaceae. Some of them are potent antineoplastic agents. Examples include **acronine** (= acronycine), extracted from *Acronychia baueri* and **rutacridone**, found in *Ruta graveolens*.

Steroidal alkaloids

Steroidal alkaloids, which often consist of a lipophilic steroid moiety and a hydrophilic oligosaccharide chain, are produced by four unrelated plant families: Apocynaceae, Buxaceae, Liliaceae and Solanaceae. They are especially widely distributed within the very large genus *Solanum* which includes potato, tomato and other food plants. These alkaloids are of the spirosolane type, with glycosides of **soladulcidine** and tomatidine as examples, or of the solanidane type, with glycosides of **solanidine** (e.g. solanine and chaconine) as examples.

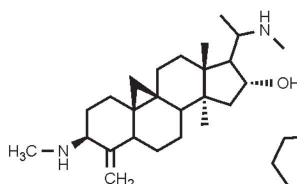


soladulcidine

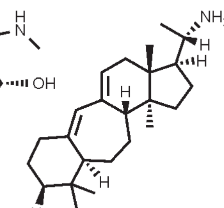


solanidine

Solanum alkaloids behave like saponins (see under saponins). This property also explains the strong skin irritation seen on mucosa and the antibacterial and antifungal properties known from saponins. In addition, the alkaloids inhibit acetylcholine esterase that breaks down acetylcholine in the synapse. Therefore, the *Solanum* alkaloids cause some neuronal effects. Several *Solanum* species, such as *Solanum dulcamara*, are part of traditional medicine used as anti-inflammatory drugs. *Solanum* alkaloids have been used in agriculture as an insecticide.



cyclobuxine D



buxamine E

Plants of the genus *Buxus* (European box and other species) contain a series of free steroidal alkaloids, such as **cyclobuxine D** and **buxamine E**, which are quite toxic and strongly purgative.

Tropane alkaloids

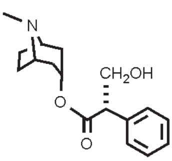
A number of plants, extracts and pure tropane alkaloids have a long history of magic and murder. They have been taken since antiquity to generate hallucinations and intoxication.

Coral tree (*Erythrina lysistemon*): erythrina alkaloids (p. 83)

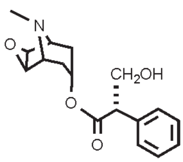
Egyptian lupin (*Lupinus albus*): lupanine and other quinolizidine alkaloids (p. 85)

Christmas cherry (*Solanum pseudocapsicum*): steroidal alkaloids

Thorn-apple (*Datura stramonium*): hyoscyamine and scopolamine

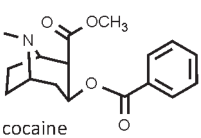


hyoscyamine



scopolamine (=hyoscine)

Alkaloids such as **hyoscyamine** (or its racemate **atropine**) and **scopolamine** are found in several genera of Solanaceae (*Atropa*, *Datura*, *Duboisia*, *Hyoscyamus*, *Mandragora*, *Physalis*, *Physoclaina*, *Salpichroa*, *Scopolia* and *Schizanthus*).



cocaine

Cocaine and related alkaloids, which are analgesics and CNS stimulants, are produced from leaves of the coca shrub (*Erythroxylum coca*).

Tropane alkaloids are antagonists at the muscarinic acetylcholine receptor and therefore show parasympatholytic properties. These alkaloids block smooth muscles, which leads to spasmolysis and loss of motility in several organs (GI tract, bladder, bronchia), inhibition of glandular secretions (salivary, bronchial, sweat glands), tachycardia, at the eye mydriasis and accommodation disturbance. Hyoscyamine and the much stronger scopolamine produce central excitation (with hallucinations) but at higher doses a central paralysis is more dominant.

Dried leaves of *Datura* species were formerly used as herbal cigarettes to treat patients with asthma and other respiratory conditions. Atropine has been used medicinally for the treatment of spasms of smooth muscles in the gastrointestinal and urinary tract, gall ducts and bronchia. It has also been used to treat bradycardia, arrhythmia and hyperhidrosis.

Atropine and scopolamine are locally employed at the eye as mydriatic and cycloplegic to facilitate inspections and diagnosis. Hyoscyamine and especially scopolamine are used as premedication for narcosis because of their sedating properties. In case of poisoning with parasympathomimetics atropine is applied as an antidote. Scopolamine is used in transdermal plasters to treat travel sickness.

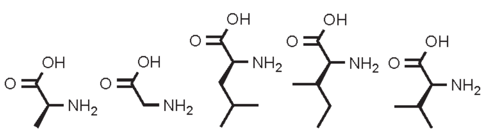
Amino acids and related compounds

Amino acids are not only the building blocks of peptides, proteins, lectins and enzymes but also the precursors of a wide range of secondary metabolites. These include amines, short-chain acids, glucosinolates and mustard oils, cyanogenic glucosides, many alkaloids and phenylpropanoids (after deamination). Many amino acids are not constituents of proteins (i.e., non-protein amino acids) but serve as protective compounds for the plants in which they occur. Amino acids are used as dietary supplements or as ingredients of general tonics and other health products.

Amino acids

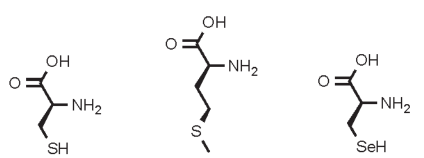
Amino acids that are naturally incorporated into polypeptides and proteins are called natural or proteinogenic amino acids. There are 23 natural amino acids, of which 21 are encoded by the universal genetic code. The remaining two (pyrrolysine and selenocysteine) have unique mechanisms through which they are incorporated into proteins.

Amino acids are all the same in having amine ($-NH_2$) and carboxylic acid (-COOH) functional groups, but differ from one another in having a specific side chain (R-group). The 21 natural amino acids can be classified in many different ways but are here grouped by their side chains:



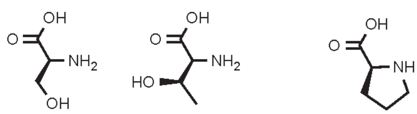
alanine glycine leucine isoleucine valine

Group 1: Aliphatic side chain (***alanine***, **glycine**, **leucine**, **isoleucine** and **valine**).



cysteine methionine selenocysteine

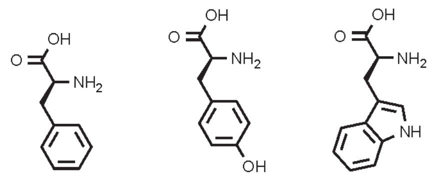
Group 2: Sulfur/selenium-containing side chain (**cysteine**, **methionine** and **selenocysteine**).



serine threonine proline

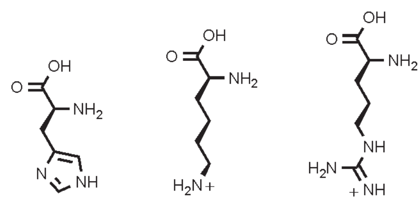
Group 3: Hydroxyl side chain (***serine*** and **threonine**).

Group 4: Cyclic side chain (**proline** only).



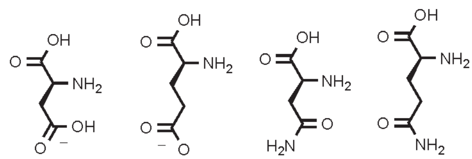
phenylalanine tyrosine tryptophan

Group 5: Aromatic side chain (**phenylalanine**, **tyrosine** and **tryptophan**).



histidine lysine arginine

Group 6: Basic side chain (**histidine**, **lysine** and **arginine**).



aspartate glutamate asparagine glutamine

Group 7: Acidic side chain, including their amides (***aspartic acid***, ***glutamic acid***, ***asparagine*** and **glutamine**).

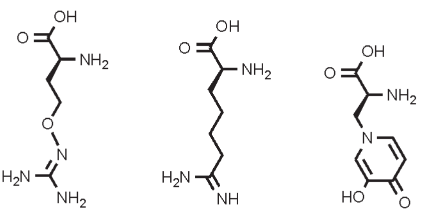
Amino acids are also grouped by their importance in the human diet. Some are called essential amino acids because humans are unable to synthesise them from other metabolites (names in bold and underlined). Others (with names in bold only) are only essential under specific circumstances (e.g. in young children). The remaining ones are non-essential (names in bold italics). The dietary importance is evident in the fact that amino acids are second only to water in making up the bulk of the human body.

Non-protein amino acids (NPAAs)

NPAAs occur in seeds, leaves and roots of legumes (Fabaceae) and some monocots (Alliaceae, Iridaceae, Liliaceae) but also Cucurbitaceae, Euphorbiaceae, Resedaceae, Sapindaceae and Cycadaceae. NPAAs often accumulate in seeds where they serve as herbivore-repellent nitrogen storage molecules, which are recycled during growth of the seedling after germination.

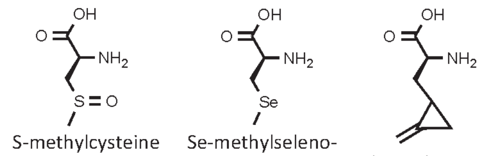
The structure of NPAAs resemble those of the 21 protein amino acids, therefore they can be considered as structural analogues. For example, 3-cyanoalanine is an analogue to L-alanine, canaline to L-ornithine, S-aminoethylcysteine to L-lysine, L-azetidine-2-carboxylic acid to L-proline, albizziine to L-glutamine, Se-methylselenocysteine to L-methionine, and L-canavanine or L-indospicine to L-arginine.

NPAAs can inhibit the uptake and transport of amino acids or disturb their biosynthetic feedback regulations. Since ribosomal transfer ribonucleic acid (tRNA) transferases cannot usually discriminate between a protein amino acid and its analogue, some NPAAs are even incorporated into proteins, resulting in defective or malfunctioning proteins. Other NPAAs interfere with neuronal signal transduction or enzymatic processes. DNA- and RNA-related processes are inhibited by canavanine and mimosine, collagen biosynthesis by mimosine, or beta-oxidation of lipids by L-hypoglycine.

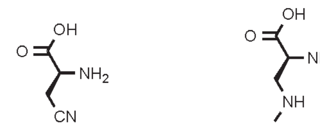

canavanine indospicine mimosine

Jackbean (*Canavalia ensiformis*), contains **L-canavanine** and causes haemorragic enteropathies. **L-indospicine** from *Indigofera spicata* causes liver cirrhosis and malformations in animals. It is teratogenic, abortifacient and hepatotoxic. A cleft palate and dwarfism have been observed in rats. **Mimosine** from *Leucaena leucocephala* is a tyrosine mimic and a cause for hair loss, weight loss, anorexia, eye inflammation and foetal malformations in animals.

S-Methylcysteine sulfoxide, which occurs in *Brassica* species, is converted in the rumen of ruminants to dimethyldisulfide. This metabolite has haemolytic activities and can cause anaemia ("kale poisoning"). **Se-Methylselenocysteine** and selenocystathionine cause selenosis with infertility, abdominal pain, nausea, vomiting and diarrhoea.

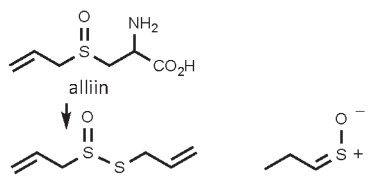

S-methylcysteine sulfoxide Se-methylseleno-cysteine hypoglycin

Hypoglycin and its derivatives occur in ackee fruits from the West Indies (*Blighia sapida*) and *Billia hippocastanum*. They are very toxic and cause a syndrome known as "vomiting sickness".


3-cyanoalanine 3-methylamino-alanine

Some NPAAs from *Lathyrus latifolius*, *L. sativus*, *L. sylvestris* and *Vicia* species, such as **L-β-cyanoalanine**, L-α-γ-diamino butyric acid, α-amino-β-oxalyl aminopropionic acid and β-N-(γ-L-glutamyl)-aminopropionic acid, cause a neuronal disorder (neurolathyrism) in humans and livestock when eaten in large quantities. *L. sativus* has been imported to India as a lentil substitute and neurolathyrism was common in times of famine in India.

3-Methylamino-L-alanine from *Cycas* species (Cycadales) is very toxic to animals, causing convulsions and even death.

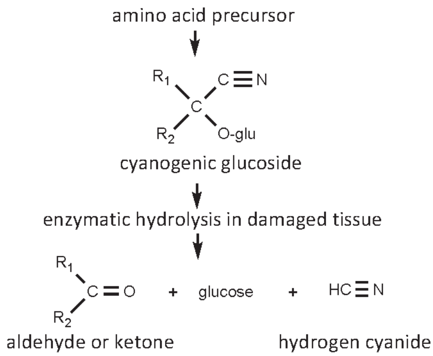


allicin propanethial *S*-oxide

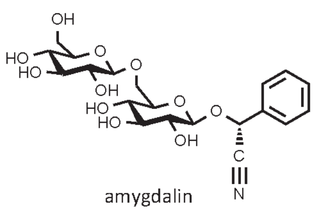
A special case of NPAAs can be found in garlic and onions (*Allium* species); **alliin** is converted into a reactive metabolite **allicin** and others that can bind to SH-groups of proteins. This would explain the wide range of pharmacological activities (antidiabetic, antihypertensive, antithrombotic and antibiotic properties) that were attributed to garlic. **Propanethial *S*-oxide** derived from ***S*-propenylcysteine *S*-oxide** occurs in onion (*Allium cepa*) and is responsible for the main lachrymatory activity when onions are cut or bruised.

Cyanogenic glucosides

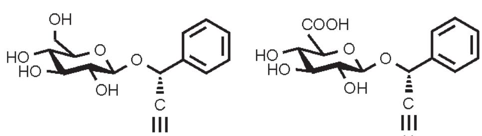
Cyanogenic glucosides are especially abundant in seeds, leaves and roots of Rosaceae, Fabaceae, Euphorbiaceae, Caprifoliaceae, Poaceae, Linaceae, Lamiaceae, Passifloraceae, Sapindaceae, Juncaginaceae and Ranunculaceae. They are stored in the vacuole as prefabricated defence chemicals (the "prodrug" principle). If tissue is damaged through wounding (by a pathogen or herbivore), then a β-glucosidase comes into contact with the cyanogenic glucosides, which are split into a sugar and a nitrile moiety that is further hydrolysed to **hydrocyanic acid** (HCN) and an aldehyde.



HCN is a strong poison (deadly gas) as it binds to cytochrome oxidase in the mitochondrial respiratory chain. HCN therefore effectively inhibits mitochondrial respiration and in consequence adenosine triphosphate (ATP) production. Death is caused by respiratory arrest.



amygdalin

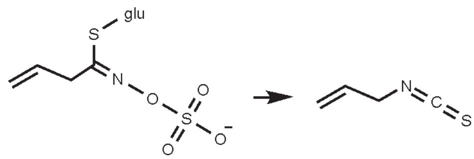


prunasin laetrile

Well-known examples of cyanogenic glucosides include **amygdalin** and **prunasin**. Laetrile (called "vitamin B17") is an ineffective anticancer drug based on amygdalin, which was widely used in the USA. It has led to several cases of severe HCN poisoning. Amygdalin is used in Traditional Chinese Medicine as an antitussive agent.

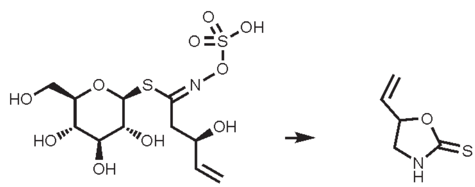
Glucosinolates and mustard oils

Glucosinolates occur in seeds, leaves and roots of plants of the order Brassicales, which comprises the Brassicaceae, Capparaceae, Tropaeolaceae, Resedaceae and Moringaceae. The glucosinolates (mustard oil glycosides) are stored as prefabricated inactive vacuolar defence compounds. When they come into contact with the enzyme myrosinase, the active mustard oils (isothiocyanates) are released. A common example is **sinigrin**, the main glucosinolate in horseradish (*Armoracia rusticana*) and black mustard (*Brassica nigra*). It is converted to **allyl isothiocyanate**, a reactive and pungent mustard oil.



sinigrin allyl isothiocyanate

Mustard oils are highly lipophilic and can disturb the fluidity and permeability of biomembranes and bind to various enzymes, receptors or other macromolecules, such as DNA (thereby exhibiting a substantial antimicrobial effect). Isothiocyanates are responsible for the distinctive, pungent flavour and odour of mustards and horseradish and are strong irritants of the skin, mucosal tissues of the mouth, throat, gastrointestinal tract and eye. Mustard oils, like capsaicin, activate TRP channels (transient receptor potential family of calcium ion channels). In addition, isothiocyanates are reactive compounds that can form covalent bonds with SH- and NH_2-groups of proteins. If many proteins are treated in such a way, the cells die and inflammation starts, usually resulting in blister formation.



progoitrin goitrin

Goitrin (5-vinyl-2-oxazolidinethione), which derives from **progoitrin** in most brassicas, inhibits the incorporation of iodine into thyroxine precursors and interferes with its secretion and can therefore induce the development of goitre.


Cassava (*Manihot esculenta*): cyanogenic glucosides (linamarin)


Black mustard (*Brassica nigra*): glucosinolates (p. 90)


Coral pea (*Abrus precatorius*): seeds – abrin (toxic lectins)


Castor oil plant (*Ricinus communis*): seeds – ricin (toxic lectins)

Plants containing glucosinolates are often used as spices or vegetables. Mustard oils have been employed in traditional medicine to treat rheumatism (topical application, as counter-irritants) and bacterial infections.

Lectins and peptides

Lectins are small glycosylated and protease-resistant proteins, which are common in seeds of several plants, such as abrin in *Abrus precatorius*, phasin in *Phaseolus vulgaris*, robin in *Robinia pseudoacacia*, and ricin in *Ricinus communis*. Many lectins are highly toxic; ricin is one of the deadliest of all plant poisons. Less toxic lectins occur in seeds of several plants, especially of legumes (Fabaceae) and mistletoe (*Viscum album*), which has been used in phytomedicine. Some of them contribute to allergic properties of a plant, such as peanut lectin (PNA) in peanut seeds (*Arachis hypogaea*) and ragweed pollen allergen (Ra5) from *Ambrosia elatior*. In plants, seed lectins serve as defence compounds against herbivores and nitrogen storage compounds that are remobilised during germination.

Lectins bind to cells via the haptomer (haemagglutinating activity) and become internalised by endocytosis. Once in the cell, they have an affinity for ribosomes and the A-chain (which has *N*-glycosidase activity) blocks ribosomal protein translation by inactivating elongation factors EF1 and EF2. A cell that is no longer able to make proteins will die.

Lectins are toxic when taken orally, but much more toxic when injected intramuscularly or intravenously. They are among the most toxic peptides produced in nature. Other toxic peptides are found in the venom of snakes, spiders, other animals and in some bacteria (causing whooping cough, cholera or botulism).

Lectins and small peptides can be inactivated by heat; therefore, extensive cooking in water at more than 65 °C usually destroys these toxins. This is why it is important to cook beans and other pulses before they are eaten.

Seeds of several plants accumulate other small peptides such as protease inhibitors. They inhibit the activity of intestinal proteases, such as trypsin and chymotrypsin.

Some plants are rich in hydrolytic proteases, such as bromelain in *Ananas comosus*, ficin in *Ficus glabrata* and papain in *Carica papaya*. They are used medicinally to treat inflammation and digestive problems.

Several small antimicrobial peptides (AMPs) are present in many plants but often overlooked in phytochemical analyses. AMPs exhibit powerful antimicrobial activities.

Format of species monographs, with abbreviations and conventions used

1. **Scientific (botanical) name**
2. **Vernacular name(s) in English**
3. **Top photograph:** main species treated (an alternative source of the drug may be shown as a second photo – then specified in the text)
4. **Classification**
   Type of toxin is indicated, with the World Health Organisation's classification of toxins (see p. 24)
   AHP = included in the African Herbal Pharmacopoeia (2010)
   Clinical studies– = no supportive evidence of efficacy reported after at least one clinical study
   Clinical studies+ = efficacy supported by at least one clinical trial
   Comm. E– = negative monograph by the German Commission E
   Comm. E+ = positive monograph by the German Commission E
   DS = Dietary Supplement
   ESCOP = included in ESCOP monographs (European Scientific Cooperative on Phytotherapy)
   ESCOP Suppl. = included in later supplements of the ESCOP monographs
   HMPC = included in the monographs of the European Medicines Agency (Herbal Medicinal Products)
   MM = Modern Medicine
   Pharm. = included in one or more pharmacopoeia
   PhEu8 = included in the 8th edition of the European Pharmacopoeia (2014)
   TCM = Traditional Chinese Medicine
   TM = Traditional Medicine
   WHO 1 = Monographs of the World Health Organisation (plus volume number)
5. **Uses & properties**
   Pharmaceutical name is provided (in English and Latin)
   The plant part used is specified (see p. 28)
   Dosage forms (see p. 30) and methods of administration (see p. 34)
   Main uses are indicated, and the dose where available (1 g = 0.035274 oz)
6. **Origin**
   Geographical region (usually continent) where the plant is indigenous
   Region(s) where it is naturalised and/or cultivated is sometimes given
7. **Botany**
   A very brief description, with emphasis on growth form (habit)
   Botanical terms are defined in the glossary (p. 274)
8. **Chemistry**
   A brief summary of the main chemical compounds of pharmacological and/or toxicological interest
   The name printed in bold refers to the given chemical structure (often the main active ingredient)
   Yields of compounds are given as % of dry weight (unless specified otherwise)
   A brief introduction to the various classes of compounds is presented elsewhere (see p. 49)
9. **Pharmacology**
   A brief summary of preclinical and clinical data, with biological activities of main compound(s)
   For definitions of pharmacological terms see glossary (p. 274)
10. **Toxicology**
    An indication of toxicity, safety, edibility and possible side effects
    LD_{50} = the dose of substance (in mg per kg body weight) that kills 50% of the specified test animals
    Methods of administration: p.o. = per os (ingested by mouth); i.p. = intraperitoneal injection; i.v. = intravenous injection; s.c. = subcutaneous injection
11. **Bottom photograph:** usually the fresh or mostly the dried raw material, as it is traded
    In the case of poisonous plants, other details (or related species) are shown
12. **Last paragraph (below photo):** scientific name of the species, with author citation, main synonym and family name; vernacular name(s) in several languages (space permitting)

Abrus precatorius

crab's eye vine • coral pea

CLASSIFICATION Cell toxin, extremely hazardous (Ia); TM: Africa, Asia.

USES & PROPERTIES The attractive seeds are used to make necklaces, rosaries, bracelets and other decorative objects. A highly resistant seed coat ensures that the intact seeds pass harmlessly through the digestive tract. However, when seeds are pierced (to make beads) or damaged, the poison is released, causing dermatitis, intoxication and even death.

ORIGIN Africa, Asia.

BOTANY Woody climber; leaves pinnate; flowers pale purple; pods 4–5-seeded; seeds 5 mm in diam.

CHEMISTRY **Abrin** (a mixture of four lectins, called abrin A–D, are present in seeds); abrusosides (sweet-tasting triterpene saponins, occur in the leaves and roots).

PHARMACOLOGY Abrin: haemagglutinating, inhibitor of ribosomal protein synthesis.

TOXICOLOGY Abrin: LD_{50} = 0.02 mg/kg (mouse, i.p.); seeds: lethal dose = 0.5 g (humans, p.o.).

NOTES Fatal cases of poisoning are rare.

Abrus precatorius L. (Fabaceae); *pois rouge* (French); *Paternostererbse* (German)

Acacia senegal

gum acacia • gum arabic tree

CLASSIFICATION TM: Africa, Europe, Asia. Pharm., PhEur8, AHP.

USES & PROPERTIES Gum arabic is the tasteless and odourless dried exudate collected from the bark. It is used topically as emollient to promote healing and to protect the skin and mucosa from bacterial and fungal infections. The main use in pharmacy is as emulsifier, stabiliser of suspensions and additive for solid formulations and tablets.

ORIGIN Africa. Gum is produced in North Africa and especially in Sudan and Ethiopia.

BOTANY Deciduous tree (to 6 m); thorns typically in groups of three; leaves pinnately compound; flowers minute, cream-coloured, in elongated spikes; pods flat, oblong.

CHEMISTRY Gum arabic is a polysaccharide (MW 270 000) with **arabinose**, galactose, D-glucuronic acid and L-rhamnose subunits.

PHARMACOLOGY Moisturising, antibiotic and protective effects on skin and mucosa.

TOXICOLOGY Non-toxic (edible).

Acacia senegal (L.) Willd. (Fabaceae); *acacie gomme arabique* (French); *Verek-Akazie* (German); *acacia del Senegal* (Italian)

Achillea millefolium

yarrow • milfoil • woundwort

CLASSIFICATION TM: Asia, Europe. Pharm., Comm. E+, ESCOP Suppl., PhEur8, HMPC.

USES & PROPERTIES The whole plant (*Millefolii herba*), flowers (*Millefolii flos*) or sometimes the essential oil are used for lack of appetite and minor dyspeptic complaints. Traditional uses include the treatment of arthritis, the common cold, fever and hypertension. Internal use: 4.5 g of the herb per day, as infusion or tincture (or 3 g flowers). External use: 100 g herb in 20 litres of bath water.

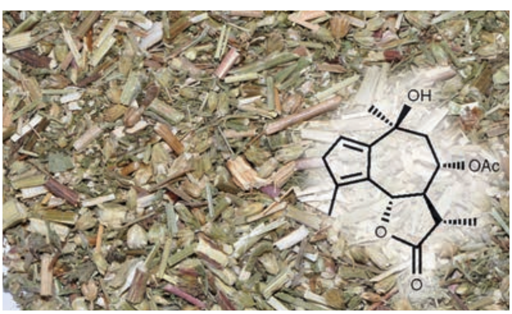
ORIGIN Europe and W Asia (widely cultivated).

BOTANY Perennial herb; leaves compound, feathery; flowers white to pink.

CHEMISTRY Pyrrolidine alkaloids (betonicine, stachydrine) flavonoids and essential oil (α-pinene, camphor, 1,8-cineole, caryophyllene and blue azulenic compounds released from lactones (e.g. **achillicin**) during steam distillation).

PHARMACOLOGY Antibacterial, anti-inflammatory, antispasmodic; antipyretic, hypotensive.

TOXICOLOGY Low toxicity; may cause dermatitis.



Achillea millefolium L. (Asteraceae); *millefeuille* (French); *Schafgarbe* (German); *achillea millefoglio* (Italian); *milenrama* (Spanish)

Aconitum napellus

aconite • monkshood • wolfsbane

CLASSIFICATION Neurotoxin, mind-altering (Ia). TM: Europe, Asia. MM and homoeopathy.

USES & PROPERTIES Dilute root tinctures are used in cough syrups and in homoeopathy. Higher concentrations (or pure alkaloid) are applied topically to treat rheumatism and neuralgia. Aconite is a psychoactive drug. In India and China, some species are used topically for analgesic, antineuralgic, anti-inflammatory and antipyretic effects. Formerly used for executions, murder, suicide and to control vermin (hence "wolfsbane").

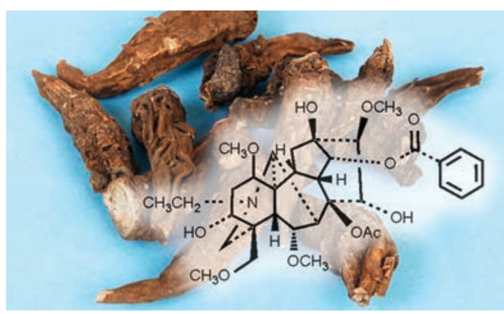
ORIGIN Europe (widely cultivated).

BOTANY Perennial herb; root tuberous; leaves dissected; flowers hood-shaped, sepals colourful.

CHEMISTRY Diterpene alkaloids (**aconitine**).

PHARMACOLOGY Aconitine stimulates Na^+-channels; peripheral nerve endings are first activated and then paralysed. It is strongly psychedelic when smoked or absorbed through the skin.

TOXICOLOGY Aconitine: lethal dose 3–6 mg (humans). All *Aconitum* species are very toxic.



Aconitum napellus L. (Ranunculaceae); *aconit napel* (French); *Blauer Eisenhut* (German); *aconito* (Italian); *acónito* (Spanish)

Acorus calamus

calamus • sweet flag

CLASSIFICATION Cell toxin, mutagenic. TM: Asia (Ayurvedic and Chinese medicine). Pharm.

USES & PROPERTIES Fresh or dried rhizomes are traditionally used as aromatic bitter tonics and appetite stimulants to treat indigestion, flatulence, stomach cramps, chronic dysentery and asthma.

ORIGIN North temperate zone (Asia, Europe and North America). It grows in water or wet places.

BOTANY Perennial herb (0.8 m); leaves linear, midribs distinct; flowers minute, in oblong spikes.

CHEMISTRY Essential oil: sesquiterpenoids (**acorenone**) and several monoterpenoids (e.g. camphene, *p*-cymene, linalool). Phenylpropanoids (β-asarone) in the Indian variety.

PHARMACOLOGY Spasmolytic, CNS sedative, toxic and mutagenic properties are ascribed to β-asarone. It is a potent carcinogen in rodents that may induce duodenal and liver cancer.

TOXICOLOGY β-asarone: LD_{50} = 184 mg/kg (mouse, i.p.). In Europe, a maximum of 0.1 mg/kg is allowed in foodstuffs. *Acorus* and its oil is prohibited for food use in the USA.

Acorus calamus L. (Acoraceae); *acore vrai* (French); *bacc* (Hindi); *Kalmus* (German); *calamo aromatico* (Italian); *cálamo aromático* (Spanish)

Adansonia digitata

baobab

CLASSIFICATION TM: Africa. AHP. DS: fruit.

USES & PROPERTIES The fruits and seeds are traditionally used in African traditional medicine to treat dysentery and fever. Numerous medicinal uses have also been reported for the leaves, bark and roots. The dry and powdered fruit pulp has become popular as a dietary supplement and health food item: in health drinks such as smoothies, fruit juices (6–8%) and cereal health bars (5–10%).

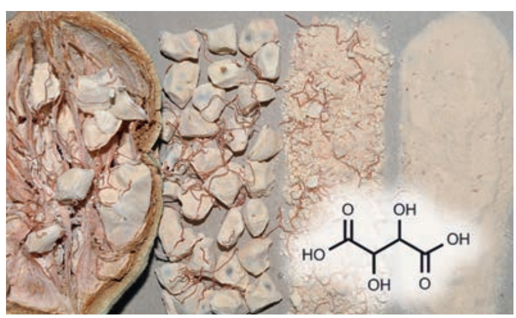
ORIGIN Africa. Trees are cultivated on a small scale in warm, tropical regions.

BOTANY Massive deciduous tree (to 15 m); trunk 20 m or more in circumference; leaves digitate; flowers large, white; fruit ovoid, velvety.

CHEMISTRY Fruit pulp contains ascorbic acid, **tartaric acid** and water-soluble pectins (to 56%).

PHARMACOLOGY Antioxidant activity (comparable to that of grape seed extract). Demonstrated activities (at high doses): analgesic, anti-inflammatory and antipyretic.

TOXICOLOGY Fruit pulp is safe to consume. It has Novel Food (EU) and GRAS (USA) status.



Adansonia digitata L. [Malvaceae (formerly Bombacaceae)]; *adansonie d'Afrique* (French); *Affenbrotbaum* (German); *baobab africano* (Italian); *baobab del África* (Spanish)

Adenium obesum

desert rose

CLASSIFICATION Heart poison (Ia).

USES & PROPERTIES The stems and roots contain watery latex that has been used as fish poison and arrow poison, often in combination with other toxic plants and plant parts.

ORIGIN Africa (southern and eastern parts).

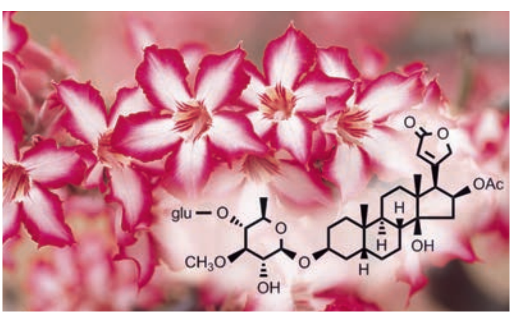
BOTANY Thick-stemmed woody shrub (to 3 m); leaves glossy green, deciduous; flowers showy, shades of red, pink and white; fruits cylindrical, dehiscent capsules; seeds numerous, hairy.

CHEMISTRY More than 30 cardiac glycosides (**obebioside B** is the main compound).

PHARMACOLOGY Cardiac glycosides: inhibition of the crucial Na^+, K^+-ATPase ion pump, which results in slow heartbeat, arrhythmia, ventricular fibrillation, cardiac arrest and death.

TOXICOLOGY Poisoned arrows may cause death within a few minutes. Lethal dose unknown (perhaps 0.1–0.6 mg/kg body weight (humans, i.v.); more for oral toxicity.

NOTES *Adenium multiflorum* (impala lily), also known as *A. obesum* var. *multiflorum*, is shown below.



Adenium obesum Forskal [= *A. obesum* var. *obesum*] (Apocynaceae); *rose du désert* (French); *Wüstenrose* (German)

Adonis vernalis

yellow pheasant's eye • spring adonis

CLASSIFICATION Heart poison (Ib). TM: Europe. Pharm., Comm. E+, homoeopathy.

USES & PROPERTIES Aerial flowering parts (*Adonidis herba*), in carefully controlled doses of a standardised mixture (see below), to treat the symptoms of heart insufficiency. Traditional use: bladder and kidney stones.

ORIGIN Europe (excluding Britain), Siberia.

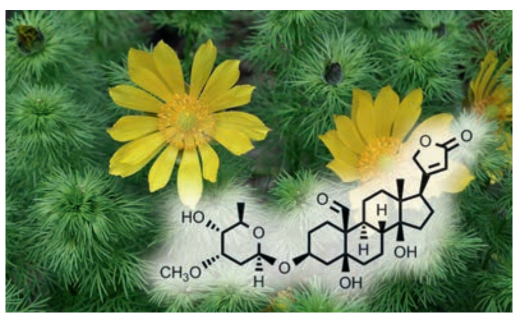
BOTANY Perennial herb; leaves compound, feathery; flowers large, bright yellow.

CHEMISTRY More than 20 cardenolides (0.2 to 0.5%); **cymarin** as main compound (hydrolysis gives kappa-strophanthidin and *D*-cymarose).

PHARMACOLOGY Cymarin: positive inotropic and venotonic activity; strengthen the contraction of the heart muscle without increasing the pulse.

TOXICOLOGY Cymarin: LD_{50} = 0.11–0.13 mg/kg (cat, i.v.); average daily dose of standardised powder (with activity equivalent of 0.2% cymarin: 0.6 g; max. single dose: 1 g, max. daily dose: 3 g.

NOTES Warning: use only under the supervision of a qualified health care professional.



Adonis vernalis L. (Ranunculaceae); *adonide du printemps* (French); *Frühlings-Adonisröschen* (German); *adonide* (Italian); *botón de oro* (Spanish)

Aesculus hippocastanum

horse chestnut

CLASSIFICATION Cell toxin (III). TM: Europe. Comm. E+, ESCOP 6, WHO 2, HMPC. MM (aescin). Clinical studies+.

USES & PROPERTIES Standardised extracts of dried seeds (*Hippocastani semen*) are used in modern phytotherapy to treat the symptoms of venous and lymphatic insufficiency. Leaves (*Hippocastani folium*): in TM (coughs, arthritis and rheumatism; in galenical preparations to treat venous conditions). Bark (*Hippocastani cortex*): rarely in TM (diarrhoea and haemorrhoids).

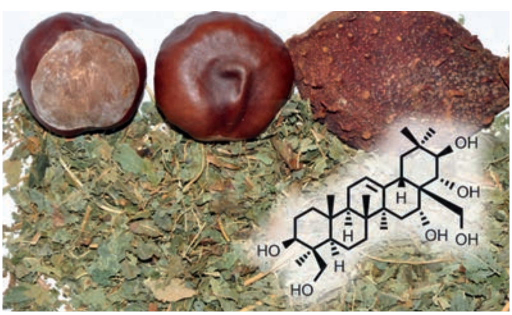
ORIGIN Eastern Europe to Central Asia.

BOTANY Large tree (to 30 m); leaves digitate; flowers showy, white with pink spots; fruit a spiny capsule; seeds large, smooth, brown.

CHEMISTRY Aescin (a mixture of triterpene saponins, to 5%; 16–21% in standardised extracts); main compound: a glycoside of **protoaescigenin**.

PHARMACOLOGY Anti-inflammatory, venotonic and anti-oedema (increased vascular tone and stability of capillary veins).

TOXICOLOGY Moderately toxic.



Aesculus hippocastanum L. [Sapindaceae (formerly Hippocastanaceae)]; *marronnier d'Inde* (French); *Rosskastanie* (German); *castagna amare* (Italian); *castaño de Indias* (Spanish)

Aframomum melegueta

Melegueta pepper • grains of paradise

CLASSIFICATION TM: Africa. AHP.

USES & PROPERTIES The seeds are used in traditional medicine to treat a wide range of ailments including infertility, cough, measles, leprosy, dysentery, stomach ailments and indigestion.

ORIGIN Africa (tropical western parts).

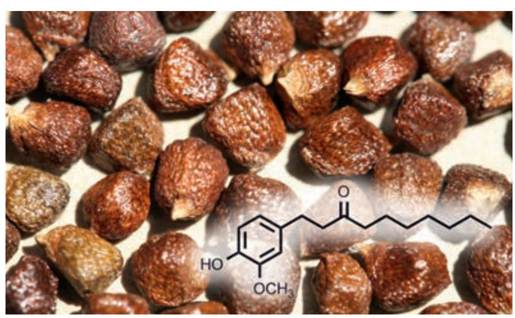
BOTANY Perennial herb (to 1 m) with creeping rhizomes; leaves large, glabrous; flowers white or pink, showy; fruit ovoid, fleshy, bright red; seeds many, angular, reddish brown, tuberculate/warty.

CHEMISTRY The seeds contain **[6]-paradol**, [6]-shogaol and other hydroxyalkylalkanones. The essential oil has α-humulene and β-caryophyllene as main compounds.

PHARMACOLOGY Both [6]-paradol and the essential oil have demonstrated antimicrobial activity. Extracts of the seeds have aphrodisiac, anti-inflammatory and analgesic properties.

TOXICOLOGY The seeds are edible and have no toxic effects even at doses of 4 g/kg (rat, p.o.).

NOTES Once an important substitute for black pepper and still a valuable spice.



Aframomum melegueta (Roscoe) K. Schum. (Zingiberaceae); *poivre de Guinée* (French); *Malagettapfeffer*, *Paradieskörner*, (German); *grani de melegueta* (Italian); *malagueta* (Spanish)

Agathosma betulina

buchu • round leaf buchu

CLASSIFICATION TM: Africa (Cape). Pharm., Comm.E–, AHP.

USES & PROPERTIES Fresh or dried leaves (*Barosmae folium; Folia Bucco*) are traditionally used as diuretic, diaphoretic and stimulant tonic (kidney and bladder ailments, rheumatism, and minor digestive disturbances). In the form of "buchu vinegar", it has been applied to wounds and bruises.

ORIGIN Africa (Western Cape, South Africa).

BOTANY Woody shrublet; leaves gland-dotted, rounded (oval – more than twice as broad) in the related oval leaf buchu (*A. crenulata*); flowers white to pale purplish; fruit a 5-seeded capsule.

CHEMISTRY Essential oil: rich in **diosphenol** (buchu camphor) but also limonene, isomenthone and terpinen-4-ol as main compounds. Leaves contain flavonoids (mainly diosmin).

PHARMACOLOGY Buchu leaf and buchu oil are believed to have urinary antiseptic, diuretic and anti-inflammatory activity.

TOXICOLOGY Round leaf buchu is non-toxic but oval leaf buchu oil has pulegone (potentially toxic).

Agathosma betulina (Berg.) Pillans [= *Barosma betulina* (Berg.) Bartl. & H.L. Wendl.] (Rutaceae); *buchu* (French); *Bucco* (German); *buchu* (Italian)

Agrimonia eupatoria

common agrimony

CLASSIFICATION TM: Europe, Asia. Pharm., Comm.E+, ESCOP, PhEur8.

USES & PROPERTIES Dried aboveground parts (*Agrimoniae herba*) are used as antidiarrhoeal, astringent and mild diuretic for treating throat infections, acute diarrhoea, cystitis, piles and ailments of the urinary tract. It is a traditional styptic to treat bleeding wounds and is claimed to have value in alleviating the symptoms of arthritis and rheumatism. An ingredient of mixtures to treat disorders of the stomach, liver and gall bladder.

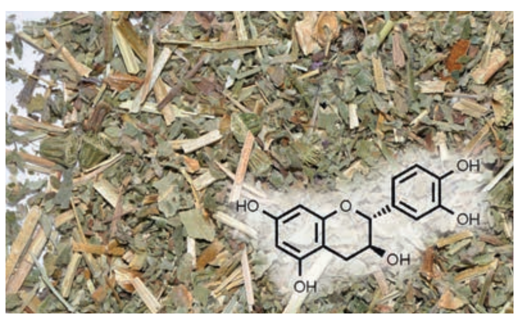
ORIGIN Europe and the Near East.

BOTANY Erect perennial herb; leaves compound, toothed, hairy; flowers small, yellow, in slender spikes. Fragrant agrimony (*A. procera*) and Chinese agrimony (*A. pilosa*) are also used.

CHEMISTRY **Catechin** tannins and gallotannins (agrimoniin is one of the main compounds).

PHARMACOLOGY Tannins are astringent and bind to proteins (hence the antiviral and antibacterial activity). Diuretic activity (not proven).

TOXICOLOGY Very low toxicity.



Agrimonia eupatoria L. (Rosaceae); *aigremoine gariot* (French); *Kleiner Odermennig* (German); *agrimonia* (Italian); *agrimonia* (Spanish)

Agrostemma githago

corn cockle

CLASSIFICATION Cell toxin (Ib). TM: Europe.

USES & PROPERTIES The plant was once an abundant weed in cereal fields and the seeds a common contaminant of grain, resulting in human and animal poisoning (sometimes with fatal results). Used to a limited extent in traditional medicine: cough, gastritis and skin ailments.

ORIGIN Europe (Mediterranean region; an introduced weed elsewhere).

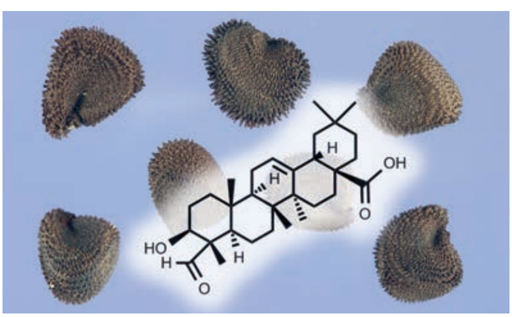
BOTANY Erect annual; leaves linear-lanceolate; flowers purple (sepals longer than the petals); capsules many-seeded; seeds orbicular, black.

CHEMISTRY Toxic triterpene saponins, especially githagin; the aglycone is **githagenin** (=gypsogenin); a toxic lectin: agrostin.

PHARMACOLOGY Saponins increase the permeability of biomembranes and thus the uptake of the lectin (the latter inhibits protein synthesis).

TOXICOLOGY Saponins: LD_{50} = 2.3 mg/kg (rats, i.p.), 50 mg/kg (rats, p.o.); seeds: lethal dose = 5 g or more (humans, p.o.).

NOTES Nowadays, cases of poisoning are rare.



Agrostemma githago L. (Caryophyllaceae); *nielle des champs* (French); *Kornrade* (German); *gittaione* (Italian)

Alchemilla xanthochlora

lady's mantle

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8.

USES & PROPERTIES The dried aerial parts of flowering plants (*Alchemillae herba*) are mainly used to treat mild diarrhoea (daily dose of 5–10 g) and throat infections. Externally it is applied to wounds and sores. Traditional uses include the treatment of dysmenorrhoea. The dry product (or extracts) is included in herbal mixtures (for diarrhoea) and in mouthwashes and lozenges (for sore throat).

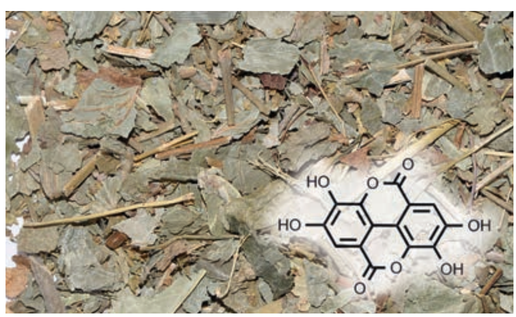
ORIGIN Europe, North America, Asia.

BOTANY Low perennial herb; leaves lobed, toothed; flowers small, yellow, in sparse clusters.

CHEMISTRY **Ellagitannins** (up to 8%): agrimoniin and others.

PHARMACOLOGY Tannins are highly astringent, non-specific protein poisons. They precipitate the proteins of the bacteria that cause diarrhoea and sore throat.

TOXICOLOGY Lady's mantle is non-toxic at the recommended daily dose.



Alchemilla xanthochlora Rothm. [= *Alchemilla vulgaris* auct. non L.] (Rosaceae); *alchimille*(French); *Gewöhnlicher Frauenmantel* (German); *alchemilla* (Italian); *pie de leon* (Spanish)

Aleurites fordii

tung oil tree

CLASSIFICATION Cell toxin, skin irritant (II).

USES & PROPERTIES Ripe seeds are the source of commercial tung oil, an ingredient of paints and quick-drying varnishes. Poisoning may occur if the fruits or seeds are eaten or if the oil is ingested.

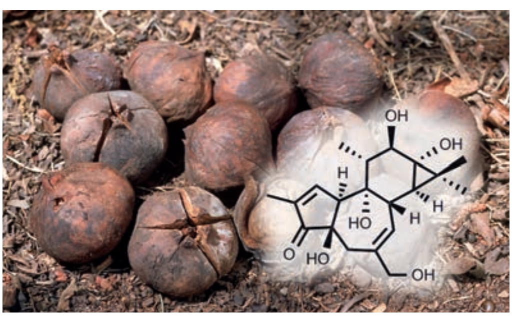
ORIGIN Asia (China).

BOTANY Tall tree (12 m); branches thick; leaves heart-shaped (two small glands are present at the insertion of the long petiole); flowers white, marked with pink or red; Capsules large, pendulous, few-seeded. The species is sometimes included in the genus *Vernicia* (as *V. fordii*).

CHEMISTRY Diterpenoids: **phorbol** esters of the tigliane type (the main compound is 12-*O*-palmitoyl-13-*O*-acetyl-16-hydroxyphorbol).

PHARMACOLOGY Phorbol esters are not only strongly purgative but potent tumour promoting agents (co-carcinogens: activation of cell division). They are skin irritants and cause painful inflammation of mucous membranes (including the eye).

TOXICOLOGY Seeds cause vomiting, stomach pain and diarrhoea; recovery within 1–2 days.



Aleurites fordii Hemsl. [= *Vernicia fordii* (Hemsl.) Airy Shaw] (Euphorbiaceae); *alévrite*, *bois de Chine* (French); *Tungölbaum* (German)

Allium cepa

onion

CLASSIFICATION TM (DS): Europe, Asia. Comm.E+, WHO 1, HMPC, clinical studies+.

USES & PROPERTIES The fresh or dried bulb (*Allii cepae bulbus*) is used as antibiotic, for cholesterol-lowering activity and to treat appetite loss. Doses of 50 g fresh onion (20 g dry) are considered effective in treating or preventing arteriosclerosis (age-related changes in blood vessels) and blood-clotting. Many traditional uses: minor digestive disturbances, insect stings, wounds, colds, cough, asthma, dysentery and diabetes.

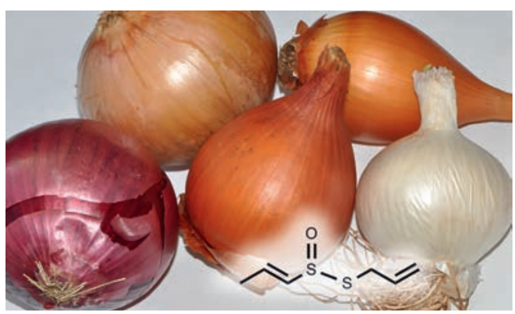
ORIGIN Uncertain (cultigen, possibly from the eastern Mediterranean region).

BOTANY Perennial herb; leaf bases forming a bulb; flowers small, white, in a rounded head.

CHEMISTRY Sulfur-containing compounds: sulfoxides (especially isoalliin) in the intact bulb (converted to **isoallicin** when cells are damaged).

PHARMACOLOGY Antimicrobial, hypoglycaemic, anti-platelet aggregation, anti-asthmatic, anti-allergic, lipid-lowering, hypotensive.

TOXICOLOGY Onions are non-toxic (edible).



Allium cepa L. [Amaryllidaceae (formerly Alliaceae)]; *oignon* (French); *Küchenzwiebel* (German); *cipolla* (Italian); *cebolla* (Spanish)

Allium sativum

garlic

CLASSIFICATION TM (DS): Europe, Asia. Comm.E+, ESCOP 3, WHO 1, PhEur8, HMPC. Clinical studies+.

USES & PROPERTIES Fresh bulb segments (*Allii sativi bulbus*), garlic powder (*Allii sativi pulvus*) or garlic oil are used for their lipid-lowering effects and also for antibacterial and antiviral activity. A daily dose of 4 g in fresh garlic (or equivalent in powder or oil) is used as supportive treatment for high blood cholesterol and the common cold.

ORIGIN Uncertain (cultigen, from Central Asia?).

BOTANY Perennial herb arising from a subterranean bulb comprising segments or cloves (axillary buds); leaves flat; flowers small, white, in a small cluster enclosed in a sheath-like bract.

CHEMISTRY Sulfur-containing compounds: sulfoxides (mainly alliin) in intact bulbs; converted to **allicin** (major compound in garlic products).

PHARMACOLOGY Demonstrated antimicrobial, antiviral, lipid-lowering and platelet aggregation inhibiting activities.

TOXICOLOGY Edible (interaction with warfarin).

Allium sativum L. [Amaryllidaceae formerly Alliaceae)]; *ail blanc* (French); *Knoblauch* (German); *aglio* (Italian); *ajo* (Spanish)

Allium ursinum

wild garlic • bear's garlic • ramsons

CLASSIFICATION TM (DS): Europe, Asia.

USES & PROPERTIES Fresh leaves (*Allii ursini herba*) or fresh bulbs (*Allii ursini bulbus*) are used in the same way as garlic (*A. sativum*). In traditional medicine: to treat digestive ailments and arteriosclerosis; externally to alleviate skin allergies. The leaves (often used as spring salad) have become popular dietary supplement or functional food and are an ingredient of commercial mixtures.

ORIGIN Europe.

BOTANY Bulbous perennial herb; leaves broad, short, flat; flowers small, white, in sparse clusters.

CHEMISTRY Sulfur-containing compounds (up to 12% in fresh bulbs): sulfoxides (mainly alliin and **methiin**) are enzymatically converted upon drying or processing.

PHARMACOLOGY As with garlic, antimicrobial, antiviral and lipid-lowering effects can be expected.

TOXICOLOGY Bear's garlic is edible but care should be taken with wild-harvested material: the leaves are easily confused with those of the poisonous lily-of-the-valley (*Convallaria majalis*).

Allium ursinum L. [Amaryllidaceae (formerly Alliaceae)]; *ail des ours* (French); *Bärlauch* (German); *aglio orsino* (Italian); *ajo de oso* (Spanish)

Aloe ferox

bitter aloe • Cape aloe

CLASSIFICATION TM (DS): Africa. Comm.E+, ESCOP 5, WHO 2, PhEur8, HMPC, AHP.

USES & PROPERTIES The bitter yellow leaf exudate is dried to a dark brown solid (commercial aloe lump or Cape aloes; *Aloe capensis*). It is a laxative medicine but also an ingredient of bitter tonic drinks. The non-bitter inner gel is used in tonic drinks and cosmetic preparations.

ORIGIN Africa (SE parts of South Africa).

BOTANY Single-stemmed succulent (2 m); leaves with sharp teeth; flowers in erect racemes.

CHEMISTRY Leaf exudate: anthraquinones, mainly **aloin** (= barbaloin), an anthrone-*C*-glycoside present as isomers (aloin A and aloin B). Leaf gel: polysaccharides and glycoproteins.

PHARMACOLOGY Aloin: a prodrug that is converted in the colon (by bacterial action) to aloe-emodin anthrone. The latter has stimulant laxative activity. Gel: hydrating and insulating effects (wound-healing and soothing properties).

TOXICOLOGY Anthraquinones may be carcinogenic (avoid chronic use or use during pregnancy).

Aloe ferox Mill. [Xanthorrhoeaceae (formerly Asphodelaceae)]; *aloès féroce* (French); *Kap-Aloe, Gefährliche Aloe* (German); *aloe del Capo* (Italian)

Aloe vera

aloe vera • Curaçao aloe

CLASSIFICATION TM (DS): Africa, Asia. Comm.E+, WHO 1 (gel), PhEur8.

USES & PROPERTIES Non-bitter leaf parenchyma (obtained by manual or mechanical "filleting") is the main product, widely used as tonic drinks but also in skincare and cosmetic products. The bitter leaf exudate (Barbados aloes, Curaçao aloes) is less often used: as stimulant laxative and bitter tonic.

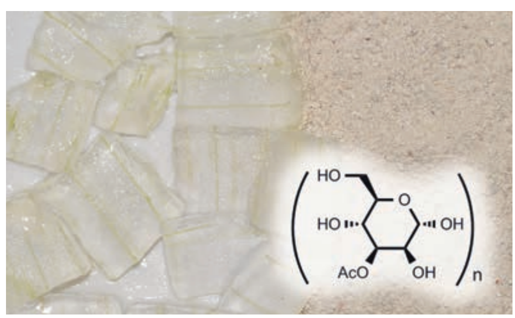
ORIGIN North Africa or Arabia (ancient cultigen).

BOTANY Stemless succulent; leaves fleshy, with harmless marginal teeth; flowers usually yellow.

CHEMISTRY Gel: 0.5–2% solids (polysaccharides – **acemannan**, glycoproteins). Leaf exudate: aloin (= barbaloin), an anthrone-*C*-glycoside (to 38%). Gel drinks usually have < 10 ppm aloin.

PHARMACOLOGY The gel has anti-inflammatory, wound-healing and immune-stimulatory effects (not scientifically fully proven). Aloin is a stimulant laxative with bitter tonic (*amarum*) effects.

TOXICOLOGY Anthraquinones are potentially carcinogenic and long-term use (and use during pregnancy) should be avoided.



Aloe vera (L.) Burm.f. [= *Aloe barbadensis* Mill.] [Xanthorrhoeaceae (formerly Asphodelaceae)]; *aloès vrai*, *laloi* (French); *Echte Aloe* (German); *aloe vera* (Italian); *sábila*, *zábila* (Spanish)

Aloysia citrodora

lemon verbena • vervain

CLASSIFICATION TM (DS): South America, Europe. PhEur8.

USES & PROPERTIES The fresh or dried leaves (*Lippiae triphyllae folium*) are used as a calming health tea (especially in France) to treat digestive ailments and minor sleeplessness. Included in mixtures to treat nervous conditions, colds, fevers, indigestion, flatulence and mild diarrhoea. Essential oil (*Lippiae triphyllae aetheroleum*) is popular in aromatherapy for its pleasant lemon smell.

ORIGIN South America (Argentina and Chile), now often cultivated (especially France and Spain).

BOTANY Woody shrub (to 3 m); leaves in groups of three or four, rough-textured, aromatic (lemon smell); flowers pale mauve, in loose panicles.

CHEMISTRY Essential oil with citral (i.e., a mixture of neral and geranial), **limonene** and several other compounds. Numerous flavonoids are present.

PHARMACOLOGY Sedative and anxiolytic properties are not yet substantiated by clinical studies.

TOXICOLOGY The leaves are often used as herb (flavour ingredient in food and beverages).

Aloysia citrodora Palau [= *A. triphylla* (L'Herit.) Britton; *Lippia citriodora* H.B.K.] (Verbenaceae); *verveine odorante* (French); *Zitronenstrauch* (German); *limoncina* (Italian)

Alpinia officinarum

galangal • Siamese ginger • lesser galangal

CLASSIFICATION TM: China, India, Europe. Pharm., Comm.E+.

USES & PROPERTIES Fresh or dried rhizomes (*Galangae rhizoma*) are used as infusions, tinctures, decoctions or powders for dyspepsia and appetite loss. In China it is also used against indigestion and stomach pain, hiccups and nausea. Tea is made from 0.5–1 g of dried rhizome, taken half an hour before meals (daily dose 2–4 g dry weight).

ORIGIN Eastern and Southeastern Asia; cultivated in China, India, Malaysia and Thailand.

BOTANY Leafy perennial herb (ca. 1 m) with fleshy rhizomes; Flowers white and reddish purple.

CHEMISTRY Essential oil (0.5–1%); non-volatile diarylheptanoids (galangols) and phenyl alkyl ketones (gingerols); flavonoids (**galangin**).

PHARMACOLOGY Galangin has antispasmodic, anti-inflammatory and antibiotic activities; diarylheptanoids inhibit prostaglandin biosynthesis and induce apoptosis in cancer cells (*in vitro*).

TOXICOLOGY The rhizomes are not toxic.

NOTES Greater galangal (*Alpinia galanga*) is a spice.

Alpinia officinarum Hance (Zingiberaceae); *gao liang jiang* (Chinese); *galanga* (French); *Echter Galgant* (German); *galanga* (Italian); *galanga* (Spanish)

Althaea officinalis

marshmallow • white mallow

CLASSIFICATION TM: Europe. Comm.E+, ESCOP 1, WHO 2, 5, PhEur8, HMPC.

USES & PROPERTIES The roots (*Althaeae radix*) are used as anti-irritant and expectorant medicine to alleviate the symptoms of cough, peptic ulcers and inflammation of the mouth, throat and stomach. Leaf infusions or marshmallow syrup (*Sirupus Althaeae*) are used to treat dry cough. Preparations are applied to burns, sores and ulcers. Daily dose (sipped or gargled): 6 g root, 5 g leaf (or 10 g marshmallow syrup, as single dose).

ORIGIN Asia; naturalised in America.

BOTANY Erect perennial herb (2 m); leaves hairy; flowers large, pink. Flowers of the related *Alcea rosea* (hollyhock) are similarly used.

CHEMISTRY Mucilages (polysaccharides): composed of **galacturonic acid**, glucuronic acid, galactose, arabinose and rhamnose (up to 15% in roots, less than 10% in leaves and flowers).

PHARMACOLOGY Polysaccharides have a soothing effect on mucosa.

TOXICOLOGY Marshmallow is safe to ingest.

Althaea officinalis L. (Malvaceae); *guimauve* (French); *Eibisch* (German); *bismalva*, *altea* (Italian); *malvavisco* (Spanish)

Ammi majus

bishop's weed • lace flower

CLASSIFICATION MM (furanocoumarins): photochemotherapy (PUVA).

USES & PROPERTIES The small fruits are a commercial source of phototoxic furanocoumarins that are used to treat skin disorders such as psoriasis and vitiligo.

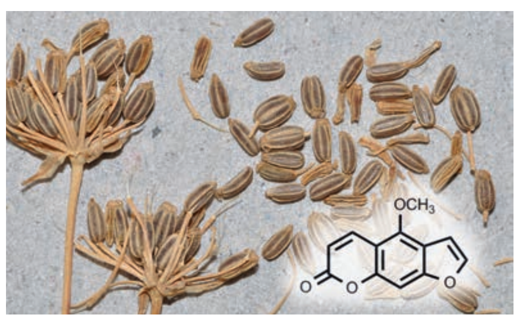
ORIGIN Europe, Asia and North Africa.

BOTANY Erect annual (0.5 m); leaves compound, with broad, serrate leaflets; flowers 50–100.

CHEMISTRY Linear furanocoumarins: **bergapten** (= 5-methoxypsoralen) and xanthotoxin are major compounds in the fruits ("seeds").

PHARMACOLOGY Furanocoumarins are phototoxic – after ingestion or skin contact, they interact with sunlight or UV light and cause acute dermatitis with blisters and vesicles. This property is used in photochemotherapy or so-called PUVA: oral administration of 20–40 mg furanocoumarins (e.g. psoralen), followed (2 hours later) by exposure to sunlight/UVA radiation (ca. 20 sessions needed).

TOXICOLOGY PUVA increases the risk of skin and lung cancer.



Ammi majus L. (Apiaceae); *grand ammi* (French); *GroBe Knorpelmöhre* (German); *visnaga maggiore* (Italian); *âmio-maior, âmio-vulgar* (Portuguese); *ameo mayor* (Spanish)

Anadenanthera peregrina

cohoba • yopo • niopo

CLASSIFICATION Hallucinogen, mind-altering, toxin (II).

USES & PROPERTIES The bark and seeds are used as psychotropic drug that has powerful hallucinogenic effects. It is a so-called entheogen used for centuries in religious, shamanic and spiritual ceremonies and rituals. Seed powder, in combination with alkaline ash, is most commonly used in an elaborate process to make preparations that are taken as snuff or as enema. It can also be taken orally (mixed with maize beer or honey) or smoked (with tobacco). The average dose is 5–10 g.

ORIGIN South America (Brazil, Andes).

BOTANY Tree (to 20 m); leaves pinnate; flowers white; pods 6–15-seeded; seeds thin, black.

CHEMISTRY Tryptamine derivatives: the alkaloid **bufotenin** is mainly responsible for the activity.

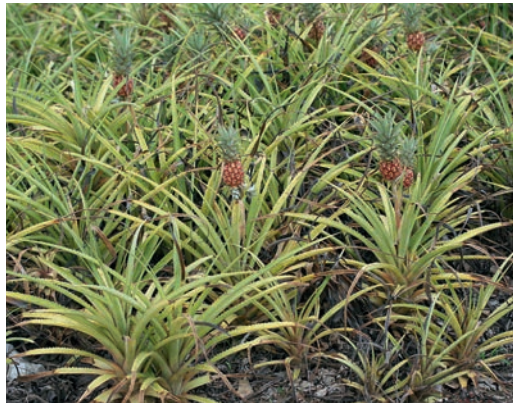
PHARMACOLOGY Bufotenin and tryptamine derivatives activate serotonin receptors.

TOXICOLOGY Yopo has a low toxicity. The LD_{50} = 200–300 mg/kg (rat, i.p.) but there are unpleasant side effects.

Anadenanthera peregrina (L.) Spegazzini [= *Piptadenia peregrina*] (Fabaceae); *yopo* (French); *Yopo* (German)

Ananas comosus

pineapple



CLASSIFICATION MM (DS): Europe. Comm.E+.

USES & PROPERTIES Pineapple juice is traditionally taken for its digestive tonic and diuretic effects. A mixture of proteolytic enzymes, extracted from fruits and stems, is known as bromelain (*Bromelainum crudum*). It is used to treat post-traumatic and post-operative swellings (and to alleviate digestive disorders). Daily dose: 80–240 mg (as tablets, 2–3 times per day, up to 10 days).

ORIGIN Central America; widely cultivated as a fruit crop in tropical parts of Africa and Asia.

BOTANY Perennial herb; leaves tough, fibrous, in rosettes, margins spiny; flower cluster purple, all parts becoming fleshy as the fruit develops.

CHEMISTRY **Bromelain**: a mixture of five or more proteolytic enzymes (mainly bromelain A and B). Rich in vitamin C (20 mg per 100 g of ripe fruit).

PHARMACOLOGY Bromelain: demonstrated anti-inflammatory, anti-oedemic, anti-platelet and fibrinolytic activities.

TOXICOLOGY Side effects of bromelain: allergic reactions, diarrhoea and indigestion.

Ananas comosus (L.) Merr. [= *A. sativa*] (Bromeliaceae); *ananas* (French); *Ananas* (German); *ananasso* (Italian); *piña* (Spanish)

Andrographis paniculata

king of bitters • kalmegh

CLASSIFICATION TM: Ayurveda, Siddha, TCM. WHO 2, HMPC.

USES & PROPERTIES Aboveground parts (*Andrographidis paniculatae herb*a) are used, in doses of 3–9 g per day, for an exceptionally wide range of ailments. It is a traditional bitter tonic and adaptogen, often used to treat fever, colds, flu, digestive complaints, sinusitis, bronchitis and tonsillitis.

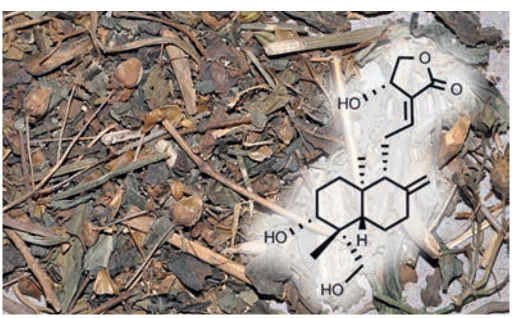
ORIGIN India and Sri Lanka (widely cultivated).

BOTANY Annual herb (1 m); leaves lanceolate; flowers two-lipped, white with purple marks.

CHEMISTRY Diterpene lactones (of the labdane type, up to 6%): **andrographolide** (the main bioactive compound) and several other diterpenes.

PHARMACOLOGY Anti-inflammatory: clinical evidence of efficacy in the treatment and prevention of upper respiratory tract infections. Reported analgesic and antimicrobial activity. Andrographolide is intensely bitter and is probably responsible for most of the claimed health benefits.

TOXICOLOGY Very low toxicity. Whole herb: LD_{50} = 40 g/kg (mouse, p.o).



Andrographis paniculata (Burm. f.) Nees. [= *Justicia paniculata* Burm. f.] (Acanthaceae); *chuan xin lian* (Chinese); *Kalmegh* (German); *kirayat* (Hindi); *bhunimba* (Sanskrit)

Anethum graveolens

dill

CLASSIFICATION TM: Europe; Pharm., Comm. E+ (fruits only).

USES & PROPERTIES The fruits (*Anethi fructus*) are traditionally used as diuretic and to treat digestive disorders (especially dyspepsia and flatulence). The daily dose is ca. 3 g (as infusion or tincture). Essential oil of the fruits (*Anethi aetheroleum*) is similarly used (daily dose: 0.1–0.3 g). The fruits are also an ingredient of gripe water for treating colic and flatulence in infants. Dill herb (*Anethi herba*) is best known for its culinary value.

ORIGIN Probably SW Asia (but cultivated since ancient times in Egypt, Europe and Asia).

BOTANY Slender annual herb; leaves feathery; flowers small, yellow, in compound umbels; fruits small, dry, 2-seeded, narrowly winged.

CHEMISTRY Essential oil (fruits): **(+)-carvone** (70%), (+)-limonene (30–40%). Fruits of Indian chemotype (*A. sowa*): dillapiole (to 40%).

PHARMACOLOGY Dill fruits (and the oil) have known antispasmodic and bacteriostatic activity.

TOXICOLOGY Dill is a culinary herb and spice.

Anethum graveolens L. (Apiaceae); *aneth* (French); *Dill* (German); *aneto* (Italian); *eneldo* (Spanish)

Angelica archangelica

garden angelica • archangel

CLASSIFICATION TM: Europe. Comm.E+, ESCOP Suppl.

USES & PROPERTIES Roots (*Angelicae radix*) are used as appetite stimulant, spasmolytic and stomachic. Infusion or tinctures: 4.5 g of dry root/day; essential oil: 10–20 drops/day. Extracts are ingredients of commercial digestive medicines. The whole herb (*Angelicae herba*), fruits (*Angelicae fructus*) or essential oil (*Oleum angelicae*) are sometimes used.

ORIGIN Europe and Asia (now widely cultivated).

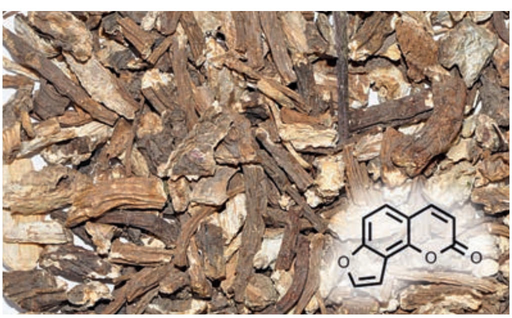
BOTANY Robust biennial herb; leaves compound, base sheathing; stems thick, hollow; flowers green, in globose umbels; fruits flat, winged, 2-seeded.

CHEMISTRY Essential oil rich in furanocoumarins (e.g. **angelicin**, imperatorin, xanthotoxin) and coumarins (e.g. osthole, osthenole, umbelliferone).

PHARMACOLOGY Digestive, antispasmodic and cholagogue activities have been demonstrated.

TOXICOLOGY Furanocoumarins are phototoxic. Side effects: skin irritation and allergic reactions.

NOTES In North America, *A. atropurpurea* is used.



Angelica archangelica L. (Apiaceae); *archangélique* (French); *Engelwurz* (German); *archangelica* (Italian); *angélica* (Spanish)

Angelica sinensis

dang gui • Chinese angelica

CLASSIFICATION TM: Asia (China); Pharm.; WHO 2, HMPC.

USES & PROPERTIES Roots of *A. sinensis* (*Angelicae sinensis radix*) and *bai zhi* (*A. dahurica*) are traditionally used as tonics to treat anaemia, constipation, irregular menstruation, pain, chronic hepatitis and cirrhosis of the liver. The recommended daily dose is 4.5–9 g. Chinese angelica is second only to ginseng in importance as tonic.

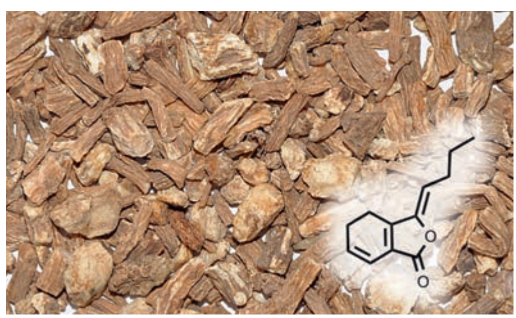
ORIGIN Asia, East Asia.

BOTANY Perennial herb; stems purple; leaves large, pinnate; flowers small, white; fruits flat, prominently winged, 2-seeded.

CHEMISTRY The roots contain essential oil rich in alkylphthalides (the main compound is **ligustilide**); also non-volatile phenylpropanoids and coumarins.

PHARMACOLOGY Smooth muscle contraction, antihepatotoxic and analgesic activities.

TOXICOLOGY The roots are not toxic but treatment should be avoided during pregnancy (and by those using aspirin or warfarin).



Angelica sinensis (Oliv.) Diels (Apiaceae); *angélique Chinoise, angélique de Chine* (French); *Chinesische Engelwurz* (German); *Kinesisk angelikarot, Kinakvanne* (Swedish)

Apium graveolens

celery

CLASSIFICATION TM: Europe, Asia.

USES & PROPERTIES The small dry fruits (*seeds*) (*Apii fructus*) are used as diuretic (kidney and bladder ailments), as adjuvant (rheumatism, arthritis), as stomachic and carminative (for nervous conditions) and in anti-inflammatory mixtures.

ORIGIN Africa, Asia, Europe.

BOTANY Erect, biennial herb; leaves large, pinnate; flowers in umbels; fruits small, dry, 2-seeded.

CHEMISTRY Essential oil (fruits) contains several aromatic compounds such as limonene and apiole. Of special interest are two minor compounds, **sedanolide** (1%) and 3-butylphthalide (1%).

PHARMACOLOGY Activity is ascribed to the essential oil compounds: 3-butylphthalide and 3-butyl-4,5-dihydrophthalide are anticonvulsant (mice, rats); sedanolide and other methylphthalides have sedative and spasmolytic activities.

TOXICOLOGY Fruits are edible. 3-butylphthalide: LD_{50} = 2450 mg/kg (rats, p.o.).

NOTES Leaves, petioles and roots are variously used as vegetables, culinary herb and spice.

Apium graveolens L. (Apiaceae); *qin cài, sai kan choi* (Chinese); *célerei* (French); *Sellerie* (German); *sèdano* (Italian); *apío* (Spanish)

Aralia racemosa

American spikenard

CLASSIFICATION TM: North America; DS, homoeopathy.

USES & PROPERTIES Roots and root bark are used in traditional medicine as adaptogen, similar to ginseng. Also used for chronic cough and infections of the upper respiratory tract. The Asian *A. elata* and *A. mandshurica* have similar uses in Chinese Traditional Medicine.

ORIGIN United States and Canada.

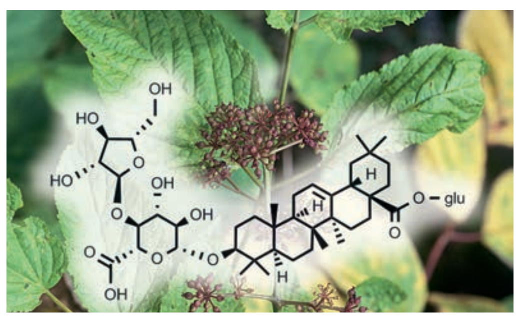
BOTANY Woody shrub (to 2 m); leaves large, pinnately compound, deciduous; flowers small, whitish, in umbels; fruits fleshy, red to purple, not edible.

CHEMISTRY Poorly known; the related *A. elata* and *A. mandshurica* have triterpenoid saponins, of which **araloside A** is a main compound.

PHARMACOLOGY Limited information available; a root extract with a terpenoid: anticancer (cytotoxic) activity; araloside A: demonstrated anti-ulcer activity.

TOXICOLOGY Details not available.

NOTES A cultivated ornamental in the USA.



Aralia racemosa L. (Araliaceae); *Amerikanische Narde* (German)

Arctium lappa

burdock • greater burdock

CLASSIFICATION TM: Europe. Pharm., HMPC.

USES & PROPERTIES Dried roots (*Arctii/Bardanae radix*) are used (also in homoeopathy) for gastrointestinal ailments. Burdock leaf (*Bardanae folium*) is an ingredient of anti-inflammatory preparations (e.g. for rheumatism). Internal use: mostly cold infusions of root or leaf; external: root oil or powdered leaves.

ORIGIN Europe (introduced to Asia and North America); cultivated in Eastern Europe (and Japan, where the roots are eaten as vegetable).

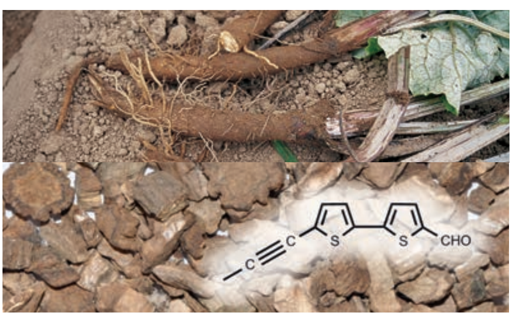
BOTANY Robust biennial herb; leaves large, hairy below; flowers purple, in hairy and bristly heads.

CHEMISTRY Roots: lignans, essential oil (with e.g. benzaldehyde, acetaldehyde and pyrazenes), inulin, triterpenes and especially various types of polyacetylenes (e.g. **arctinal**, lappaphens).

PHARMACOLOGY Anti-inflammatory, antimicrobial, hypoglycaemic and diuretic activities (ascribed to the lignans and polyacetylenes).

TOXICOLOGY No risks are known.

NOTES Alternatives: lesser burdock (*A. minus*) (in the UK) and woolly burdock (*A. tomentosum*).



Arctium lappa L. [= *A. majus* Bernh.] (Asteraceae); *gouteron, grateron* (French); *Große Klette* (German); *bardana* (Italian); *bardana* (Spanish)

Arctostaphylos uva-ursi

bearberry • uva-ursi

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 5, WHO 2, PhEur8, HMPC.

USES & PROPERTIES Dried leaves (*Uvae ursi folium*) are a traditional urinary antiseptic and ingredient of commercial preparations for kidney and bladder health. The daily dose is 10 g (equivalent of 400–700 mg of arbutin) or 2 g in 150 ml water, taken 3 or 4 times a day (maximum single dose of 3 g).

ORIGIN Arctic region (Europe, Asia, N. America).

BOTANY Woody shrub; branches trailing; bark reddish brown, smooth, flaking; flowers white, urn-shaped; fruit a bright red berry.

CHEMISTRY The leaves are chemically diverse (rich in tannins and acids) but **arbutin** and other hydroquinone derivatives are of special interest.

PHARMACOLOGY The free hydroquinone is the active compound which exhibits pronounced antimicrobial activities. It is not clear if the glucoside arbutin appears in the urine and where and how it is converted into the free aglycone.

TOXICOLOGY Do not use for prolonged periods: up to 7 days only; up to 5 treatments per year.

Arctostaphylos uva-ursi (L.) Spreng. (Ericaceae); *raisin d'ours, busserole officinale* (French); *Echte Bärentraube* (German); *uva ursina* (Italian); *gayuba del pays* (Spanish)

Areca catechu

areca nut

CLASSIFICATION Neurotoxin, stimulant (II). TM: Asia (taenicide – humans and animals).

USES & PROPERTIES Slices of betel nuts are habitually chewed by millions of people in Asia and Africa. It is mixed with betel vine leaves (*Piper betle*) and lime; tobacco, various spices, sweets and other flavourants may be added.

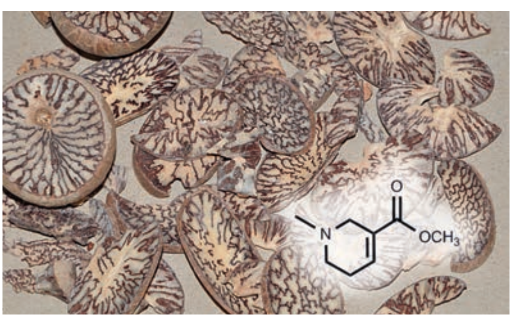
ORIGIN Cultigen of Asian origin; widely cultivated in tropical Asia, Africa and Madagascar.

BOTANY Single-stemmed palm tree (to 15 m or more); leaves pinnately dissected; fruit a fibrous 1-seeded drupe; seed globose, 20 mm in diameter.

CHEMISTRY Alkaloids (0.2–0.5%): **arecoline** (the main compound), with arecaidine, guvacoline, and guvacine. Lime is added to convert the alkaloids to their free bases. Condensed tannins (to 15%); bright red phlobatannins are formed.

PHARMACOLOGY Arecoline is a parasympathomimetic which acts on muscarinic receptors (and also nicotinic receptors, at high doses).

TOXICOLOGY Fatal dose: 8–10 g of seed; increased risk of oral cancer.



Areca catechu L. (Arecaceae); *aréquier* (French); *Betelnusspalme* (German); *avellana d'India* (Italian)

Argemone ochroleuca

prickly poppy • Mexican poppy

CLASSIFICATION Neuro- and cell toxin, mind-altering (II). TM: C and S America, India, Africa.

USES & PROPERTIES The yellow sap is widely used against skin ailments. Seeds may contaminate cereals such as wheat (with fatal results) and are an adulterant of mustard seed and mustard oil (resulting in epidemic dropsy). It is an addictive stimulant, marijuana substitute and aphrodisiac.

ORIGIN Central and South America; now a common weed in Africa, Europe and Asia.

BOTANY Annual herb (to 1 m); stems and leaves prickly, with bright yellow sap; flowers bright (*A. mexicana*) or pale yellow (*A. ochroleuca*); fruit a many-seeded capsule; seeds small, globose, black.

CHEMISTRY Isoquinoline alkaloids: berberine and protopine (plant); **sanguinarine** (seeds).

PHARMACOLOGY Berberine and sanguinarine are potentially carcinogenic. Berberine: moderately toxic; sanguinarine: toxic, linked to glaucoma.

TOXICOLOGY Sanguinarine: LD_{50} = ca. 18 mg/kg (mouse, i.p.); seed oil: at least 8.8 ml/kg required to produce toxicity symptoms in humans.

Argemone ochroleuca Sweet (Papaveraceae); *pavot épineux* (French); *Stachelmohn* (German); *pavero messicano* (Italian)

Aristolochia clematitis

birthwort

CLASSIFICATION Cell toxin, mutagen (II). TM: Europe (no longer allowed).

USES & PROPERTIES The whole herb (*Aristolochiae herba*) was traditionally used to induce labour, abortion and menstruation. The flowers resemble the human foetus in shape and orientation, hence the uses associated with childbirth. Externally it has been applied to sores and wounds. *Aristolochia* species (and *Asarum europaeum*, photo below) are no longer considered safe to ingest.

ORIGIN Southern and central Europe.

BOTANY Perennial herb with creeping rhizomes; stems erect; leaves heart-shaped; flowers yellow.

CHEMISTRY The main compounds of interest are aristolochic acids I–IV.

PHARMACOLOGY **Aristolochic acid I** and others are nephrotoxins, potent mutagens and carcinogens (metabolically activated in the liver).

TOXICOLOGY *Aristolochia* species are the known cause of several human fatalities; 70 cases of fibrous interstitial nephritis were recorded in Belgium.

Aristolochia clematitis L. (Aristolochiaceae); *sarrasine* (French); *Gewöhnliche Osterluzei* (German); *aristolochia* (Italian); *aristoloquia* (Spanish)

Armoracia rusticana

horseradish

CLASSIFICATION Cell toxin (III). TM: Europe. Pharm., Comm.E+.

USES & PROPERTIES The fresh root (*Armoraciae radix*) is traditionally ingested to treat bronchial and urinary tract infections (ca. 20 g/day). Preparations with 2% mustard oil are applied topically as counter-irritant for treating inflammation and rheumatism. Best known as a pungent condiment and source of the enzyme peroxidase.

ORIGIN Uncertain (SE Europe or W Asia); a partly sterile cultigen, cultivated as a crop (root cuttings).

BOTANY Stemless leafy perennial with a thick taproot; leaves oblong; flowers white.

CHEMISTRY Glucosinolates (also known as mustard oil glycosides); sinigrin (the main compound) is enzymatically converted to the volatile, pungent and highly reactive **allyl isothiocyanate**.

PHARMACOLOGY Isothiocyanates form covalent bonds with proteins: they are antimicrobial, cytotoxic, spasmolytic and skin irritant (hyperaemic).

TOXICOLOGY Very high oral doses can be fatal; 3 g allyl isothiocyanate is a lethal dose in cattle.

Armoracia rusticana P. Gaertn., Mey. & Scherb. [= *Armoracia lapathifolia* Gilib.] (Brassicaceae); *grand raifort* (French); *Meerrettich* (German); *cren* (Italian); *rábano picante* (Spanish)

Arnica montana

arnica

CLASSIFICATION Cell toxin (II). TM: Europe;. Pharm., Comm.E+, ESCOP 4, WHO 3, HMPC.

USES & PROPERTIES Mainly the flower heads (*Arnicae flos*) are used (topically only!) for bruises, burns, diaper rashes, haematomas, sprains and sunburn. It can also be used as a mouthwash and gargle to treat inflammation of the mucous membranes. Infusions or tinctures (2 g dry herb in 100 ml) are used (diluted when used as mouthwash). Ointments contain 20–25% tincture.

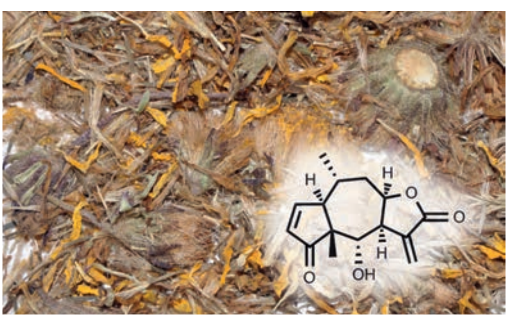
ORIGIN Europe; the North American *A. chamissonis* and *A. fulgens* are now the main sources.

BOTANY Perennial herb; leaves oblong, hairy; flower heads large, deep yellow.

CHEMISTRY Sesquiterpenoids (0.2–0.5%): **helenalin** is the main compound.

PHARMACOLOGY Helenalin (when used topically): analgesic, anti-inflammatory, antiseptic, hyperaemic and wound-healing.

TOXICOLOGY Sesquiterpenes bind to proteins, causing allergic reactions; potentially lethal when ingested. Avoid contact with eyes or open wounds.



Arnica montana L. (Asteraceae); *arnica* (French); *Arnika*, *Bergwohlverleih* (German); *arnica* (Italian); *arnica* (Spanish)

Aronia melanocarpa

black chokeberry

CLASSIFICATION TM (DS): N America, Europe.

USES & PROPERTIES The small black berries (ripe or dried) or juices/concentrates became popular as dietary supplements and functional foods. Therapeutic value: reduction of oxidative stress (due to high levels of reactive oxygen free radicals) resulting from injury, operations, chemotherapy and chronic ailments (metabolic syndrome, diabetes).

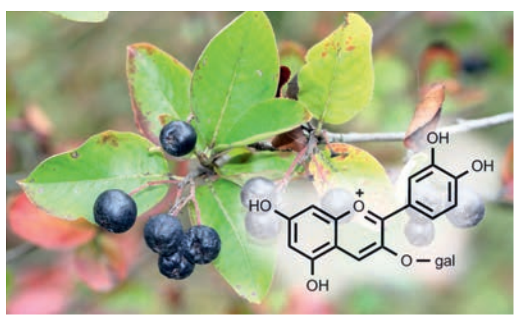
ORIGIN North America (USA and Canada).

BOTANY Woody shrub (to 2 m); flowers white; fruit a small berry (ca. 1 g).

CHEMISTRY Polyphenols, especially proanthocyanidins; anthocyanins: **cyanidin 3-*O*-galactoside** (the main pigment, up to 14.8 mg/g); organic acids; vitamin C (ca. 50 mg per 100 g).

PHARMACOLOGY Health benefits are ascribed to the free radical scavenging and antioxidant activity of the proanthocyanidins, anthocyanidins and vitamin C. The antioxidant flavonoids can modulate several targets, mediating possible venotonic and anti-inflammatory effects.

TOXICOLOGY The berries are edible (non-toxic).



Aronia melanocarpa (Michx.) Elliot [= *Mespilus arbutifolia* L. var. *melanocarpa*] (Rosaceae); *hei guo xian lei hua qiu* (Chinese); *aronie à fruits noirs* (French); *Schwarze Apfelbeere* (German)

Artemisia absinthium

wormwood • absinthe

CLASSIFICATION Neurotoxin, mind-altering (II–III). TM: Europe. Comm.E+, ESCOP 4, PhEur8, HMPC.

USES & PROPERTIES Upper leafy parts (*Absinthii herba*) are used (3 g/day, infusion) to stimulate appetite (taken before the meal) and to treat digestive disorders and gall bladder complaints (taken after the meal, as cholagogue). Topical use: skin ailments. Also extracts, tinctures and solid formulations.

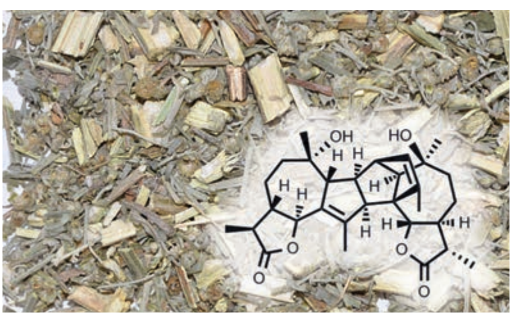
ORIGIN Europe and Western Asia.

BOTANY Perennial herb (to 1 m); leaves silvery, deeply dissected; flower heads small, pale yellow.

CHEMISTRY Sesquiterpene lactones: **absinthin** and artabsin. Essential oil: α-thujone, and/or β-thujone, and chrysanthenyl acetate.

PHARMACOLOGY Essential oil and bitter sesquiterpenoids: antimicrobial and aromatic bitter tonic.

TOXICOLOGY Thujone enhances the effects of alcohol but is toxic and hallucinogenic (at high doses or with chronic use). LD_{50} (α-thujone) = 87.5 mg/kg (mouse, s.c.). Sporadic use of small quantities as medicine (and as absinth liqueur) is probably safe.



Artemisia absinthium L. (Asteraceae); *grande absinthe, herbe d´absinthe* (French); *Wermut, Absinth* (German); *assenzio* (Italian); *ajenjo* (Spanish)

Artemisia afra

African wormwood

CLASSIFICATION TM: Africa; AHP.

USES & PROPERTIES The twigs and leaves, fresh or dried (*Artemisiae africanae herba*) are used by many cultural groups as an aromatic bitter tonic and general medicine for a very wide range of ailments, including respiratory tract infections (colds, sore throat, bronchitis), stomach ailments (indigestion, stomach pain, flatulence, intestinal worms). A wide range of dosage forms are traditionally used (infusions, decoctions, steam baths, poultices and nasal plugs (to treat a blocked nose).

ORIGIN Africa (southern and eastern parts).

BOTANY Perennial herb, woody at base; leaves dissected, silvery; flower heads small, pale yellow.

CHEMISTRY Essential oil: variable (**thujone**, 1,8-cineole, camphor, borneol); also sesquiterpene lactones, coumarins and polyacetylenes.

PHARMACOLOGY Analgesic, antihistamine and antimicrobial activity. An aromatic bitters (similar to *A. absinthium* and *A. vulgaris* (mugwort)).

TOXICOLOGY Thujone is toxic – excessive and chronic ingestion should be avoided.

Artemisia afra Jacq. ex Willd. (Asteraceae); *wildeals* (Afrikaans); *armoise d'Afrique* (French); *Afrikanischer Wermut* (German); *lengana* (Sotho); *umhlonyane* (Zulu)

Artemisia annua

Chinese wormwood • sweet wormwood

CLASSIFICATION TM: Asia (TCM). MM (artemisinin), clinical studies+.

USES & PROPERTIES Infusions and tinctures of the whole herb are used as tonic to treat fever, dyspepsia and a wide range of other ailments. It is highly effective against malaria (as treatment and prophylaxis) and has become an industrial source of raw material for the production of modern, cost-effective antimalarial drugs.

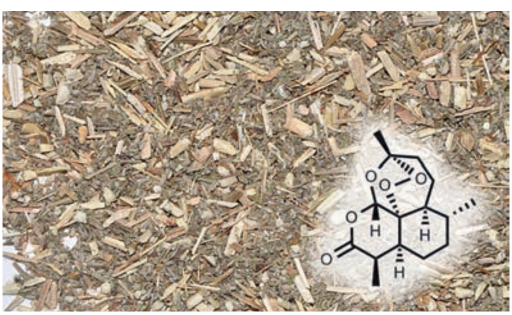
ORIGIN Eastern Europe and Asia; widely naturalised and cultivated on a commercial scale (in China, the Balkans, East Africa and India).

BOTANY Erect annual herb; leaves bright green, feathery; flower heads minute, cream-coloured.

CHEMISTRY The main compound of interest is **artemisinin**, a sesquiterpene lactone with an endoperoxide bridge. Artemether, a semisynthetic drug based on artemisinin, is used to treat malaria.

PHARMACOLOGY Artemisinin (and derivatives) have antimalarial activity and are highly effective.

TOXICOLOGY Clinical studies showed that artemisinin and derivatives are safe when correctly used.



Artemisia annua L. (Asteraceae); *qing hao* (Chinese); *absinthe chinoise* (French)*; Einjähriger Beifuß* (German)

Arum maculatum

lords and ladies

CLASSIFICATION Cell toxin (Ia). TM: Europe.

USES & PROPERTIES All parts of the plant are poisonous (but the rhizomes are edible when processed and cooked); the attractive bright red fruits are sometimes eaten by children and cause severe distress (burning of the mouth and throat, swollen tongue, salivation, vomiting, rare gastrointestinal disruptions, internal bleeding and convulsions).

ORIGIN Africa, Asia.

BOTANY Perennial herb with an underground rhizome; leaves arrow-shaped; flower with a greenish-white spathe; fruits bright orange-red.

CHEMISTRY Oxalate crystals, cyanogenic glucosides (triglochinin), lectins and saponins.

PHARMACOLOGY **Oxalic acid** and oxalate crystals (present as minute sharp needles) penetrate the skin and mucosal cells and allow other toxins (cyanogenic glucosides and lectins) to enter.

TOXICOLOGY The combined toxic effect is extremely hazardous but the initial burning sensation usually prevents the ingestion of large amounts.

NOTES Fatal poisoning is extremely rare.

Arum maculatum L. (Araceae); *gouet maculé*, *arum tacheté* (French); *Aronstab* (German); *aro gigaro* (Italian)

Ascophyllum nodosum

knotted wrack

CLASSIFICATION TM (DS): Europe.

USES & PROPERTIES The tallus of two brown algae (pharmaceutical name: *Fucus*) are widely used in dietary supplements, claimed to have value in weight loss and weight management: *A. nodosum* and *Fucus vesiculosus* (bladder wrack).

ORIGIN North Atlantic (Europe, N America).

BOTANY Brown algae; fronds long (to 2 m), somewhat compressed, olive-brown; air-bladders single, egg-shaped. *Fucus vesiculosus* (photo below) has almost spherical air-bladders borne in pairs.

CHEMISTRY Minerals (iodine, ca. 0.01%), **phlorotannins** (e.g. tetraphlorethol) and **polysaccharides**, e.g. fucoidan and algin (= alginate, alginic acid).

PHARMACOLOGY Traditionally used to treat goitre (swollen thyroid gland due to iodine deficiency). Increased thyroid hormones and thus metabolism claimed to remove fat deposits. Algin: additive in slimming aids (as appetite suppressant). Dietary alginates reduce fat uptake in humans.

TOXICOLOGY Iodine: daily dose above 0.15 mg may pose a risk of excessive thyroid stimulation.

Ascophyllum nodosum Le Jolis (Fucaceae); *knotswier* (Dutch); *ascophylle, goémon noir* (French); *Knotentang* (German)

Aspalathus linearis

rooibos tea

CLASSIFICATION TM (DS): Africa.

USES & PROPERTIES The tea, made from finely cut (and usually fermented/enzymatically oxidised) stems and leaves (*Aspalathi linearis herba*), is traditionally enjoyed as a general health tea and dietary supplement. Commonly used in cosmetic products.

ORIGIN Africa (Western Cape of South Africa).

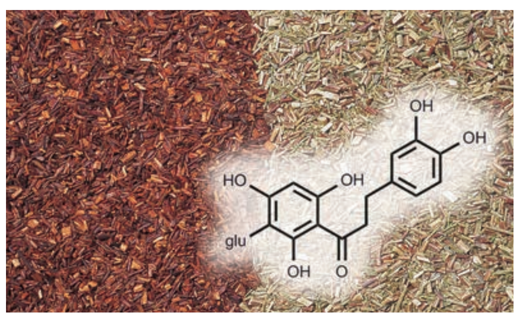
BOTANY An erect shrub (to 2 m); stems slender, reddish brown; leaves needle-shaped; flowers small, yellow; pods small, 1–2-seeded.

CHEMISTRY Flavonoid glycosides: **aspalathin** (the main compound, a dihydrochalcone). Higher levels are found in non-fermented (green) rooibos tea than in red rooibos (photo below). Devoid of caffeine and other potentially harmful stimulants.

PHARMACOLOGY Aspalathin: antioxidant, anti-ageing activity.

TOXICOLOGY Not toxic; long history of safe use as a herbal tea or black tea substitute, with no reported side effects.

NOTES The product is often included in herbal mixtures to improve the colour and taste.



Aspalathus linearis (Burm.f.) Dahlg. (Fabaceae); *rooibos* (Afrikaans); *aspalathus* (French); *Rotbusch, Rooibos* (German); *aspalathus* (Italian)

Asparagus officinalis

asparagus

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (rhizomes).

USES & PROPERTIES Dried rhizomes (*Asparagi radix*) are a traditional diuretic that has been used since ancient times to treat urinary tract infections and to prevent the formation of kidney stones. The stems are popular vegetables.

ORIGIN Europe, North Africa and Asia (cultivated as a food crop in many temperate regions).

BOTANY Perennial herb (to 1 m); stems green, stem tips needle-shaped; leaves absent; flowers minute.

CHEMISTRY Shoots contain high levels of the amino acid **asparagine**, together with several other amino acids. Also present are steroidal saponins (derivatives of sarsasaponin and diosgenin), flavonol glycosides and unusual sugars (fructans).

PHARMACOLOGY The diuretic activity and increased urine flow (confirmed in animal studies) is at least partly due to the presence of asparagin.

TOXICOLOGY The rhizomes are not poisonous.

NOTES A strong odour develops in the urine of some people after they have eaten asparagus.

Asparagus officinalis L. (Asparagaceae); *asperge* (French); *Spargel* (German); *asparago* (Italian); *esparrago* (Spanish)

Astragalus membranaceus

astragalus • membranous milk vetch

CLASSIFICATION TM: Asia (TCM). Pharm., WHO 1, PhEur8.

USES & PROPERTIES Dried roots (*Astragali radix*) are used in traditional and modern Chinese medicine as adaptogenic tonic and immune stimulant. It is widely used to reduce the duration and severity of the common cold and infections, as well as to treat general debility, slow healing wounds, diabetes and kidney ailments.

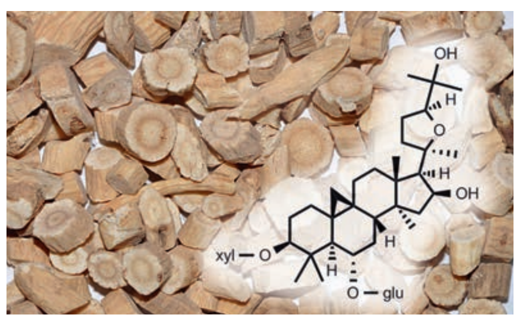
ORIGIN Asia (cultivated in China and Korea).

BOTANY Perennial herb (to 0.4 m); leaves pinnate; flowers yellow; pods papery, several-seeded.

CHEMISTRY Roots contain triterpenoid saponins: **astragaloside A** (and several structurally related compounds); also polysaccharides and isoflavones.

PHARMACOLOGY The reported immune stimulation and possible anticancer activity have not yet been linked to any specific compound(s); synergism between the diverse chemical constituents is possible. Animal studies have shown that the astragalosides are antimutagenic (no clinical data).

TOXICOLOGY Astragalus root is not toxic.



Astragalus membranaceus Bunge (Fabaceae); *huang qi, huang-chi* (Chinese); *astragale* (French); *Chinesischer Tragant* (German); *astragalo* (Italian); *astragálo* (Spanish)

Atropa belladonna

deadly nightshade • belladonna

CLASSIFICATION Neurotoxin, hallucinogen (Ia); TM: Europe. Comm.E+, PhEur8. MM: (atropine).

USES & PROPERTIES Leaves (*Belladonnae folium*) and roots (*Belladonnae radix*) are famous for their traditional uses in treating pain and asthma. The isolated alkaloids (up to 2.2 mg per day) have many uses in modern medicine, as tranquillisers, spasmolytics and eye drops (to dilate the pupil of the eye, e.g. for eye diagnosis). Belladonna is infamous for its aphrodisiac and hallucinogenic uses.

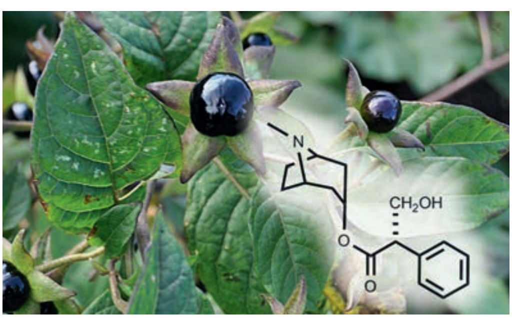
ORIGIN Europe, Asia and North Africa.

BOTANY Perennial herb; leaves simple, lanceolate; flowers brownish-pink; fruit a shiny black berry.

CHEMISTRY Tropane alkaloids (1% in leaves, 2% in roots): ***L*-hyoscyamine** is the main compound in fresh leaves. It forms a racemic mixture called atropine when the leaves are dried.

PHARMACOLOGY Hyoscyamine: depressant and sedative at low doses; analgesic, hallucinogenic and potentially fatal at high doses.

TOXICOLOGY Atropine: the lethal oral dose is 10 mg in adults.



Atropa belladonna L. (Solanaceae); *belladonne*, *morelle furieuse* (French); *Tollkirsche* (German); *belladonna* (Italian); *belladonna* (Spanish)

Avena sativa

oats

CLASSIFICATION TM (DS): Europe. Comm.E+ (oat straw only), HMPC.

USES & PROPERTIES Aerial parts, harvested just before full flowers, are known as "oats green tops" (*Avenae herba recens*) and are believed to have sedative effects. Oats straw (*Avenae stramentum*) is added to bath water to treat skin ailments. Ripe oats fruits (*Avenae fructus*) are considered beneficial as a dietary supplement for relief of digestive ailments and general weakness. Oat bran (100 g per day) is believed to lower cholesterol levels.

ORIGIN Mediterranean region (southern Europe and North Africa) to Ethiopia. A major crop.

BOTANY Annual grass (to 1 m); spikelets pendulous, with persistent glumes.

CHEMISTRY Soluble silica and minerals; amino acids; B-vitamins; polysaccharides; triterpene saponins; **gramine** (an indole alkaloid).

PHARMACOLOGY The therapeutic benefits of oats straw are associated with silica and minerals. Gramine may have a sedative effect.

TOXICOLOGY Oats products are not toxic.

Avena sativa L. (Poaceae); *avoine* (French); *Hafer* (German); *avena* (Italian); *avena* (Spanish)

Azadirachta indica

neem tree • neem • nim

CLASSIFICATION TM: Asia (Ayurveda). WHO 3. Natural insecticide.

USES & PROPERTIES The bark, leaves, twigs and seeds are all used. The leaves are famous for their insecticidal properties; watery extracts are used by farmers as a natural and cheap insecticide. The seed oil, and infusions and extracts of bark and leaves are traditionally used to treat wounds, skin infections, stomach ailments, haemorrhoids, malaria and intestinal parasites. An ingredient of commercial skin care products (soaps, lotions).

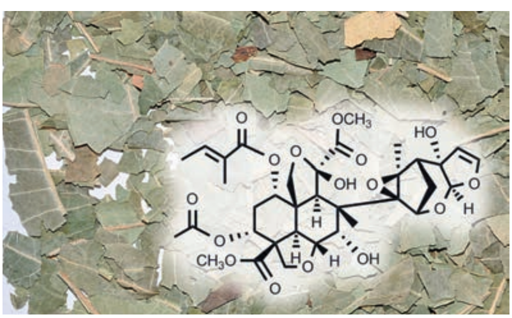
ORIGIN South Asia (India, Sri Lanka and Burma); cultivated in Asia, Africa and Latin America.

BOTANY Evergreen tree (10 m or more); leaves compound, the leaflets asymmetrical, margins serrate; flowers small, white; fruit fleshy, 1-seeded.

CHEMISTRY Tetranortriterpenoids (limonoids) with **azadirachtin** as one of the main compounds.

PHARMACOLOGY Azadirachtin is an insect antifeedant, disrupting the metabolism of moth larvae.

TOXICOLOGY Seed oil: LD_{50} = 14 ml/kg (rat, p.o.); known to be toxic if taken internally.



Azadirachta indica A. Juss. (Meliaceae); *margousier, neem* (French); *Nimbaum, Neembaum* (German); *nem* (Italian); *margosa* (Spanish)

Bacopa monnierii

brahmi • water hyssop

CLASSIFICATION TM: Asia (Ayurveda).

USES & PROPERTIES The herb or extracts are traditionally used as a nerve tonic and to improve learning. Daily dose: 300 mg of extract.

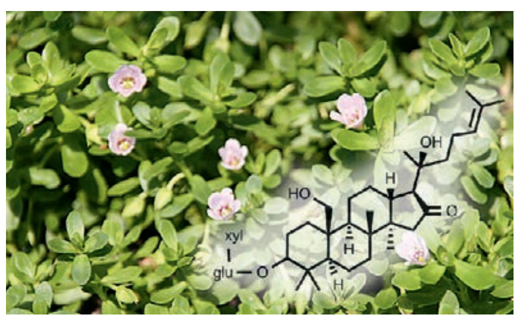
ORIGIN Asia (India); widely naturalised and cultivated (marshy areas), e.g. USA (Florida, Hawaii).

BOTANY Creeping perennial herb; leaves small, succulent; flowers white or pink. The name brahmi is also used for *gotu kola* (*Centella asiatica*): apparently a mistake dating from the 16th century.

CHEMISTRY Complex mixtures of triterpenoid saponins (called bacosides and bacopasides, e.g. **bacoside B**). Bacoside A is often studied (it is actually a mixture of several saponins, with bacoside A3 as one of the main constituents).

PHARMACOLOGY The saponins are believed to enhance cognitive function and have neuroprotective activity. They inhibit acetylcholinesterase and increase cerebral blood flow.

TOXICOLOGY Hardly any side effects (rarely nausea, diarrhoea and upset stomach). Not toxic: LD_{50} = 2400 mg/kg (rat, p.o., single dose).



Bacopa monnieri (L.) Wettst. (Plantaginaceae); *jia ma chi xian* (Chinese); *bacopa de Monnier* (French); *brahmi* (Hindi); *Bacopa, Kleines Fettblatt, Wasser-Ysop* (German)

Ballota nigra

black horehound

CLASSIFICATION TM: Europe. Pharm., PhEur8, ESCOP Suppl.

USES & PROPERTIES The flowering tops (*Ballotae nigrae herba*) are traditionally used (in doses of 2–3 g, taken three times a day) for symptomatic relief of cough and nervous conditions (minor sleeplessness, stomach spasms, nausea, dyspepsia). Also liquid extracts and tinctures.

ORIGIN Europe and Asia. It has become naturalised in North America. Commercial material is mostly wild-harvested.

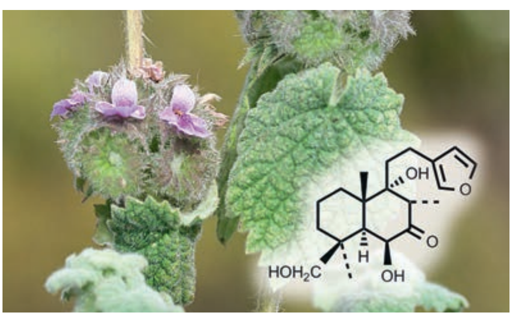
BOTANY Erect perennial herb; leaves opposite, aromatic (with an offensive smell); flowers small, purple, in clusters.

CHEMISTRY Diterpenes (labdane type): **ballotenol** (the main compound) and several others.

PHARMACOLOGY Considered to be a mild sedative and anti-emetic (experimental data is lacking).

TOXICOLOGY No side effects are known.

NOTES White horehound (*Marrubium vulgare*) and African horehound (*Ballota africana*, photo below) have similar diterpenes (and medicinal uses).



Ballota nigra L. [= *B. foetida* Hayek] (Lamiaceae); *ballote* (French); *Schwarznessel, Schwarzer Andorn* (German); *ballota nera* (Italian); *balota* (Spanish)

Banisteriopsis caapi

ayahuasca

CLASSIFICATION Hallucinogen (II). TM: South America.

USES & PROPERTIES Infusions of the bark are traditionally used as a cure-all but mainly as a ritual intoxicant and hallucinogen. Names include *caapi* (Brazil), *ayahuasca* (Peru) and *yagé* (Colombia). It may be mixed with other plants (often *Psychotria viridis*) and is sometimes smoked.

ORIGIN Tropical South America (Brazil, Colombia, Ecuador and Peru). Cultivated in Hawaii.

BOTANY Large woody climber (vine); leaves simple, opposite; flowers pink.

CHEMISTRY β-Carboline alkaloids: **harmine** (the main compound, up to 2% in bark) with harmaline and others (fluorescent in ultraviolet light).

PHARMACOLOGY Harmine and related alkaloids are powerful hallucinogens; they activate serotonin receptors and inhibit monoamine oxidase (but also affect dopamine, GABA and other receptors).

TOXICOLOGY Side effects include nausea and vomiting. Overdosing can be fatal. LD_{50} of harmine = 38 mg/kg (mouse, i.v.).

Banisteriopsis caapi (Spruce ex Griseb.) Morton (Malpighiaceae); *ayahuasca* (French); *Ayahuasca* (German); *ayahuasca* (Spanish)

Berberis vulgaris

common barberry • European barberry

CLASSIFICATION TM: Europe. Comm. E+, WHO 4. MM: berberine (clinical studies+).

USES & PROPERTIES Fresh or dried fruits (*Berberidis fructus*), stem bark (*Berberidis cortex*), roots (*Berberidis radix*) or root bark (*Berberidis radici cortex*) are traditionally used as digestive bitter tonics, antibiotics and liver stimulants. An infusion of 2 g bark or root is taken once or twice a day to treat digestive, liver, kidney, bladder and gall bladder ailments. Pure alkaloid was once included in eye drops, used to treat conjunctivitis.

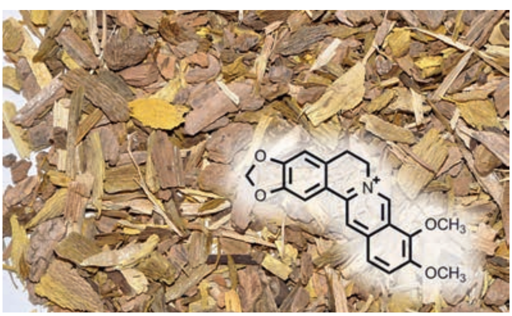
ORIGIN Europe and Asia. Commonly cultivated.

BOTANY Woody and spiny shrub (to 3 m); leaves in clusters; flowers yellow; fruit small, red, fleshy.

CHEMISTRY Isoquinoline and protoberberine alkaloids (up to 13%): **berberine** (the main compound, a bright yellow substance) and others.

PHARMACOLOGY Berberine has hypotensive, cholekinetic and antimicrobial activity. It activates smooth muscles.

TOXICOLOGY Berberine is toxic to humans if the dose exceeds 0.5 g; LD_{50} = 0.5 g/kg (mouse, p.o.).



Berberis vulgaris L. (Berberidaceae); *épine-vinette, berbéris commun* (French); *Gewöhnliche Berberitze, Sauerdorn* (German); *crespino* (Italian); *bérbero, agracejo* (Spanish)

Betula pendula

birch • silver birch

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 1, PhEur8, HMPC.

USES & PROPERTIES Leaves (*Betulae folium*), bark (*Betulae cortex*), leaf buds (*Betulae gemmae*) and tar oil from the bark (*Betulae pix*) are used in traditional medicine. The leaf is used as diuretic to treat inflammation of the urinary tract, to prevent kidney and bladder stones and to alleviate the symptoms of rheumatism, gout and oedema. The tar oil is applied to itchy skin associated with eczema and psoriasis.

ORIGIN Europe and Asia (popular garden trees).

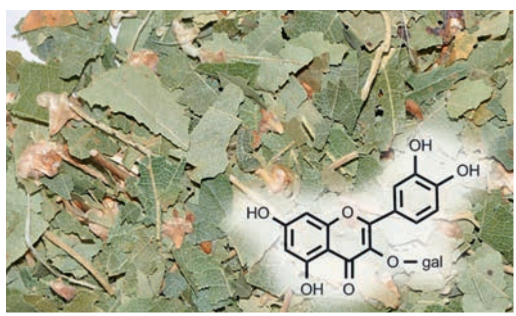
BOTANY Tree (to 30 m); bark white, papery; leaves toothed; flowers in slender pendulous catkins.

CHEMISTRY Flavonoid glucosides are present: mainly **hyperoside** and quercetrin. The tar is rich in phenolic compounds.

PHARMACOLOGY Diuretic activity of the flavonoids has been confirmed in animal studies.

TOXICOLOGY No serious adverse side effects.

NOTES *Betula* species have numerous other practical uses in most parts of the northern hemisphere.



Betula pendula Roth (Betulaceae); *bouleau blanc* (French); *Hängebirke* (German); *betulla bianca* (Italian); *abedul* (Spanish)

Blighia sapida

akee • ackee

CLASSIFICATION Cell toxin (Ib).

USES & PROPERTIES The ripe seed arils, parboiled in salt water and fried in oil, are a popular food item in West Africa and the West Indies (used in Jamaican akee and saltfish). Canned arils are exported from Jamaica (formerly banned in the USA).

ORIGIN West Africa; introduced into the West Indies and Central America during the slave trade.

BOTANY Evergreen tree (to 12 m); leaves compound; flowers small, white; fruit a pear-shaped capsule; seeds black, surrounded by a fleshy, cream-coloured aril. The genus is named after Captain Bligh, who brought specimens to Kew.

CHEMISTRY Unripe arils contain toxic non-protein amino acids (hypoglycins). **Hypoglycin A** (= hypoglycin) is more toxic than hypoglycin B.

PHARMACOLOGY Hypoglycin mimics glutamic acid (reactive cyclopropane moiety) and causes metabolic disturbances that lead to neurotoxic effects.

TOXICOLOGY Arils of unripe or over-ripe fruits and the raphe of ripe fruits cause potentially deadly akee poisoning (especially in children).

Blighia sapida Koenig (Sapindaceae); *akée d'Afrique*, *arbre fricassé* (French); *Akeepflaume* (German); *arbol de seso*, *seso vegetal* (Spanish)

Boophone disticha

bushman poison bulb

CLASSIFICATION Neurotoxin, hallucinogenic (Ib).TM: Africa.

USES & PROPERTIES The bulb scales are applied topically in African traditional medicine to treat painful wounds and decoctions are ingested as hallucinogens in trance (healing) dances and traditional psychotherapy. It is a well-known arrow poison and the bulb scales have been used in southern Africa to mummify bodies.

ORIGIN Africa (southern and eastern parts).

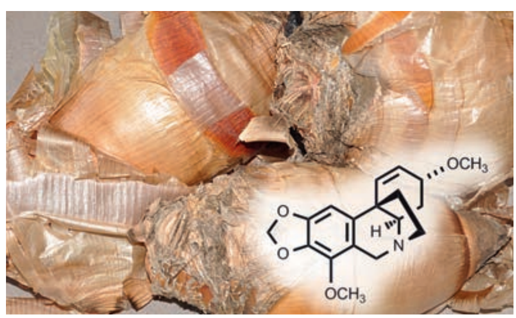
BOTANY Large bulb with papery scales; leaves strap-shaped, fan-like; flowers red or pink.

CHEMISTRY Isoquinoline alkaloids (0.3%): **buphanidrin** (the main compound) and several others.

PHARMACOLOGY Buphanidrin is a powerful analgesic, hallucinogen and neurotoxin.

TOXICOLOGY Lethal dose of buphanidrin: < 10 mg / kg (mouse, s.c.). Symptoms of human poisoning include dizziness, impaired vision, unsteady gait, visual hallucinations, coma and death.

NOTES Fatal cases of poisoning (due to overdose, murder or suicide) have been reported.



Boophone disticha (L.f.) Herb. [=*Boophane disticha*] (Amaryllidaceae or Asparagaceae); *Fächerlilie* (German)

Borago officinalis

borage

CLASSIFICATION Cell toxin and neurotoxin (II). TM: Europe. Pharm., PhEur8. DS: seed oil.

USES & PROPERTIES Flowers (*Boraginis flos*) or flowering tops (*Boraginis herba)* are traditionally used as anti-inflammatory, antidepressant, diaphoretic, diuretic, emulcent, expectorant and mild sedative. The seed oil ("starflower oil") has become popular as a dietary supplement and for treating the symptoms of eczema and psoriasis.

ORIGIN Mediterranean region. Cultivated herb.

BOTANY Bristly annual herb (0.5 m); flowers usually bright blue; seeds urn-shaped, ribbed, black.

CHEMISTRY Polysaccharides (mucilages, 11%); traces of unsaturated pyrrolizidine alkaloids (e.g. amabiline); the seed oil is rich in **gamma-linoleic acid** (GLA), up to 21% (apparently alkaloid-free).

PHARMACOLOGY GLA improves stress reaction and cardiovascular performance. Mucilage has demulcent effects. The alkaloids are mutagenic.

TOXICOLOGY Pyrrolizidine alkaloids are cumulative liver poisons; flower and herb infusions are no longer considered safe to ingest.

Borago officinalis L. (Boraginaceae); *bourrache* (French); *Borretsch* (German); *boragine* (Italian); *borraja* (Spanish)

Boswellia sacra

frankincense tree

CLASSIFICATION TM: Africa, Asia. AHP.

USES & PROPERTIES Resin (*Olibanum,* frankincense), used since ancient times for religious and medicinal purposes, as analgesic, antiseptic, expectorant and sedative. The aromatic resin is applied for relief of rheumatism or rarely ingested for respiratory and urinary infections. Essential oil distilled from the resin is used in aromatherapy for relief of anxiety and tension.

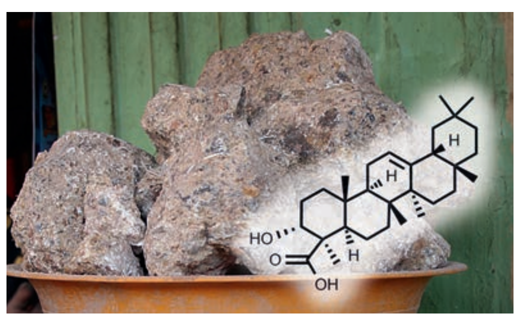
ORIGIN Northeastern Africa and southern Arabia.

BOTANY Small trees with thick trunks; bark papery; leaves compound; flowers small, yellow.

CHEMISTRY Resin contains solids (ca. 60%) with pentacyclic triterpenoids (e.g. **α-boswellic acid** and acetates), mucilages and essential oil (5–9%, with α-pinene, phellandrene and 1-octylacetate).

PHARMACOLOGY Boswellic acid exhibits anti-inflammatory effects (probably through inhibition of 5-lipoxygenase). Essential oil compounds are inhaled and the resin applied topically for their decongestant and antibiotic activity.

TOXICOLOGY Safely used in small amounts.



Boswellia sacra Flueckiger [= *B. carteri* Birdw.] (Burseraceae); *arbre-à-encens* (French); *Weihrauchbaum* (German); *incenso* (Italian); *incienso* (Spanish)

Brugmansia suaveolens

angel's trumpet

CLASSIFICATION Neurotoxin, hallucinogen, extremely hazardous (Ia). TM: South America.

USES & PROPERTIES Leaves, in the form of ointments applied to the skin, have been used as a traditional narcotic and hallucinogen by shamans.

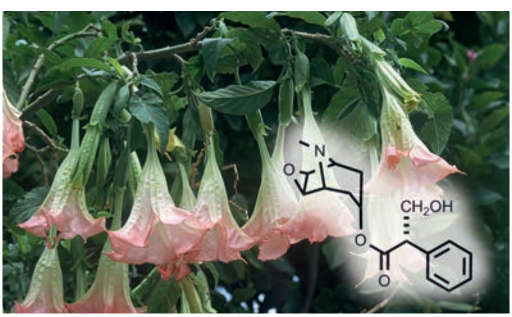
ORIGIN Central and South America. A specific selection/cultigen called *Methysticodendron* has been grown by shamans using vegetative propagation to maintain the desired properties.

BOTANY Shrub or small tree; leaves large, velvety; flowers enormous, pendulous, attractive, fragrant.

CHEMISTRY Tropane alkaloids (to 0.3% in leaves): **scopolamine** (hyoscine), hyoscyamine, norhyoscine and tigliate esters of tropine.

PHARMACOLOGY The tropane alkaloids are mACh-R antagonists which work as parasympatholytics and cause euphoria and hallucinations (e.g. the feeling of being able to fly that may last for several hours). High doses lead to death by respiratory arrest. Mydriatic effects last up to six days.

TOXICOLOGY Cases of severe poisoning are quite common (see *Datura stramonium*).



Brugmansia suaveolens (Willd.) Bercht. & C.Presl (Solanaceae); *stramoine odorante*, *Brugmansia* (French); *Engelstrompete* (German)

Bulbine frutescens

bulbine • burn jelly plant

CLASSIFICATION TM: Africa. AHP.

USES & PROPERTIES The colourless and slimy leaf parenchyma is traditionally applied to treat minor cuts, burns; wounds and itching (e.g. mosquito bites). The gel has been used as a famine food and has become popular as an ingredient of cosmetic and skin care products (comparable to *Aloe vera* gel).

ORIGIN Africa (South Africa); a popular garden succulent; grown on a small commercial scale.

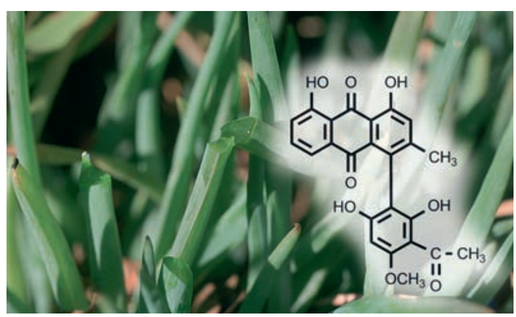
BOTANY Perennial herb (ca. 0.2 m); leaves cylindrical, succulent; flowers small, yellow or orange; stamens hairy; fruit a small capsule.

CHEMISTRY The leaf contains polysaccharides and mucilages of as yet unknown composition. The roots contain anthraquinones (including chrysophanol and **knipholone**).

PHARMACOLOGY The soothing and anti-itching effects are ascribed to the demulcent and anti-inflammatory activities of the leaf gel.

TOXICOLOGY The gel is not toxic (edible).

NOTES Roots or stems of several *Bulbine* spp. are used in African traditional medicine.



Bulbine frutescens Willd. [Xanthorrhoeaceae (formerly Asphodelaceae)]; *rankkopieva* (Afrikaans); *bulbine* (French); *Bulbine* (German)

Cajanus cajan

pigeon pea • pigeonpea

CLASSIFICATION TM: Africa, Asia. AHP.

USES & PROPERTIES Seeds are used in preparations to treat sickle cell anaemia. The roots, leaves, flowers and seeds have numerous medicinal uses. Infusions of the leaves: anaemia, diabetes, hepatitis, urinary infections and yellow fever. Flower infusions: dysentery, menstrual disorders. Immature fruits: kidney and liver ailments; fresh seeds are also used against urinary incontinence.

ORIGIN Asia (probably India), but spread to Africa and the rest of Asia centuries ago.

BOTANY Shrub (to 4 m); leaves trifoliolate; flowers yellow or multi-coloured; pods 2–9-seeded.

CHEMISTRY Free amino acids in seeds: **phenylalanine** (5 mg/g); also hydroxybenzoic acid (21 mg/g). Leaves: prenylated stilbenes (longistylin A and C), flavonoids and triterpenoids.

PHARMACOLOGY Activity against sickling (proven clinically) is ascribed to phenylalanine and hydroxybenzoic acid. Longistylin A is cytoxic.

TOXICOLOGY Seeds are edible (but contain trypsin and chymotrypsin inhibitors).

Cajanus cajan (L.) Millsp. (Fabaceae) *mu do* (Chinese); *pois cajun* (French); *arhar*, *tuur* (Hindi); *Straucherbse* (German); *caiano* (Italian); *gandul* (Spanish)

Calendula officinalis

marigold • pot marigold

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 1, WHO 2, HMPC.

USES & PROPERTIES Flower heads are used (*Calendulae flos, Calendulae flos sine calyce*), mainly for local applications to treat slow healing wounds, burns, eczema, dry skin, oral thrush and haemorrhoids. Preparations for external application contain 2–5 g of crude herb per 100 g. Infusions of 1–2 g of herb are taken 2–3 times per day for inflammation of the mouth and throat, indigestion (stimulation of bile production), gastric ulcers and menstrual disorders.

ORIGIN Europe (widely cultivated).

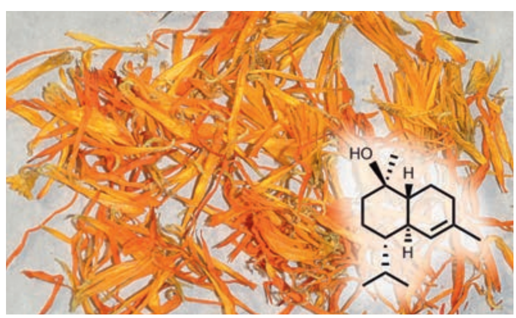
BOTANY Annual herb; leaves glandular, aromatic; flower heads large, shades of yellow and orange.

CHEMISTRY Flavonoids (to 0.8%, e.g. isorhamnetin 3-*O*-glucoside); saponins (to 10%); triterpenes; essential oil (**α-cadinol**, α-ionone, β-ionone).

PHARMACOLOGY Anti-inflammatory and antispasmodic effects have been demonstrated.

TOXICOLOGY Edible (but use sparingly).

NOTES Flowers add colour to herbal teas.



Calendula officinalis L. (Asteraceae); *souci des jardins* (French); *Ringelblume* (German); *calendola* (Italian); *caléndula* (Spanish)

Callilepis laureola

ox-eye daisy

CLASSIFICATION Cell toxin, highly hazardous (Ib). TM: Africa.

USES & PROPERTIES Weak infusions of the tuberous roots are used in traditional medicine to treat a wide range of ailments, including cough in adults. It is always expelled immediately after being drunk and is never taken as a enema. The Zulu name *impila* means "health". Traditionally, only weak infusions are used, and for adults only. However, fatal cases of poisoning regularly occur as a result of overdose and inappropriate use (e.g. when used to treat infants and young children).

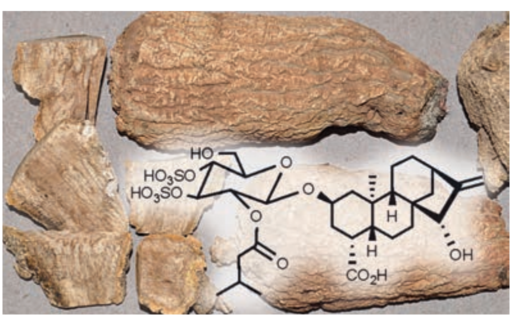
ORIGIN Africa (eastern parts of South Africa).

BOTANY Perennial herb (to 0.5 m); leaves sparsely hairy; flower heads large with white ray florets.

CHEMISTRY The toxic compound is **atractyloside** (a kaurene glycoside).

PHARMACOLOGY Atractyloside inhibits ATP/ADP transport at the mitochondrial membrane, disrupting the energy supply within cells.

TOXICOLOGY A common cause of human fatalities. Atractyloside: LD_{50} = 431 mg/kg (rat, i.m.).



Callilepis laureola DC. (Asteraceae); *impila* (French); *Impila* (German); *impila, ihlmvu* (Zulu)

Camellia sinensis

tea • chai

CLASSIFICATION TM: Asia, East (China), Europe. Pharm., HMPC. DS: especially green tea.

USES & PROPERTIES Infusions of young leaves (*Theae folium*), usually accompanied by the unopened apical bud (*pekoe*) are used as a refreshing and stimulating beverage. Tea is used topically for weight loss and to treat skin ailments. Green tea (unfermented; heat-treated and rapidly dried) has become popular: antioxidant and diuretic, thought to be antimutagenic and anticarcinogenic.

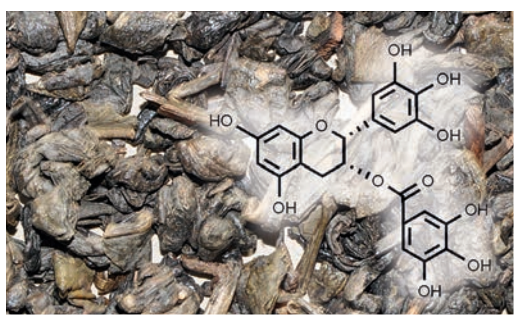
ORIGIN Southern and eastern Asia. Cultivated in China since ancient times and later spread to India, Sri Lanka, Malaysia, Indonesia and Africa.

BOTANY Large shrub (pruned to 1.5 m for ease of harvesting); leaves glossy; flowers white.

CHEMISTRY Caffeine, phenolic acids and tannins.

PHARMACOLOGY Caffeine is a stimulant (it affects adenosine receptors). **Epigallocatechin gallate** is the most important catechin: antidiarrhoeal, antioxidant, diuretic and possible antimutagenic and anticholesterol activities).

TOXICOLOGY Safe, even in large amounts.



Camellia sinensis (L.) O.Kuntze (Theaceae); *chai* (Chinese); *théier* (French); *Teestrauch* (German); *tè* (Italian); *té* (Spanish)

Camptotheca acuminata

camptotheca • cancer tree

CLASSIFICATION Cell toxin, highly hazardous (Ib). TM: Asia (China). MM: clinical studies+.

USES & PROPERTIES The tree is used in traditional medicine in China to treat colds and psoriasis, as well as ailments of the stomach, spleen, liver and gall bladder. In modern medicine, pure alkaloid is administered by intravenous drip in cancer therapy (colorectal, ovarian and pancreatic cancers).

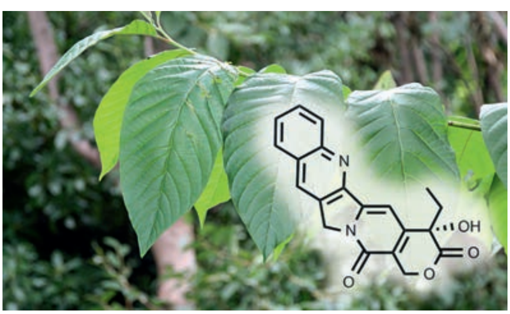
ORIGIN East Asia (China); cultivated as ornamental tree and as crop in India, Japan and the USA.

BOTANY Large tree (to 25 m); leaves large; flowers small, white, in rounded heads.

CHEMISTRY Pentacyclic quinoline alkaloids: **camptothecin** as main compound.

PHARMACOLOGY Camptothecin: cytostatic and antitumour activity (interrupts replication and transcription of nuclear DNA). Severe side effects (diarrhoea, haemorrhagic cystitis), so that several semisynthetic (and more soluble) analogues have been developed, e.g. topotecan, irinotecan.

TOXICOLOGY Camptothecin: LD_{50} = 50.1 mg/kg (mouse, p.o.).



Camptotheca acuminata Decne [Cornaceae (formerly Nyssaceae)]; *xi shu* (Chinese); *camptotheca* (French); *Glücksbaum* (German); *camptotheca* (Italian)

Canella winterana

winter bark

CLASSIFICATION TM: Central America.

USES & PROPERTIES The bark (called cinnamon bark, wild cinnamon or white cinnamon) is a traditional spice, aromatic tonic and antiseptic. It has been used to treat colds and poor circulation. It has been used as an insecticide.

ORIGIN Central America (Florida to Bahamas). Small-scale production continues.

BOTANY Evergreen shrub or tree (to 10 m); leaves bright green; flowers small; fruit fleshy, red.

CHEMISTRY The bark contains numerous drimane-type sesquiterpenes (**muzigadial** is one of the main compounds) and essential oil with pinene, eugenol and other monoterpenoids.

PHARMACOLOGY The sesquiterpenes have a peppery taste; they are dialdehydes which can bind to proteins, thus explaining the antiseptic and tonic effects. Muzigadial has antifeedant activity against the African army worm and also shows potent molluscicidal effects.

TOXICOLOGY The sesquiterpenoids are cytotoxic but more poisonous to insects than mammals.

Canella winterana L. (Canellaceae); *cannelle blanche* (French); *Weißer Zimtrindenbaum* (German); *curbana, macambo* (Spanish)

Cannabis sativa

marijuana • Indian hemp

CLASSIFICATION Mind-altering (III); TM: Asia (China, India).

USES & PROPERTIES Female flowers with leaves (*Cannabis indicae herba*) are known as marijuana and the resin of female flowers as hashish (both are smoked as popular recreational drugs). Seeds (*huo ma ren* in TCM) are a mild laxative. In recent years, the herb is used medicinally to treat the nausea of chemotherapy, the depression and lack of appetite of AIDS patients and glaucoma (to lower intra-ocular pressure).

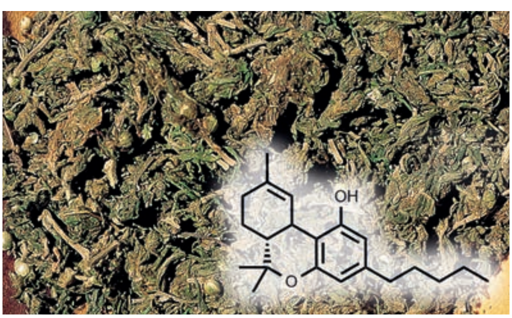
ORIGIN Asia; cultivated in temperate regions, as oil and fibre crop or (often illegal) intoxicant.

BOTANY Erect annual (to 4 m); leaves palmate; flowers small, female and male on separate plants.

CHEMISTRY Phenolic terpenoids (cannabinoids): mainly **Δ^9-tetrahydrocannabinol** (THC).

PHARMACOLOGY THC: psychotropic (euphoria, relaxation, slurred speech); also analgesic, antiemetic, bronchodilatory, spasmolytic, hypotensive.

TOXICOLOGY THC: LD_{50} = 43 mg/kg (mouse, i.v). Cannabis possession is illegal in most countries.



Cannabis sativa L. (Cannabaceae); *chanvre* (French); *Hanf* (German); *canapa indiana* (Italian); *cánamo* (Spanish)

Capsella bursa-pastoris

shepherd's purse • capsella

CLASSIFICATION TM: Europe. Comm.E+, HMPC.

USES & PROPERTIES The whole herb (*Bursae pastoris herba*) is traditionally used as tea (3–5 g, 10–15 g per day) to stop bleeding and to treat heavy periods (menorrhagia), diarrhoea and cystitis. It is applied to bleeding wounds or instilled in the nose to stop nosebleeds. In China the herb is used against eye diseases and dysentery. Commercial products (tinctures, tablets) are available.

ORIGIN Europe; now a cosmopolitan weed.

BOTANY Small annual or biennial herb (to 0.4 m); leaves in a rosette; flowers small, white; fruits shaped like a traditional shepherd's purse.

CHEMISTRY Diverse: amino acids, amines, flavonoids, monoterpenoids, glucosinolates, saponins.

PHARMACOLOGY The antihaemorrhagic activity is ascribed to a **peptide**; many other activities (but not linked to any single compound): anti-inflammatory, anti-ulcer, diuretic, urinary antiseptic and hypotensive effects.

TOXICOLOGY Avoid large doses.

Capsella bursa-pastoris L. (Brassicaceae); *bourse-à-pasteur* (French); *Hirtentäschel* (German); *borsa del pastore* (Italian); *bolsa de pastor* (Spanish)

Capsicum frutescens

chilli pepper • Tabasco pepper

CLASSIFICATION TM: South America, Europe. Pharm., Comm.E+ (external, capsaicin-rich species), ESCOP Suppl., HMPC, clinical studies+.

USES & PROPERTIES The whole dried fruit with seeds (*Capsici fructus acer*) and fruits of *C. anuum* (*Capsici fructus*) are used topically (in skin creams) for pain relief. Conditions treated include arthritis, rheumatism, neuralgia, lumbago, itching and spasms. It is taken against colic, dyspepsia and flatulence, or gargled to treat a sore throat.

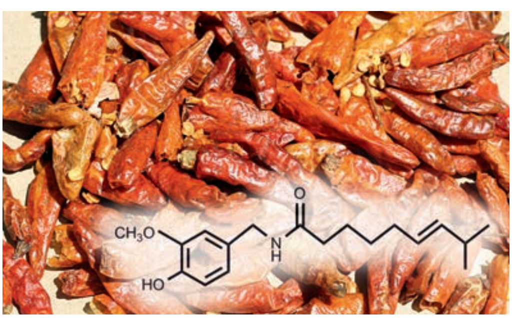
ORIGIN Tropical America; a popular spice crop.

BOTANY Perennial herb (to 0.7 m); leaves glabrous; flowers white; fruit a berry, carried upright (drooping in *C. annuum*, an annual).

CHEMISTRY Pungent capsaicinoids: mainly **capsaicin**. The red pigments are carotenoids.

PHARMACOLOGY Capsaicin is a topical analgesic, carminative and counter-irritant. It causes a warm and painful sensation, followed by a long-lasting reversible desensitisation of nerve ends.

TOXICOLOGY Excessive use can be painful and may be dangerous (even lethal, in infants).



Capsicum frutescens L. (Solanaceae); *piment* (French); *Tabasco, Chili* (German); *peperoncino arbustivo* (Italian)

Carica papaya

papaya tree • paw paw

CLASSIFICATION TM: Central and South America. MM: papain (proteolytic enzyme).

USES & PROPERTIES The unripe fruits are a source of latex (papaya-latex, *papayotin*, *Caricae papayae succus*), from which papain is extracted. The crude or purified enzyme is included in digestive preparations and has been used (in doses of 1500 mg papain per day) to treat post-traumatic and post-operative swellings and oedemas. It is also used in wound treatment and injected to treat damaged intervertebral cartilage.

ORIGIN Central and South America. It is widely cultivated in the tropics.

BOTANY Small tree; leaves large, deeply lobed; flowers white; fruit a large, many-seeded berry.

CHEMISTRY Proteolytic enzymes (mainly **papain**) are extracted from the crude latex of unripe fruits.

PHARMACOLOGY Papain: digestive, wound-healing and anti-oedema activities have been demonstrated; it is a putative anthelmintic.

TOXICOLOGY The enzyme is not toxic but is best used in standardised preparations.

Carica papaya L. (Caricaceae); *papayer* (French); *Papaya, Melonenbaum* (German); *papaia* (Italian); *higo de mastuero* (Spanish)

Carthamus tinctorius

safflower • saffron thistle

CLASSIFICATION TM: Africa, Asia (China). Pharm., WHO 3, PhEur8. DS: seed oil.

USES & PROPERTIES The flowers (*Carthami flos*), seeds and seed oil (*Carthami oleum*) are used as emmenagogue and anti-inflammatory medicine. The seeds are used in Chinese traditional medicine for gynaecological ailments.

ORIGIN North Africa and the Middle East; a commercial crop.

BOTANY Annual herb (to 1 m); leaves with spiny margins; flower heads thistle-like, yellow/orange; fruit small, white, one-seeded achenes (nutlets).

CHEMISTRY Glucosylated dichalcones (the yellow pigments in the flowers): carthamine and others. Also present are polysaccharides, flavonoids and α-tocopherol. The seed oil is rich in **linoleic acid**.

PHARMACOLOGY The oil and flowers both lower cholesterol. Carthamine is an emmenagogue and has anti-inflammatory activity. The polysaccharides are claimed to be immune-stimulating.

TOXICOLOGY Safflower and safflower oil are edible and both are used in the food industry.

Carthamus tinctorius L. (Asteraceae); *hong hua* (Chinese); *carthame* (French); *Färberdistel, Saflor* (German); *cartamo* (Italian); *cártamo* (Spanish)

Carum carvi

caraway

CLASSIFICATION TM: Africa, Asia, Europe. Comm.E+, ESCOP, PhEur8.

USES & PROPERTIES The ripe fruits (*Carvi fructus*) are used, or the volatile oil (*Carvi aetheroleum*) extracted from them. Caraway has a great reputation as carminative for treating dyspepsia and especially flatulence, and to prevent griping. It is also used in cough medicines and as a general tonic, appetite stimulant and breath deodorant.

ORIGIN Europe and Asia. Cultivated in herb gardens and commercially as a spice plant.

BOTANY Biennial herb; leaves compound, finely dissected; flowers small, white, in terminal umbels; fruit a schizocarp, separating into two mericarps.

CHEMISTRY Essential oil (2–7% in fruit): **(+)-carvone** (45–65%), with limonene, carveol and others. Also present are phenylpropanoids, flavonoids, flavonol glycosides and polysaccharides,

PHARMACOLOGY The fruit and the essential oil have spasmolytic and antimicrobial activity; the oil has carminative and stomachic effects.

TOXICOLOGY Caraway is a culinary spice.

Carum carvi L. (Apiaceae); *carvi* (French); *Kümmel* (German); *carvi, cumino tedesco* (Italian); *alcaravea* (Spanish)

Catha edulis

khat tree

CLASSIFICATION Mind-altering, stimulant (II–III). TM: Africa.

USES & PROPERTIES Fresh leaves are chewed for their stimulant effect. Khat-chewing is particular popular (and socially acceptable) in Ethiopia, Somalia and southern Arabia (Yemen). The leaves are used in traditional African medicine to treat asthma, cough, fever and malaria.

ORIGIN Africa (South Africa to Ethiopia); grown in plantations in East Africa and Yemen.

BOTANY Evergreen tree (to 15 m); leaves glossy, toothed; flowers small, white; fruit a small capsule.

CHEMISTRY Phenylethylamines: **cathinone** (the main compound). It is structurally closely related to amphetamine, a well-known recreational drug.

PHARMACOLOGY Cathinone is a stimulant, appetite suppressant (anorectic) and local anaesthetic. Activity lasts for 2–4 h after ingestion.

TOXICOLOGY Khat is not toxic but habitual use may lead to undesirable side effects. There are legal restrictions in many countries. Cathinone: LD_{50} = 263 mg/kg (mouse, i.p.).

Catha edulis (Vahl) Endl. (Celastraceae); *qat* (French); *Kathstrauch, Abyssinischer Tee* (German); *catha* (Italian)

Catharanthus roseus

Madagascar periwinkle

CLASSIFICATION Cell toxin (Ia). TM: Africa. MM: isolated alkaloids (clinical studies+).

USES & PROPERTIES Weak infusions of the leaves but mainly the roots are used in traditional medicine to treat diabetes and rheumatism. Several pure alkaloids, extracted from aerial parts, are used in modern medicine (administered intravenously) to treat various types of cancer.

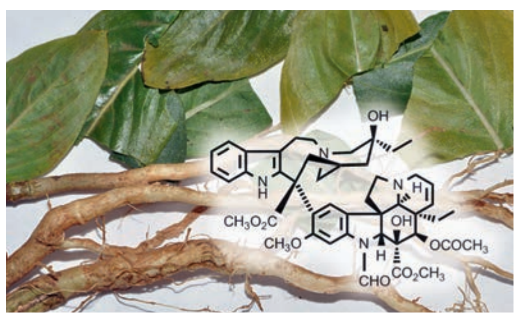
ORIGIN Africa (Madagascar). The plant is a popular garden subject and is grown commercially.

BOTANY Perennial herb (to 0.6 m); leaves glossy; flowers various shades of pink/purple or white.

CHEMISTRY Monoterpene indole alkaloids: two dimeric alkaloids, **vincristine** and vinblastine (or derivatives) are used in cancer therapy.

PHARMACOLOGY Vincristine and vinblastine are powerful spindle poisons that stop cell division. Other alkaloids (e.g. catharanthine and vindoline) have hypoglycaemic activity.

TOXICOLOGY The alkaloids are extremely poisonous (do not attempt self-medication!). Vincristine: LD_{50} = 2 mg/kg (mouse, i.v.).



Catharanthus roseus (L.) G. Don [= *Vinca rosea* L.] (Apocynaceae); *pervenche de Madagascar* (French); *Madagaskar-Immergrün* (German); *vinca* (Italian)

Centaurea benedicta

holy thistle • blessed thistle

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES The whole herb (*Cnici benedicti herba*) is used in European traditional medicine as a bitter tonic (*amarum*) to stimulate appetite and to treat dyspepsia. A dose of 2–3 g is taken as a tea twice a day, one hour before a meal. The herb is included in mixtures (cholagogues, stomachics) and has also been used for numerous ailments, including cancer, diabetes, gout and rheumatism. Externally: wounds and ulcers.

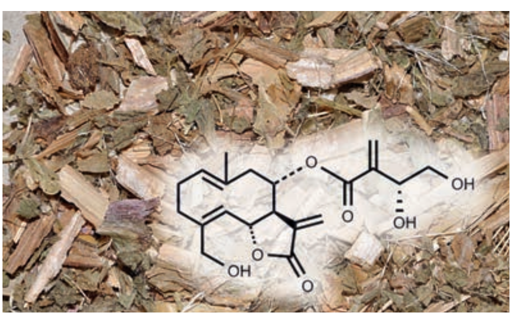
ORIGIN Europe (Mediterranean region). It has been introduced to many parts of the world.

BOTANY Erect annual (to 0.7 m); leaves lobed, hairy; flower heads with spine-tipped bracts.

CHEMISTRY Bitter-tasting sesquiterpene lactones of the germacrene type (**cnicin** is the main compound) and lignan lactones (trachelogenin). Also essential oil, triterpenes and flavonoids.

PHARMACOLOGY The herb stimulates the flow of saliva and gastric juices and improves appetite.

TOXICOLOGY Low toxicity; safe to use at prescribed doses.



Centaurea benedicta (L.) L. [= *Cnicus benedictus* L.] (Asteraceae); *Benediktenkraut* (German); *chardon bénit* (French); *cardo santo* (Italian); *cardo santo* (Spanish)

Centaurea cyanus

blue cornflower

CLASSIFICATION TM: Europe, Asia (Pharm).

USES & PROPERTIES Dried flower heads (*Cyani flos*) or the dried ray florets are used as general tonic, stomachic and diuretic medicine. It is also used in lotions and eye washes to soothe irritation. The bright blue flowers are an ingredient of herbal tea, the natural pigments providing colour.

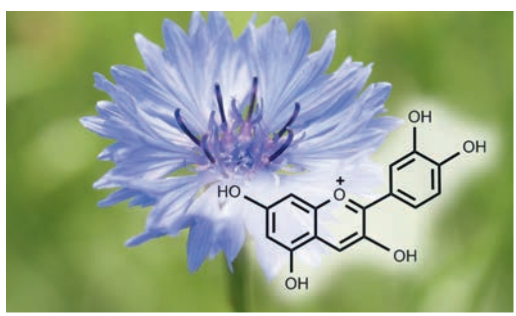
ORIGIN Europe and the Near East (once a common weed of cornfields). It is now available as cultivars with colourful flower heads.

BOTANY Annual herb (to 0.5 m); leaves lobed and stalked, the upper ones simple and sessile; flower heads bright blue (also pink, purple and white in modern garden cultivars).

CHEMISTRY Anthocyanins (anthocyanidin glycosides): **cyanidin** is often a main aglycone (hence the name); also present are sesquiterpene lactones (cnicin), polyacetylenes and flavonoids.

PHARMACOLOGY Anthocyanins have some antibacterial and antioxidant properties. The activity is also ascribed to cnicin and other sesquiterpenoids.

TOXICOLOGY There is no evidence of toxicity.



Centaurea cyanus L. (Asteraceae); *bleuet* (French); *Kornblume* (German); *fioraliso* (Italian); *azulejo* (Spanish)

Centaurium erythraea

common centaury

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 6, PhEur8, HMPC.

USES & PROPERTIES The dried herb, collected while in flower (*Centaurii herba*), is used as a bitter tonic tea (6 g per day, as lukewarm infusion) to treat digestive problems, chronic dyspepsia and lack of appetite. Traditionally it is considered to be helpful in cases of fever and ailments of the liver, bile and bladder. Extracts are used as bitter food flavourants.

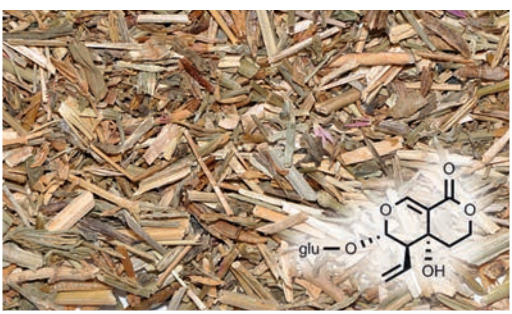
ORIGIN Europe and the Mediterranean region.

BOTANY Biennial herb; basal leaves in a rosette (first year); slender branches with small leaves and small pink flowers (formed in the second year).

CHEMISTRY Bitter iridoid glycosides (secoiridoids): **swertiamarin** is the main compound. Also other iridoids, flavonoids, triterpenes and sterols.

PHARMACOLOGY *Amarum* effect: stimulation of appetite (increased flow of saliva and gastric juices). Anti-inflammatory and antipyretic effects.

TOXICOLOGY Not safe to use in case of stomach or duodenal ulcers.



Centaurium erythraea Rafin. (Gentianaceae); *petite centaurée* (French); *Echtes Tausendgüldenkraut* (German); *centaurea minore* (Italian); *centaura menor* (Spanish)

Centella asiatica

Indian pennywort • hydrocotyle

CLASSIFICATION TM: Asia (India), Africa. ESCOP, WHO 1, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES The whole herb (*Centellae asiaticae herba*) or leaves (*Centellae folium*) are traditionally used as an adaptogen and general health tonic to treat a wide range of ailments. It has been used for venous insufficiency and externally for wound healing. Extracts are used in modern medicine for post-operative wound treatment to prevent scar tissue formation.

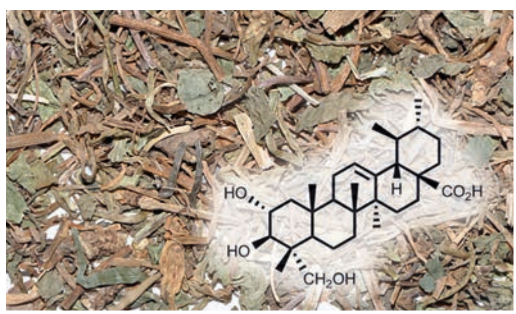
ORIGIN Cosmopolitan and pantropical (wet places). Production is centred in Africa (Madagascar) and Asian countries.

BOTANY Perennial herb; stems stoloniferous; leaves rounded; flowers small; fruit small, dry.

CHEMISTRY Triterpenoid glycosides: mainly asiaticoside, also **asiatic acid** and madecassic acid.

PHARMACOLOGY The triterpenoids act as spindle poisons (metaphase) to prevent cell division.

TOXICOLOGY Exceeding the prescribed dose and prolonged ingestion may have side effects. Madecassic acid may have tumour-promoting activity.



Centella asiatica (L.) Urban (Apiaceae); *hydrocotyle asiatique* (French); *Asiatischer Wassernabel* (German); *brahmi* (Hindi); *idrocotile* (Italian); *gotu kola* (Sanskrit)

Ceratonia siliqua

carob tree

CLASSIFICATION TM: Europe. DS: carob powder.

USES & PROPERTIES Powdered ripe fruits (carob powder) are used in specialised diets to treat diarrhoea and are thought to be of benefit in the management of coeliac (celiac) disorders. It is free from caffeine and theobromine and is therefore used as a chocolate substitute in the health food industry. The seed powder (locust bean powder) is a thickener, emulsifier and gelling agent in the food and pharmaceutical industries.

ORIGIN Mediterranean Europe (widely cultivated as a drought-tolerant street and fruit tree).

BOTANY Evergreen tree (to 15 m); leaves compound; flowers without petals (male and female on separate trees); fruit a many-seeded fleshy pod.

CHEMISTRY Polysaccharides (with **galactose** and mannose), sugars, crude fibre, tannins, proteins.

PHARMACOLOGY Antidiarrhoeal activity, probably due to tannins (they inactivate bacterial proteins). Soluble fibres are thought to prevent heart disease and lower serum cholesterol.

TOXICOLOGY The pulp of ripe fruits is edible.

Ceratonia siliqua L. (Fabaceae); *caroubier* (French); *Johannisbrotbaum* (German); *carrubio* (Italian); *algarrobo* (Spanish)

Cerbera odollam

suicide tree • odollam tree

CLASSIFICATION Heart poison, extremely hazardous (Ia). TM: Pacific (Fiji).

USES & PROPERTIES Fruits of this tree (the bitter taste masked by sugar or spices) have the reputation of having killed more people (through suicide or murder) than any other plant poison. Hundreds of deaths have been reported from India. The related *C. manghas* of Madagascar is a traditional ordeal poison, responsible for thousands of deaths. Decoctions have been used as purgative medicine.

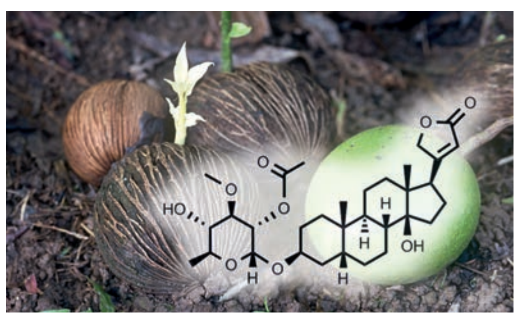
ORIGIN Asia (India, southeast Asia), Australia, Pacific region (sometimes grown in gardens).

BOTANY Evergreen shrub or small tree; flowers attractive, white; fruits large, fleshy, fibrous.

CHEMISTRY Cardiac glycosides (cardenolides): **cerberin** (=2'-acetylneriifoline) and several others.

PHARMACOLOGY Heart glycosides such as cerberin inhibit Na^+, K^+-ATPase in the heart muscle leading to cardiac arrest.

TOXICOLOGY Extremely toxic – death may follow within a few minutes of ingesting a concentrated decoction. Cerberin: LD_{50} = 0.147 mg/kg (cat, i.v.).



Cerbera odollam Gaertn. (Apocynaceae); *Zerberusbaum*, *See-Mango* (German)

Cetraria islandica

Iceland moss

CLASSIFICATION TM: Europe. Pharm., ESCOP, WHO 4, PhEur8, clinical studies+.

USES & PROPERTIES The whole herb (lichen thallus) is known as *Lichen islandicus* or *Cetrariae lichen*. Cold-water macerates: traditional bitter tonic (to reverse appetite loss); infusions (4–6 g of herb/day): cough, sore throat and gastroenteritis. Externally: applied to wounds to promote healing.

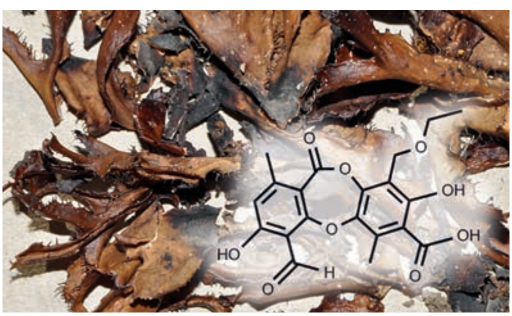
ORIGIN Arctic regions (wild-harvested).

BOTANY Small lichen; thallus branches up to 0.1 m high, brown above, greyish below.

CHEMISTRY Polysaccharides (mainly lichenin and isolichenin), up to 50% and bitter lichenolic acids (depsidones). The main acids are fumaro-protocetraric acid and **cetraric acid** (converted to other acids upon drying).

PHARMACOLOGY Antitussive and emollient (anti-irritant) activity, as well as immune-stimulant properties, are ascribed to the polysaccharides. The tonic properties and antibacterial activity are linked to the bitter-tasting lichenolic acids.

TOXICOLOGY Non-toxic at prescribed doses.



Cetraria islandica (L.) Ach. (Parmeliaceae); *lichen d'Islande* (French); *Isländisches Moos* (German); *lichene islandico* (Italian); *liquen islandico* (Spanish)

Chamaemelum nobile

Roman chamomile

CLASSIFICATION TM: Europe. Comm.E+, PhEur8, HMPC.

USES & PROPERTIES Dried flower heads (*Chamomillae romanae flos*) are traditionally used to treat stress-related dyspepsia (flatulence, nausea, vomiting and dysmenorrhoea). The essential oil (*Chamomillae romanae aetheroleum*) is used in cosmetics (e.g. shampoo) and in aromatherapy.

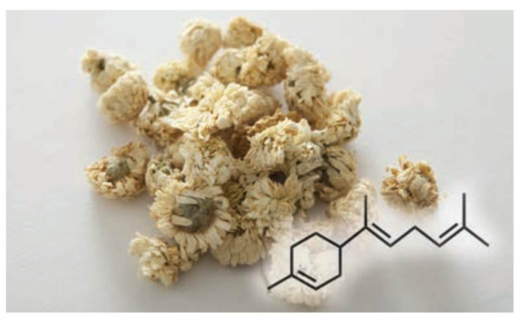
ORIGIN Europe. Widely cultivated.

BOTANY Perennial herb; leaves dissected; flower heads solid (hollow in German chamomile – *Matricaria chamomilla*) ray florets white.

CHEMISTRY Essential oil: bright blue azulenes (artefacts due to steam distillation); also sesquiterpenoids (mainly **α-bisabolene**, nobilin), flavones, organic acids and polyacetylenes.

PHARMACOLOGY The herb has demonstrated sedative, antispasmodic and anti-inflammatory activities. The volatile oil is antimicrobial.

TOXICOLOGY Large doses are emetic. Allergic and anaphylactic reactions are ascribed to the sesquiterpene lactones.



Chamaemelum nobile (L.) All. [= *Anthemis nobilis* L.] (Asteraceae); *camomille romaine* (French); *Römische Kamille* (German); *camomilla romana* (Italian); *manzanilla romana* (Spanish)

Chelidonium majus

greater celandine

CLASSIFICATION Cell toxin (II). TM: Europe. Comm.E+, ESCOP, WHO 5, PhEur8, HMPC .

USES & PROPERTIES The whole herb (*Chelidonii herba*) is traditionally used to treat spasms of the gastrointestinal tract and bile duct. The daily dose is 2–5 g (taken as infusion of 0.5–1 g, three times per day). It is believed to act as cholagogue (to stimulate bile flow) in treating hepatitis, jaundice and gall stones. There are many topical uses to treat warts, ringworm, eczema and eye complaints.

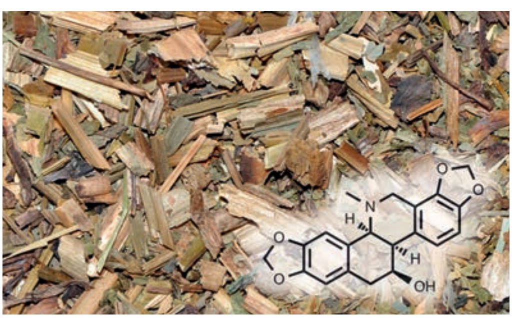
ORIGIN Europe, Asia and North Africa.

BOTANY Perennial herb with bright orange sap; leaves deeply lobed; flowers yellow.

CHEMISTRY Alkaloids: protopine, protoberberine and benzophenanthridine alkaloids: **chelidonine**, berberine, sanguinarine and others.

PHARMACOLOGY The alkaloids are DNA intercalculating and have antimicrobial, antispasmodic, analgesic and cholagogue (choleretic) activities.

TOXICOLOGY It is difficult to regulate the dose (overdosing causes side effects such as stomach cramps, dizziness). Possible liver toxicity.



Chelidonium majus L. (Papaveraceae); *chélidoine*, *grande-éclaire* (French); *Schöllkraut* (German); *celidonia*, *cinerognola* (Italian); *celidonia* (Spanish)

Chenopodium ambrosioides

wormseed goosefoot

CLASSIFICATION Cell toxin; oil is highly hazardous (Ia). TM: South America, Europe. Pharm.

USES & PROPERTIES The essential oil (*Chenopodii aetheroleum*) is traditionally used as anthelmintic medicine in domestic animals and humans. The human dose is 1 g oil in castor oil (2.5% solution). Jesuit tea (*Tinctura botryos mexicanae*), made from the dried herb, was once used for abortion.

ORIGIN South and Central America (Mexico). Naturalised in many parts of the world.

BOTANY Erect perennial herb (to 1 m); leaves toothed; flowers minute.

CHEMISTRY Essential oil: **ascaridol** is the main compound.

PHARMACOLOGY Ascaridol has anthelmintic activity; it kills ascaris (maw worms) and hook worms in humans (and trematodes in animals).

TOXICOLOGY The essential oil is very toxic and may cause spasm and coma if the dose is not carefully controlled (maximum of 1 g per day). It is nowadays rarely used. Ascaridol: LD_{50} = 157 mg/kg (mouse, p.o.); lethal dose (rabbit): 0.6 ml/kg.

Chenopodium ambrosioides L. var. ***anthelminticum*** (L.) A. Gray (Amaranthaceae); *chénopode anthelmintique* (French); *Wurmtreibender Gänsefuß* (German)

Chondrodendron tomentosum

curare vine

CLASSIFICATION Neurotoxin, highly hazardous when injected (Ia); MM: muscle relaxant.

USES & PROPERTIES Pure alkaloid has been used as skeletal muscle relaxant in surgery (anaesthesia) but safer alternatives are nowadays available. The alkaloids are components of blow dart poisons used by South American Indians to ensure that prey animals (birds, monkeys) fall to the ground (because of the muscle-relaxant effect); the meat is safe to consume because the alkaloids are only poisonous when injected into the bloodstream.

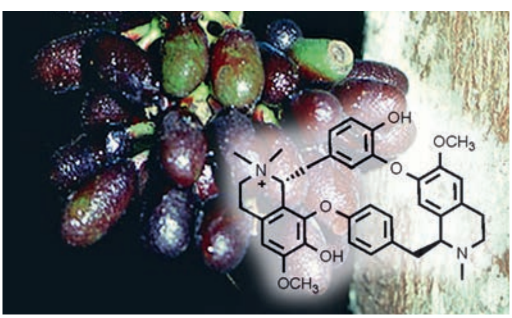
ORIGIN Central and South America.

BOTANY Woody climber; leaves silver below; flowers small; fruit fleshy; seed halfmoon-shaped.

CHEMISTRY Dimeric isoquinoline alkaloids: **D-tubocurarine** (the major compound) and others.

PHARMACOLOGY Tubocurarine is a muscle-relaxant (binds to nACh-R as an antagonist). Injection causes paralysis, coma and death.

TOXICOLOGY Tubocurarine: LD_{50} = 0.23–0.70 mg/kg (various animals, i.v.); the lethal dose in rabbits (s.c.) is 3–5 mg.



Chondrodendron tomentosum Ruiz & Pav. (Menispermaceae); *vigne sauvage*, *curare* (French); *Behaarter Knorpelbaum*, *Pareira* (German); *pareira brava* (Spanish)

Chondrus crispus

Irish moss • carragheen

CLASSIFICATION TM: Europe. PhEur8.

USES & PROPERTIES The dried whole algae (or isolated polysaccharides) are traditionally used to treat inflammation of the upper respiratory tract and stomach (especially cough and bronchitis), Used as bulk-forming laxatives and also as non-digestible adjuncts in weight loss diets.

ORIGIN North Atlantic region (Europe, America).

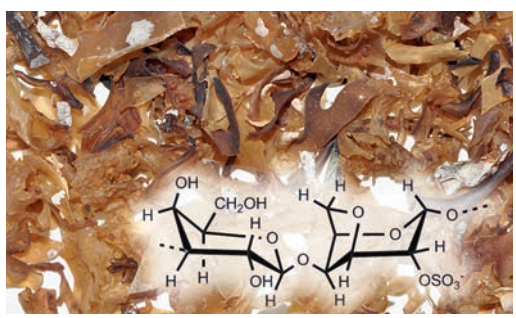
BOTANY A small seaweed (red algae) that grows on rocks along the intertidal zone.

CHEMISTRY The main compounds of interest are polysaccharides known as **carrageenans**. They are galactans (polymers of sulfated galactose). Also present are amino acids, proteins and iodine and bromine salts.

PHARMACOLOGY Polysaccharides are anti-irritant (demulcent), also thought to be mildly expectorant and laxative.

TOXICOLOGY Non-toxic but high doses of iodine may be harmful.

NOTES A source of polysaccharides used in the food, pharmaceutical and cosmetics industries.



Chondrus crispus (L.) Stackh. (Gigartinaceae); *mousse d'Irlande* (French); *Knorpeltang, Irisch Moos* (German)

Chrysanthemum cinerariifolium

pyrethrum • Dalmation chrysanthemum

CLASSIFICATION Neurotoxin (II). Natural insecticide: Europe.

USES & PROPERTIES Powdered dried flower heads were once sold as lice remedies (as Persian powder: brand name Zacherlin). Flower heads and/or seed extracts have become commercial sources of natural, biodegradable insecticide.

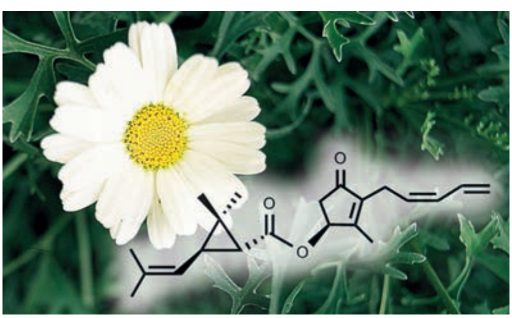
ORIGIN Eastern Europe (Balkans). It is widely cultivated (Kenya, Tanzania, Ecuador, Tasmania).

BOTANY Perennial herb (to 0.8 m); leaves compound, deeply lobed, silvery; flower heads white.

CHEMISTRY The toxins are natural pyrethrins, with **pyrethrin I** and II as the main compounds. Synthetic pyrethroids are also used.

PHARMACOLOGY Pyrethrins are much more toxic to insects than to humans, with a rapid knockout effect. Piperonyl butoxide is added to synergistically enhance the toxicity to insects.

TOXICOLOGY Pyrethrin I: LD_{50} = 1.2 g/kg body weight (rat, p.o.). Synthetic pyrethroids are more toxic to humans than the natural ones. Both can cause severe allergic reactions in sensitive persons.



Chrysanthemum cinerariifolium (Trevir.) Vis. or ***Tanacetum cinerariifolium*** (Trevir.) Sch. Bip. (Asteraceae); *pyrèthre* (French); *Dalmatiner Insektenblume*, *Pyrethrum* (German)

Chrysanthemum ×morifolium

chrysanthemum

CLASSIFICATION TM: Asia (China). Pharm.

USES & PROPERTIES An infusion of a few dried flower heads (*Chrysanthemi flos*) is a popular general tonic and anti-inflammatory in Chinese medicine. It is widely used as an ingredient of medicinal teas to treat fevers, high blood pressure, infections and sore eyes. Powdered herb or poultices are applied to acne, sores, boils and skin infections.

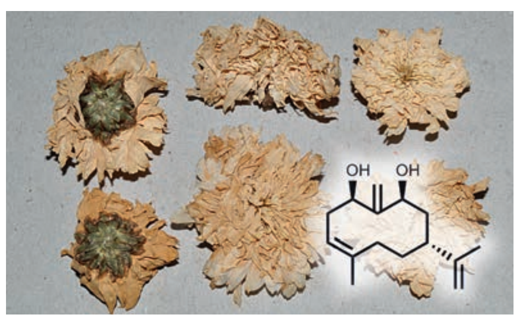
ORIGIN Eastern Asia. A cultivar with small white flower heads (used for medicine) is commercially cultivated in China. Many other cultivars are grown all over the world as cut flowers.

BOTANY Perennial herb; leaves deeply lobed, aromatic; flower heads variable, in many colours.

CHEMISTRY Sesquiterpene alcohols: e.g. **chrysanthediol A**; triterpenes: e.g. helianol.

PHARMACOLOGY Chrysanthediol A and other terpenes are anti-inflammatory (and cytotoxic against human cancer cells). The herb is antimicrobial and appears to lower blood pressure.

TOXICOLOGY The flower heads are edible.



Chrysanthemum ×morifolium Ramat. (Asteraceae); *ju hua* (Chinese); *chrysanthème des fleuristes* (French); *Garten-Chrysantheme* (German); *chrysantemo* (Italian)

Cichorium intybus

chicory

CLASSIFICATION TM: Asia and Europe. Pharm., Comm.E+, HMPC.

USES & PROPERTIES The whole herb (*Chicorii herba*) is used as bitter tonic and "blood purifier" to treat dyspepsia and a loss of appetite. It is a traditional cholagogue, choleretic, carminative and diuretic in both Ayurvedic and European medicine. Chicory syrup is used as a tonic (infants) and cleansing medicine in cases of gout and rheumatism. Roots (*Chicorii radix*) are used to produce chicory (a coffee substitute and additive).

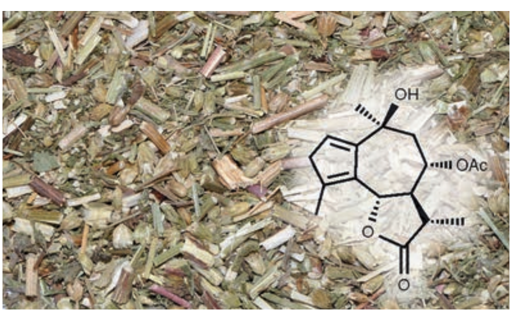
ORIGIN Europe and Asia (the wild form is naturalised in many parts of the world); commercial cultivars are grown for their root (source of chicory) or their leaves (vegetable and salad).

BOTANY Erect perennial herb (to 1 m); leaves large, dentate; flower heads sessile, pale blue.

CHEMISTRY Sesquiterpene lactones: **lactucin**.

PHARMACOLOGY Lactucin and other sesquiterpenes are responsible for the bitter taste. The herb has mild choleretic and diuretic activities.

TOXICOLOGY Non-toxic.



Cichorium intybus L. (Asteraceae); *chicorée sauvage* (French); *Wegwarte* (German); *cicoria* (Italian)

Cicuta virosa

cowbane • water hemlock

CLASSIFICATION Cell toxin, highly hazardous (Ib). TM: Europe. Pharm.

USES & PROPERTIES The herb (*Cicutae herba*) has been used in Europe as an antispasmodic and to alleviate the symptoms of rheumatism.

ORIGIN Northern Europe, northern Asia and North America (found in wet places).

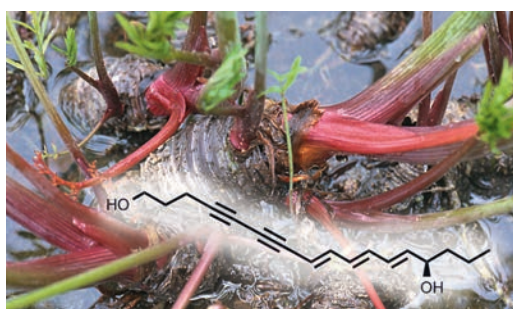
BOTANY Perennial herb with thick rhizomes; Leaves compound; flowers small, white, in umbels; fruit a small (2 mm long) schizocarp.

CHEMISTRY Polyacetylenes (0.2% in fresh material, 3.5% in dried rhizomes): **cicutoxin** and cicutol are the main compounds.

PHARMACOLOGY Analgesic and antispasmodic activities; antileucaemic effects. The polyacetylenes are highly reactive and form covalent bonds with macromolecules in the cell, causing CNS symptoms and cell death.

TOXICOLOGY The LD_{50} for cicutoxin = 9.2 mg/kg (mouse, i.p.).

NOTES Related plants (*Cicuta maculata*, *Aethusa cynapium* and *Oenanthe crocata*) are also toxic.



Cicuta virosa L. (Apiaceae); *cigué aquatique* (French); *Giftiger Wasserschierling* (German); *cicuta aquatica* (Italian)

Cimicifuga racemosa

black cohosh • black snakeroot

CLASSIFICATION TM: North America. Comm. E+, WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Dried rhizomes and roots (*Cimicifugae racemosae rhizoma*) are traditionally used against premenstrual and menopausal disorders (0.5–1 g, up to three times per day). It is included in tonics and cough mixtures and used to treat chorea, rheumatism, dizziness and tinnitus.

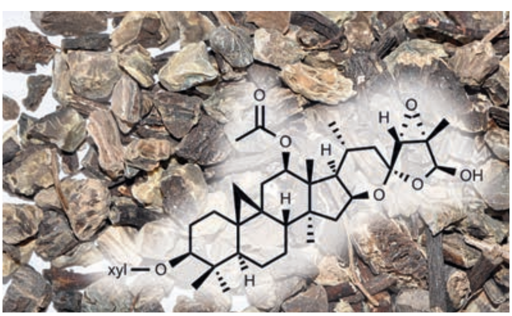
ORIGIN North America (Canada and northeastern USA). Raw material is mostly wild-harvested.

BOTANY Perennial herb; leaves pinnately compound; flowers small, white, in elongated clusters.

CHEMISTRY Tetracyclic triterpenoids glycosides: **actaein** and cimicifugoside (and their aglycones, cimigenol and acetylacteol). Also formononetin (an isoflavonoid), gallotannins and organic acids.

PHARMACOLOGY Actaein is considered to be spasmolytic, vasodilatory and hypotensive. The drug has an oestrogen-like action.

TOXICOLOGY More than 5 g can cause toxic effects. Continuous use should be avoided.



Cimicifuga racemosa (L.) Nutt. or ***Actaea racemosa*** L. (Ranunculaceae); *actée à grappet* (French); *Amerikanische Traubensilberkerze* (German); *cimicifuga* (Italian, Spanish)

Cinchona pubescens

Peruvian bark tree • red cinchona

CLASSIFICATION Cell toxin (II). TM: South America, Europe. Comm.E+ (tonic), PhEur8. MM: alkaloids (quinine, quinidine).

USES & PROPERTIES Bark (*Cinchonae cortex*) is traditionally used as bitter tonic (appetite stimulant) and treatment against malaria. Pure alkaloids (and synthetic derivatives) are used as antimalarial and anti-arrhythmic drugs.

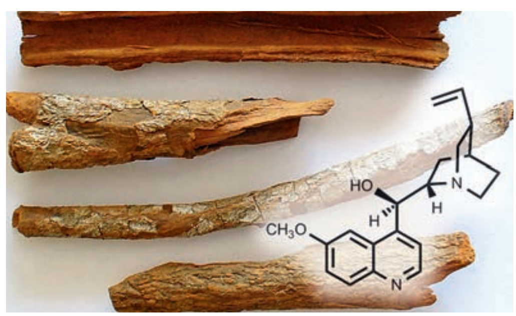
ORIGIN South America (Colombia, Ecuador, Peru). Cultivation: India, Indonesia and Africa.

BOTANY Evergreen tree; bark reddish; leaves simple, large. Species such as *C. officinalis* (yellow bark) are also used for alkaloid extraction.

CHEMISTRY Quinoline alkaloids (5–15%): **quinine** is the main compound (also quinidine).

PHARMACOLOGY Quinine and synthetic derivatives disrupt the metabolism of *Plasmodium* parasites but many strains have become resistant. Quinidine inhibits Na^+-channels and is used as an anti-arrhythmic drug.

TOXICOLOGY Quinine has a relatively low toxicity and is used in tonic water (ca. 67 mg per litre).



Cinchona pubescens Vahl [= *Cinchona succirubra* Pav. ex Klotsch] (Rubiaceae); *quina*, *quinquina* (French); *Roter Chinarindenbaum* (German); *china rossa* (Italian)

Cinnamomum camphora

camphor tree

CLASSIFICATION TM: East Asia (China), Europe. Pharm., Comm.E+.

USES & PROPERTIES Wood is distilled to obtain a camphor fraction (gum camphor) and a white essential oil rich in cineole (*Cinnamomi camphorae aetheroleum*). Both are used as circulatory and respiratory stimulants, as counter-irritants and ingredients of ointment (for rheumatism and congestion). It is used for relief of colds, fever, influenza, inflammation, pneumonia and diarrhoea.

ORIGIN China, Japan and Taiwan. Widely introduced as a popular ornamental tree.

BOTANY Large evergreen tree (to 50 m); leaves glossy, indistinctly trinerved; fruit a black drupe.

CHEMISTRY Essential oil, with **camphor** and 1,8-cineole (= eucalyptol) as main compounds.

PHARMACOLOGY Camphor and 1,8-cineole have (synergistic) antiseptic, analeptic, carminative, counter-irritant, spasmolytic and stimulant effects. Stimulation of cold receptors in the nasal passages gives a cooling effect.

TOXICOLOGY Camphor is toxic in high doses.

Cinnamomum camphora (L.) J. Presl (Lauraceae); *camphrier du Japon* (French); *Kampferbaum* (German); *camfora* (Italian); *alcanfor* (Spanish)

Cinnamomum verum

cinnamon bark tree • Ceylon cinnamon

CLASSIFICATION TM: Asia (India and Sri Lanka), Europe. Comm.E+, WHO 1, PhEur8, HMPC.

USES & PROPERTIES The inner bark of branches and coppice shoots (cinnamon; *Cinnamomi ceylanici cortex*) is used as appetite stimulant and to treat indigestion, dyspeptic complaints and other conditions (e.g. inflammation, nausea, loss of appetite, diarrhoea). The daily dose is 2–4 g (bark) or 0.05–0.2 g (essential oil).

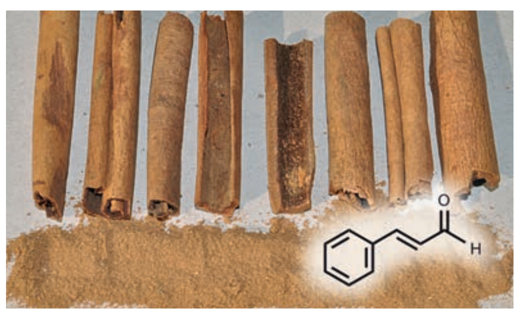
ORIGIN Asia (Sri Lanka and parts of India); trees are cultivated in many tropical regions.

BOTANY Evergreen medium-sized tree; leaves glossy, trinerved; fruit an oblong, black drupe.

CHEMISTRY The essential oil is dominated by **cinnamaldehyde** (65–80%), with smaller amounts of eugenol and others. Bark is rich in procyanidins.

PHARMACOLOGY Cinnamaldehyde has antispasmodic and antimicrobial activity; the bark and tannins are astringent and the procyanidins contribute to antioxidant effects.

TOXICOLOGY Non-toxic at low doses and widely used as a spice (true cinnamon).



Cinnamomum verum J. Presl [= *C. zeylanicum* Nees] (Lauraceae); *canellier, canelle de Ceylan* (French); *Ceylon-Zimtbaum* (German); *cannella* (Italian); *canelo de Ceilán* (Spanish)

Citrullus colocynthis

colocynth • bitter apple

CLASSIFICATION Cell toxin (Ib). TM: Africa, Asia.

USES & PROPERTIES Fruits are no longer used in traditional medicine as purgatives (too toxic, side effects). Formerly used as insecticide and for rodent control. Seeds of wild watermelon (*Citrullus lanatus*) yield an edible oil, used in cosmetics.

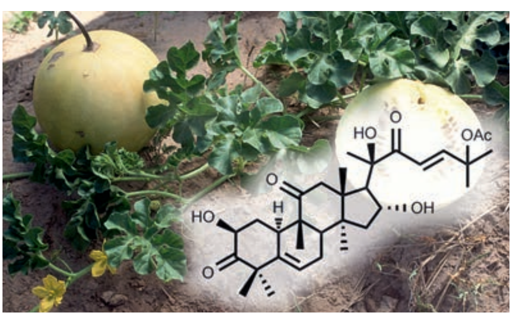
ORIGIN West Africa (naturalised in Arabia, the Mediterranean region, Australia and India). Cultivated since Assyrian times.

BOTANY Annual trailing herb; leaves hairy; flowers yellow; fruit large, globose, many-seeded (resembling a small watermelon).

CHEMISTRY Cucurbitacins (bitter-tasting triterpenoids): **Cucurbitacins B**, E and J, together with their glycosides, are the main toxic compounds.

PHARMACOLOGY Cucurbitacins are cytotoxic; they have purgative, analgesic and antitumour activities but are too poisonous to be used medicinally.

TOXICOLOGY The lethal dose in humans is 3 g of the fruit. Exposure to skin may cause blisters.



Citrullus colocynthis (L.) Schrad. (Cucurbitaceae); *coloquinthe* (French); *Koloquinte*, *Bittermelone* (German); *coloquintide* (Italian)

Citrus aurantium

bitter orange • Seville orange

CLASSIFICATION TM: Asia (China), Europe. Pharm., Comm.E+, PhEur8, HMPC.

USES & PROPERTIES The glandular outer fruit peel (*Aurantii pericarpium*), or essential oil extracted from it, are traditionally used as aromatic bitter tonic to stimulate appetite and to treat indigestion, flatulence and bloating. Unripe fruits (*zhi shi*) are used in Chinese medicine for relief of bloating. Ripe fruits are used to make marmalade.

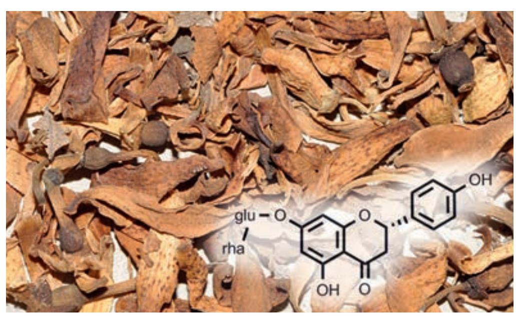
ORIGIN Southern Asia. Cultivated as a fruit tree in most warm regions of the world.

BOTANY Evergreen tree (to 10 m); leaves glabrous, aromatic; flowers white; fruits depressedly ovate. The form used for bergamot oil (subsp. *bergamia*) is a smaller tree (to 5 m).

CHEMISTRY Bitter flavone glycosides (**naringenin**, neohesperidin); essential oil (limonene, linalool, terpineol); bitter triterpenes (limonin).

PHARMACOLOGY Bitter substances stimulate appetite; essential oil acts as aromatic and stomachic.

TOXICOLOGY Small amounts of phototoxic coumarins in the oil may cause photosensitisation.



Citrus aurantium L. subsp. ***aurantium*** (Rutaceae); *orange amère* (French); *Pomeranze*, *Bitterorange* (German); *arancio amaro* (Italian); *naranjo amargo* (Spanish)

Coffea arabica

coffee tree • Arabian coffee

CLASSIFICATION Stimulant (III). TM: Africa, Europe. Comm.E+ (coffee charcoal). MM: caffeine.

USES & PROPERTIES Roasted seeds (*Coffeae semen*) are used medicinally as stimulant and diuretic. Caffeine is an ingredient of preparations used to treat fever, pain and influenza (and modern energy drinks). Coffee carbon (*Coffeae tostae carbo*) is taken orally (9 g per day) to treat diarrhoea and mild inflammation of the mouth and throat.

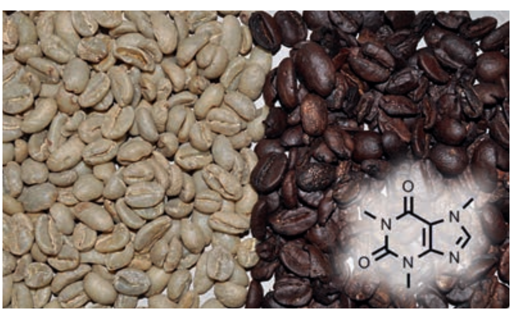
ORIGIN Africa (Ethiopia); cultivated commercially in many parts of the world.

BOTANY Evergreen shrub or small tree; leaves opposite; flowers fragrant; fruit a 2-seeded drupe.

CHEMISTRY Purine alkaloids: mainly **caffeine** (1–2% in ripe seeds, or 150 mg per cup).

PHARMACOLOGY Caffeine is a central stimulant (it inhibits adenosine receptors and cAMP phosphodiesterase) and has a positive inotropic action. Coffee enhances gastric secretions and gut motility.

TOXICOLOGY Caffeine is addictive. Excessive amounts may lead to high blood pressure, palpitations, nervousness, insomnia and indigestion.



Coffea arabica L. (Rubiaceae); *caféier d'Arabie* (French); *Kaffeestrauch* (German); *caffè* (Italian); *cafeto* (Spanish)

Cola acuminata

cola nut tree

CLASSIFICATION Stimulant. TM: Africa, Europe. Pharm., Comm.E+, PhEur8, HMPC.

USES & PROPERTIES The ripe dried seeds, with the seed coat removed (*Colae semen*) are traditionally used to treat mental and physical fatigue. Their astringency makes them useful to treat diarrhoea, wounds and inflammation. Cola nuts were formerly an ingredient of cola drinks and are still used in energy drinks.

ORIGIN West Africa (Nigeria, Sierra Leone to Gabon); cultivated in tropical Asia and America.

BOTANY Evergreen tree (to 15 m); leaves oblong; flowers yellow; fruit a large, multi-seeded follicle.

CHEMISTRY Purine alkaloids: caffeine (1.5–3%) and **theobromine**; phenolic compounds (4–6%).

PHARMACOLOGY The purine alkaloids have a stimulant activity (on the heart and central nervous system, see *Coffea*). The nuts have positive chronotropic and weak diuretic effects in humans.

TOXICOLOGY Non-toxic. Excessive amounts may be harmful to those with ulcers, heart disorders or hypertension.

Cola acuminata (Pal.) Schott & Endl. [Malvaceae (formerly Sterculiaceae)]; *colatier* (French); *Kolabaum* (German); *cola* (Italian); *cola* (Spanish)

Colchicum autumnale

autumn crocus • meadow saffron

CLASSIFICATION Cell toxin, extremely hazardous (Ia). TM: Europe. Comm.E+. MM: pure alkaloid.

USES & PROPERTIES Cut and dried corms (*Colchici tuber*), seeds (*Colchici semen*) or fresh flowers are used. Extracted alkaloids, in carefully controlled doses, are used in modern medicine to treat gout and familial Mediterranean fever. The maximum daily amount is 8 mg (administered orally, 0.5–1.5 mg every 2–3 hours). The plant and alkaloids are very toxic and not suitable for self-medication.

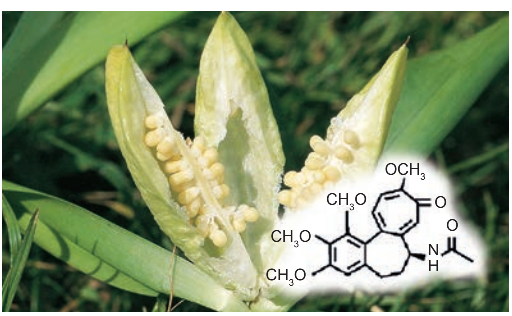
ORIGIN Europe and North America. The species and relatives are grown as garden plants.

BOTANY Deciduous bulbous plant; leaves in summer; flowers pink or purple, emerging in autumn.

CHEMISTRY Phenethylisoquinoline alkaloids: **colchicine** is the main compound.

PHARMACOLOGY Colchicine: anti-inflammatory and painkiller (prevents macrophages from reaching inflamed joints). The alkaloid is used as a spindle poison when studying chromosomes.

TOXICOLOGY Colchicine: the toxic dose is 10 mg; lethal dose 40 mg. All *Colchicum* species are toxic.



Colchicum autumnale L. (Colchicaceae); *colchique d'automne* (French); *Herbstzeitlose* (German); *crocus autumnale*, *colchico* (Italian); *cólquico* (Spanish)

Commiphora myrrha

myrrh tree • African myrrh

CLASSIFICATION TM: Africa, Europe, Asia. Pharm., Comm.E+, ESCOP 6, PhEur8.

USES & PROPERTIES The oleoresin gum that exudes naturally from the bark (myrrh; *Myrrha*) has many uses in traditional medicine – mainly topically against mouth and throat infections, to promote wound healing and for treating various skin conditions (as antibiotic treatment and to stop bleeding and swelling). Myrrh tincture is dabbed onto wounds or 60 drops in a glass of warm water can be used as gargle or mouth rinse.

ORIGIN Northeastern Africa (Kenya, Ethiopia and Somalia). The resin is wild-harvested.

BOTANY Small deciduous tree (to 3 m); stems somewhat thorny; leaves small, on short shoots; flowers pink and yellow; fruits small, oval capsules.

CHEMISTRY Myrrh contains oleoresins, essential oil and polysaccharides. The essential oil (3–6%) contains about 50% **furanoeudesma-1,3-diene**.

PHARMACOLOGY Astringent, antiseptic, anti-inflammatory and antipyretic.

TOXICOLOGY Myrrh is non-toxic in small doses.

Commiphora myrrha (Nees) Engl. [= *C. molmol* Engl.] (Burseraceae); *myrrhe* (French); *Myrrhe* (German); *mirra* (Italian); *mirra* (Spanish)

Conium maculatum

poison hemlock

CLASSIFICATION Neurotoxin, extremely hazardous (Ia). TM: Europe.

USES & PROPERTIES The herb or seeds have been used in traditional medicine as sedative, antispasmodic, antaphrodisiac and anti-ulcer treatment. It has also been used since ancient times for murder, suicide and execution. It was the main ingredient of the poison that allegedly killed Socrates.

ORIGIN Europe. Naturalised in Africa and Asia. Hemlock grows as a weed in disturbed places.

BOTANY Erect biennial herb (to 1.5 m); stems purple-spotted; leaves compound; flowers white. After handling the plant or its alkaloids, a characteristic mousy smell is left on the hands.

CHEMISTRY Piperidine alkaloids (up to 3.5% in fruits): mainly **coniine** and γ-coniceine, with several minor alkaloids. Toxic polyacetylenes in roots.

PHARMACOLOGY Coniine: sedative, antispasmodic, analgesic and extremely poisonous.

TOXICOLOGY Coniine: LD_{50} (mouse) = 19 mg/kg (i.v.), 100 mg/kg (p.o). The lethal oral dose of coniine in humans is 0.5–1 g.

Conium maculatum L. (Apiaceae); *cigué tachée* (French); *Gefleckter Schierling* (German); *cicuta maggiore* (Italian)

Convallaria majalis

lily-of-the-valley

CLASSIFICATION Heart poison, highly hazardous (Ia). TM: Europe. Pharm., Comm.E+.

USES & PROPERTIES The whole herb (*Convallariae herba*), harvested during flowering, is traditionally used as a heart stimulant to treat the symptoms of mild cardiac insufficiency.

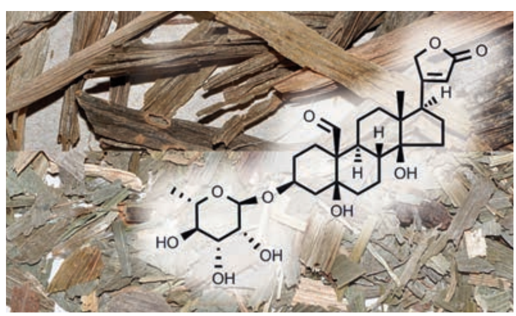
ORIGIN Europe and northeast Asia (naturalised in North America). Cultivated as ornamental plant. Raw material is harvested in eastern Europe.

BOTANY Small clump-forming perennial; leaves in a single pair; flowers white, bell-shaped; fruit a few-seeded berry, orange-red when ripe.

CHEMISTRY Several cardiac glycosides (0.1–0.5% of dry weight) and saponins. The main compound is **convallatoxin** (40% of total heart glycosides).

PHARMACOLOGY Convallatoxin is similar to other heart glycosides which inhibits Na^+, K^+-ATPase. It strengthens the contraction of the heart muscle and decreases the internal heart pressure.

TOXICOLOGY Convallatoxin is very poisonous: lethal dose = 0.5 g (humans, p.o.). Accidental poisoning (mistaken for *Allium ursinum*) is rarely fatal.



Convallaria majalis L. [Asparagaceae (formerly Convallariaceae)]; *muguet* (French); *Maiglöckchen* (German); *mughetto* (Italian); *lirio de los valles* (Spanish)

Coptis chinensis

Chinese goldthread

CLASSIFICATION TM: Asia (China). Pharm., WHO 1.

USES & PROPERTIES The rhizomes (*Coptidis rhizomae*), yellow or orange inside, are traditionally used in Chinese medicine to treat bacterial diarrhoea, gastroenteritis, inflammation, ulcers, sores and conjunctivitis. The daily dose of crude product is 1.5–6 g. Other species are used as bitter tonic and stomachics, and to treat oral infections.

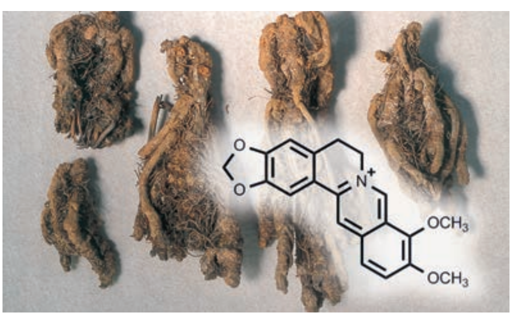
ORIGIN Eastern Asia (China, also grown there).

BOTANY Perennial herb; leaves compound, on long stalks; flowers white or pale pink. Several other species are used in India (*C. teeta*), Japan (*C. japonica*) and North America (C. *trifolia*).

CHEMISTRY Isoquinoline (protoberberine) alkaloids: **berberine** is the main compound (5–7%).

PHARMACOLOGY The DNA intercalating berberine has documented antimicrobial activity against a wide range of organisms (see *Berberis vulgaris*).

TOXICOLOGY Berberine (and the rhizomes) are potentially mutagenic, so that they should be used with caution (e.g. not during pregnancy).



Coptis chinensis Franch. (Ranunculaceae); *huang lian* (Chinese); *huánglián*, *coptide chinois* (French); *Chinesischer Goldfaden* (German); *cottide* (Italian)

Coriandrum sativum

coriander

CLASSIFICATION TM: Asia, Europe. Pharm., Comm.E+, PhEur8.

USES & PROPERTIES Ripe fruits (*Coriandri fructus*) or their essential oil (*Coriandri aetheroleum*) are traditionally used against loss of appetite and as a stomachic to treat minor digestive disturbances, including indigestion, bloating and griping. They can also be used topically on wounds and burns and as counter-irritant on painful joints.

ORIGIN Eastern Mediterranean region and western Asia. Cultivated as an important culinary herb (cilantro, Chinese parsley) and spice (coriander, much used in curry powder).

BOTANY Annual herb (to 0.5 m); leaves dimorphic (basal ones undivided, upper much dissected; flowers asymmetrical; fruit a small dry schizocarp.

CHEMISTRY Essential oil: **linalool** (60%) as main compound. Also coumarins and triterpenoids.

PHARMACOLOGY The fruits (and essential oil) are spasmolytic, carminative and antimicrobial.

TOXICOLOGY Edible (but allergic skin reactions may occur in sensitive persons).

Coriandrum sativum L. (Apiaceae); *coriandre* (French); *Koriander* (German); *coriandolo* (Italian); *cilantro* (Spanish)

Crataegus monogyna

hawthorn

CLASSIFICATION TM: Europe, Asia. Comm.E+, ESCOP 6, WHO 2, 5, PhEur8, clinical studies+.

USES & PROPERTIES Flowers and leaves (*Crataegi folium cum flore*) are used in traditional medicine as heart tonic to treat cardiac insufficiency and heart rhythm disorders (NYHA I, II or III). The related *C. laevigata* (Europe) and *C. pinnatifida* (China) are also used. Special extracts are used in modern phytotherapy.

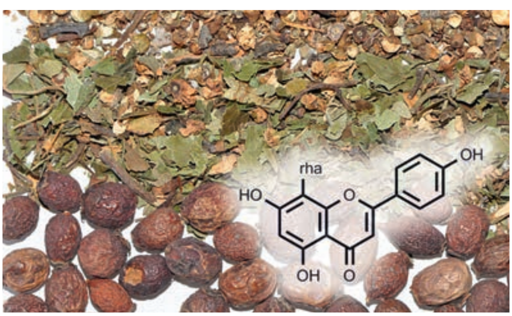
ORIGIN Europe, Asia (*C. laevigata* in Europe).

BOTANY Deciduous small tree; leaves deeply lobed; fruits fleshy, single-seeded (leaves shallowly lobed and fruits 2–3-seeded in *C. laevigata*).

CHEMISTRY Oligomeric procyanidins (1–3%), flavonoids (1–2%, e.g. **vitexin** rhamnoside), organic acids and triterpenes.

PHARMACOLOGY Cardiotonic activity is due to the procyanidins and flavonoids: their hydroxy groups interfere with enzymes and increase the strength of contraction and stroke volume of the heart. There are also anti-arrhythmic effects.

TOXICOLOGY Safe at recommended doses.



Crataegus monogyna Jacq. (Rosaceae); *aubépine* (French); *Eingriffeliger Weißdorn* (German); *bianco spino* (Italian); *espino albar* (Spanish)

Crocus sativus

saffron • saffron crocus

CLASSIFICATION Neurotoxin, mind-altering (II). TM: Europe, Asia. Pharm., Comm.E+, WHO 3.

USES & PROPERTIES The dried stigmas and style branches of the flowers (*Croci stigma*) are traditionally used to treat spasms and asthma. It is a component of "Swedish bitters". Saffron is the most expensive of spices and provides both colour and flavour to many Mediterranean and Middle Eastern traditional dishes (e.g. paella). About 150 000 flowers are required to produce 1 kg of dry spice.

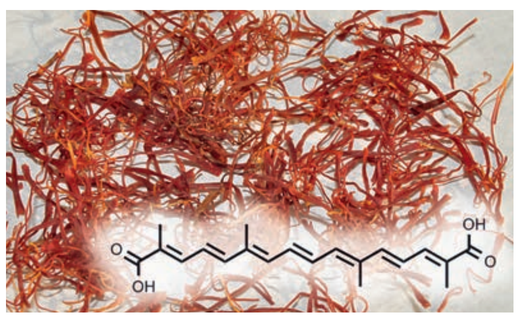
ORIGIN A sterile cultigen developed in ancient Greece. Production is centred in Spain and Iran.

BOTANY Small deciduous bulbous plant; leaves slender, needle-shaped; flowers purple; stamens 3; stigmas bright red, on forked style branches.

CHEMISTRY Main compounds: **crocetin** (a diterpene) and picrocrocin (a glycoside). The essential oil contains safranal as the main active constituent.

PHARMACOLOGY Saffron has sedative and antispasmodic activities. Crocetin is lipid-lowering.

TOXICOLOGY Saffron is toxic at high doses. The lethal oral dose in humans is 5–20 g.



Crocus sativus L. (Iridaceae); *safran* (French); *Safran* (German); *zafferano* (Italian); *azafrán* (Spanish)

Croton tiglium

purging croton

CLASSIFICATION Cell toxin, skin irritant, extremely hazardous (Ia). TM: Europe (obsolete).

USES & PROPERTIES The seeds or seed oil were once popular and effective purgative medicines (no longer used due to toxicity and carcinogenic effects). Laxative medicines are less important now because of improved food hygiene and healthier diets. Habitual purgation may be harmful.

ORIGIN Asia (China, India, Malaysia).

BOTANY Shrub or small tree; leaves with two small glands; flowers small; fruit a dehiscent capsule; seeds marbled (resembling castor beans).

CHEMISTRY Phorbol esters of the tigliane type, such as TPA or 12-*O*-tetradecanoylphorbol-13-acetate; seeds contain fatty acids (**crotonic acid**), crotonide (purine alkaloid, 3.8%) and a toxic lectin (crotin).

PHARMACOLOGY Phorbol esters are co-carcinogens and extremely toxic. The purgative action is due to crotonic acid. Crotin is similar to ricin.

TOXICOLOGY Lethal dose in humans: four seeds or 0.5–1 ml (20 drops) of seed oil.

Croton tiglium L. (Euphorbiaceae); *croton revulsif* (French); *Krotonölbaum* (German); *crotone* (Italian)

Cucurbita pepo

pumpkin

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP, HMPC.

USES & PROPERTIES Ripe, dried pumpkin seeds (*Cucurbitae peponis semen*) or seed oil are traditionally used in central Europe as vermifuge (to expel tapeworms and roundworms) and to treat the symptoms of benign prostate hyperplasia. The daily dose is 10 g but treatment should be maintained for several weeks or months to be effective.

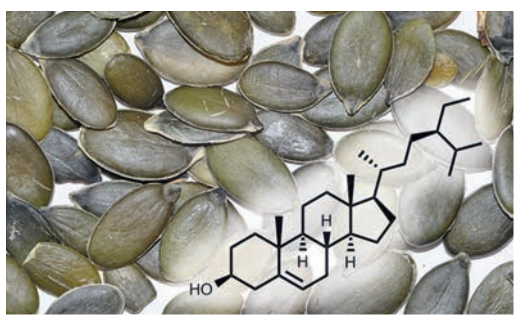
ORIGIN Central and South America. Now a popular vegetable in most parts of the world.

BOTANY Trailing annual; leaves large, hairy; flowers yellow, short-lived; fruit fleshy, many-seeded.

CHEMISTRY The seed oil contains fatty acids (mainly linoleic acid), plant sterols and sterol glycosides (Δ^7-sterols) and tocopherols. **β-sitosterol** is a main compound. Also present is cucurbitine (a cyclic non-protein amino acid).

PHARMACOLOGY Δ^7-sterols inhibit the binding of dihydrotestosterone and/or 5α-amilase and aromatase. Cucurbitine is thought to be anthelmintic.

TOXICOLOGY Phytosterols are not poisonous.



Cucurbita pepo L. (Cucurbitaceae); *pépon*, *citrouille* (French); *Gartenkürbis* (German); *zucca* (Italian); *calabaza* (Spanish)

Curcuma longa

turmeric

CLASSIFICATION TM: Asia, Europe. Comm.E+, WHO 1, ESCOP Suppl., PhEur8, HMPC .

USES & PROPERTIES The rhizomes (*Curcumae longae rhizoma*) are used in Ayurvedic medicine for numerous ailments, including indigestion and inflammatory conditions. It is used as a cholagogue (to stimulate bile flow) and as carminative (to reduce bloating). Turmeric (fresh or dried) is an important spice and natural food dye.

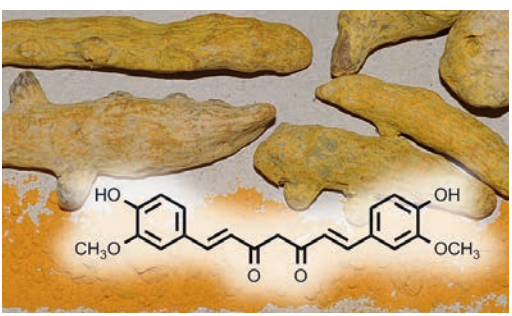
ORIGIN Asia (a sterile cultigen, thought to have originated in India). The spice is grown commercially in tropical areas around the world.

BOTANY Leafy perennial herb; rhizomes bright yellow; leaves large; flowers yellow and white.

CHEMISTRY The yellow pigments are curcuminoids (**curcumin** is the main compound). The essential oil contains bisabolane.

PHARMACOLOGY Curcumin and related compounds are anti-inflammatory, antioxidative, antimicrobial and cytotoxic to tumour cells. They are thought to have choleretic activity.

TOXICOLOGY Turmeric is non-toxic (edible).



Curcuma longa L. [= *C. domestica* Valeton] (Zingiberaceae); *curcuma* (French); *Kurkuma*, *Gelbwurzel* (German); *curcuma* (Italian); *turmérico* (Spanish)

Cyamopsis tetragonolobus

cluster bean • guar

CLASSIFICATION TM: Asia, Europe. Pharm. DS: prebiotic (dietary fibre).

USES & PROPERTIES Seeds or seed oil are used in Ayurvedic medicine (and in Europe) as traditional dietary supplements and functional food, in supportive treatment of digestive ailments, constipation and diabetes. The seed gum (guar gum) is an industrial food additive, stabiliser and emulsifier. The gum or partially hydrolysed guar gum (PHGG) has health benefits as a dietary fibre.

ORIGIN A cultigen (unknown in the wild), probably originating from West African *C. senegalensis*. Cultivated in India and Pakistan for centuries.

BOTANY Erect annual herb; leaves trifoliate; flowers white or pink; fruit an oblong, 10-seeded pod.

CHEMISTRY Polysaccharides: mainly guaran, a galactomannan in the endosperm (MW 25 000, with **mannose** and galactose subunits).

PHARMACOLOGY The gum is considered to be a prebiotic (non-digestible fibre that acts as a substrate for beneficial microorganisms in the colon).

TOXICOLOGY The seeds and gum are edible.

Cyamopsis tetragonolobus (L.) Taubert (Fabaceae); *guar* (French); *Guarbohne*, *Büschelbohne* (German); *guar*, *guwar*, *guar-phali* (Hindi); *guar* (Italian); *guar* (Spanish)

Cyclopia genistoides

honeybush tea

CLASSIFICATION TM: Africa (Cape). AHP.

USES & PROPERTIES Enzymatically oxidised, air-dried leaves and stems (sometimes with flowers included) are traditionally used as a tasty general health tea. It is best prepared as a decoction (boiled for a short while). Used as a dietary supplement in supportive treatment of digestive ailments and diabetes.

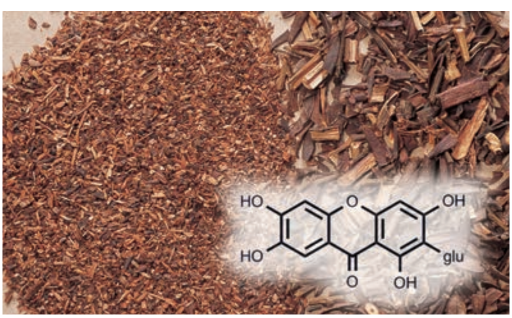
ORIGIN Africa (South Africa); commercial cultivation is increasing.

BOTANY Woody shrubs (to 1.2 m); leaves narrowly linear; flowers yellow; pods few-seeded. The main commercial species are *C. intermedia* (mostly wild-harvested) but it is rapidly being replaced by cultivated *C. genistoides* and *C. subternata*.

CHEMISTRY Xanthones (**mangiferin** is the dominant compound); flavones; organic acids; pinitol.

PHARMACOLOGY Mangiferin: antioxidant and possible antimutagenic effects; pinitol: antidiabetic; other phenolic compounds: antioxidant; isoflavones: phytoestrogenic activity.

TOXICOLOGY No toxicity or side effects are known.



Cyclopia genistoides (L.) R.Br. (Fabaceae); *heuningbostee* (Afrikaans); *cyclopia* (French); *Honigbusch* (German)

Cymbopogon citratus

lemongrass

CLASSIFICATION TM: Asia (India). Pharm., Comm.E+, PhEur8.

USES & PROPERTIES Dried aboveground parts (*Cymbopogonis citrati herba*) are a weak sedative and stomachic in Ayurvedic medicine. The herb and/or essential oil are used for relief of dyspeptic problems, colds, nervous conditions and exhaustion. The essential oil is used in aromatherapy. Lemongrass is important in oriental cooking.

ORIGIN Unknown (thought to be of southern Indian or Sri Lankan origin); widely cultivated.

BOTANY Perennial grass (to 1 m); leaves broad, pale green, hairy; flowers are rarely seen.

CHEMISTRY Essential oil with citral (a mixture of **geranial** and neral) as main ingredient.

PHARMACOLOGY The beneficial effects (digestive, calming) are ascribed to the essential oil components. Antimicrobial, sedative, spasmolytic and carminative effects have been described.

TOXICOLOGY The essential oil is not toxic in the small quantities that are typically used but large amounts can be dangerous and even lethal.

Cymbopogon citratus (DC.) Stapf (Poaceae); *verveine des Indes* (French); *Lemongras*, *Zitronengras* (German); *citronella* (Italian); *sontol* (Spanish)

Cynara cardunculus

globe artichoke • garden artichoke

CLASSIFICATION TM: Europe. Comm.E+ (dyspepsia only), WHO 4, PhEur8, HMPC.

USES & PROPERTIES Leaves (*Cynarae folium*) are traditionally used to treat dyspeptic complaints. It increases the flow of bile and is thought to detoxify and protect the liver. The daily dose is 6 g of the herb (or equivalent amounts in extracts).

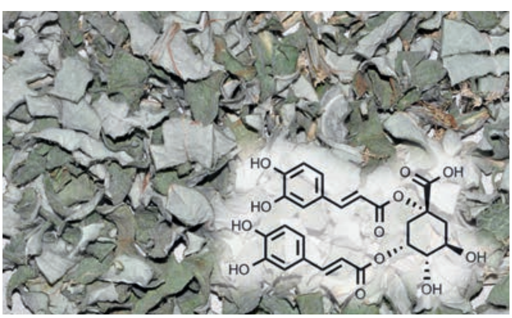
ORIGIN Europe (an old cultigen, commonly cultivated as a vegetable for its flower heads).

BOTANY Robust perennial herb; leaves large, compound, silvery; flower heads large, blue or purple.

CHEMISTRY Sesquiterpene lactones: cynaropicrin is the main compound. Also present are phenolic acids (especially dicaffeoylquinic acids such as **cynarin**) and flavonoids.

PHARMACOLOGY Choleretic, liver-protectant, lipid-lowering and antioxidant activities are attributed to cynarin and to chlorogenic and neochlorogenic acids. The bitter-tasting cynaropicrin is linked to tonic and digestive effects.

TOXICOLOGY Non-toxic, with no noteworthy side effects.



Cynara cardunculus L. [= *Cynara scolymus* L.] (Asteraceae); *artichaut* (French); *Artischocke* (German); *carciofo* (Italian); *alearrhofa*, *alcachofera* (Spanish)

Cytisus scoparius

common broom • Scotch broom

CLASSIFICATION Neurotoxin (II) cardiotonic; TM: Europe; Pharm., Comm.E+. MM: alkaloid.

USES & PROPERTIES The whole herb or flowering tops (*Cytisi scoparii herba*) are used in traditional medicine as diuretic and for heart ailments and circulatory disorders. A tea is made of 1–2 g of the herb and taken up to four times per day. Pure alkaloid (sparteine) is used in modern medicine for uterus contraction and as anti-arrhythmic.

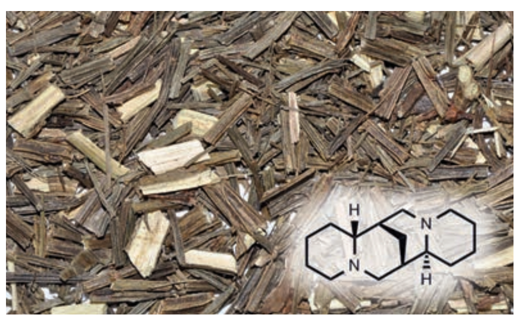
ORIGIN Europe. Product is wild-harvested. Ornamental cultivars are grown as garden plants.

BOTANY Shrub (to 2 m); leaves small, trifoliolate; flowers yellow; pods flat, few-seeded.

CHEMISTRY Quinolizidine alkaloids: **sparteine** (the main compound in stems) and several others.

PHARMACOLOGY Sparteine is responsible for the beneficial effects in regulating circulation. It is an anti-arrhythmic and has a positive inotropic effect.

TOXICOLOGY The alkaloids are relatively poisonous (and abortive) and should be used only under medical supervision. Sparteine: LD_{50} (mouse) = 360 mg/kg (i.p.), 220 mg/kg (p.o.).



Cytisus scoparius (L.) Link [= *Sarothamnus scoparius* (L.)Wimmer ex Koch] (Fabaceae); *genêt à balai* (French); *Besenginster* (German); *ginestra scopareccia* (Italian)

Daphne mezereum

mezereon

CLASSIFICATION Cell toxin, extremely hazardous (Ia). TM: Europe (now obsolete).

USES & PROPERTIES The bark (*Daphneae cortex*) has been used as a remedy for skin disorders, while fruits had traditional uses as purgative and emetic, and as a treatment for pain and cancer. The use of the herb is now obsolete because of the risk of acute toxicity.

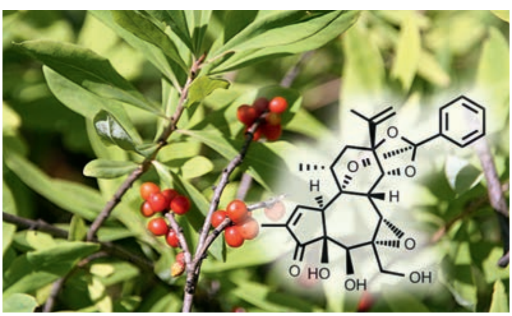
ORIGIN Europe and western Asia. Plants are grown as ornamental garden shrubs.

BOTANY Deciduous shrub (to 1.5 m); flowers pink, fragrant; fruit fleshy, pea-sized, bright red.

CHEMISTRY Phorbol esters of the daphnane type (in all parts except the fruit pulp): **daphnetoxin** and mezerein are the main compounds. Also present are coumarins (daphnin, umbelliferone).

PHARMACOLOGY Daphnetoxin and mezerein are cellular poisons, co-carcinogens, abortifacients and skin irritants (skin inflammation and blisters).

TOXICOLOGY The seeds of about 10 fruits can be lethal for adults (two or three for children). Daphnetoxin: LD_{50} = 0.27 mg/kg (mouse, p.o.).



Daphne mezereum L. (Thymelaeaceae); *mézeréon*, *bois jentil*, *bois joli* (French); *Gemeiner Seidelbast* (German); *mezereo* (Italian)

Datura stramonium

thorn-apple • Jimson weed

CLASSIFICATION Neurotoxin, extremely hazardous (Ia). TM: South and North America, Africa, Europe, Asia. Pharm., PhEur8. MM: alkaloids.

USES & PROPERTIES Leaves (*Stramonii folium*) or seeds (*Stramonii semen*) are used as topical analgesics to reduce pain and in mixtures to treat asthma and cough. Ear patches are used to treat motion sickness and pure alkaloid as spasmolytic and mydriatic for eye examinations. *Datura* is well known as a narcotic drug and hallucinogen.

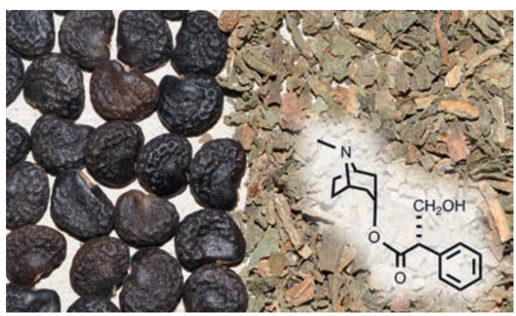
ORIGIN Tropical North America (widely naturalised and an invasive weed of cultivation).

BOTANY Annual herb (to 1.5 m); leaves pungent; flowers tubular, white or purple; fruit a spiny capsule; seeds small, black.

CHEMISTRY Tropane alkaloids: **hyoscyamine** (70%) and scopolamine (20%). Hyoscyamine converts to atropine (the racemic mixture).

PHARMACOLOGY The alkaloids: parasympatholytic, with analgesic, sedative and intoxicant effects.

TOXICOLOGY Extremely toxic. Lethal dose in adults: 10 mg (atropine); 2–4 mg (scopolamine).



Datura stramonium L. (Solanaceae); *stramoine* (French); *Stechapfel* (German); *stramonio* (Italian); *estramonio* (Spanish)

Daucus carota

wild carrot

CLASSIFICATION TM: Europe, Asia. DS: juice.

USES & PROPERTIES Aerial parts (*Dauci carotae herba*), dried roots (*Dauci carotae radix*) or fruits (*Dauci carotae fructus*) are used (2–4 g, 3 times per day) as diuretic, anthelmintic and carminative medicine (bladder and kidney ailments: urinary calculus, gravel, lithuria and cystitis). It is also used to treat indigestion, flatulence and gout. Carrot juice (both orange and purple) has become a popular health drink and functional food.

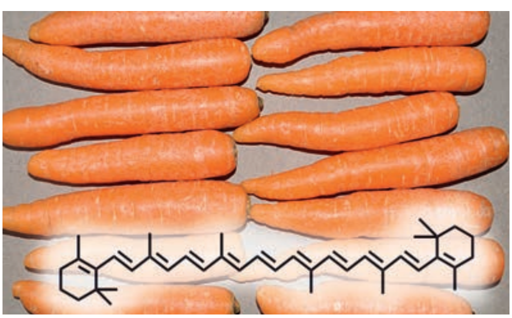
ORIGIN Europe, Asia (naturalised in temperate areas); carrot (subsp. *sativa*) is grown as vegetable.

BOTANY Biennial herb; leaves compound, feathery; fruits bristly; roots are fibrous (subsp. *carota*).

CHEMISTRY The herb: flavonoids, polyacetylenes and furanocoumarins; fruits: flavones, essential oil (terpinen-4-ol and others). **Carotene** (as a precursor of vitamin A) in orange carrots; anthocyanins in the purple type, nowadays used for juice.

PHARMACOLOGY Terpinen-4-ol may be responsible for the diuretic effect.

TOXICOLOGY No toxicity at moderate doses.



Daucus carota L. (Apiaceae); *carotte* (French); *Wilde Möhre* (German); *carota* (Italian)

Derris elliptica

tuba root • derris root

CLASSIFICATION Cell toxin, hazardous (Ib).

USES & PROPERTIES The roots are traditionally used as a natural insecticide and fish poison. It has also been used for suicide and abortion. *Derris* root powder is a source of pure rotenone and it is used as a biopesticide.

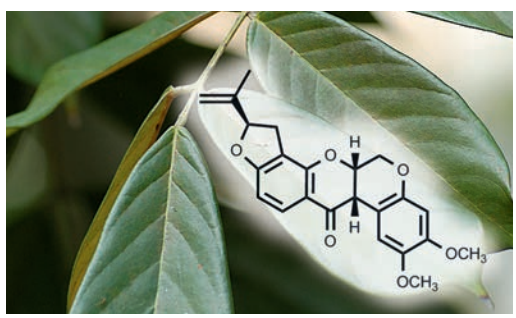
ORIGIN Tropical Asia. It is cultivated in tropical regions for the production of rotenone.

BOTANY Woody climber with thick roots; leaves large, compound; flowers white and pink; fruit a narrowly winged pod. The roots are aromatic and have a slightly sour, metallic taste.

CHEMISTRY The characteristic compounds in *Derris* are isoflavones. Rotenone is the main compound (up to 16% in the dry root).

PHARMACOLOGY **Rotenone** inhibits the mitochondrial respiratory chain, thus blocking cellular, neurological and muscular activity.

TOXICOLOGY Derris powder is more toxic to invertebrates than vertebrates. The toxicity is enhanced when oil is used as a carrier. Rotenone: LD_{50} = 2.8 mg/kg (mouse, i.v.).



Derris elliptica (Wall.) Benth. (Fabaceae); *derris* (French); *Tubawurzel* (German)

Dichapetalum cymosum

poison leaf

CLASSIFICATION Cell toxin, hazardous (Ia).

USES & PROPERTIES The plant is extremely poisonous and has formerly been used to destroy vermin such as monkeys and rats. It is one of the most important causes of stock and game losses in southern Africa.

ORIGIN Africa (endemic to southern Africa).

BOTANY Deciduous woody, deep-rooted shrub with massive permanent branches below the ground; leaves on annual short shoots that emerge early in spring; flowers white; fruit fleshy, orange.

CHEMISTRY **Monofluoroacetic acid** occurs in all parts of the plant but especially newly emerging leaves in spring (when limited other fodder is available). It is converted to highly toxic fluorocitrate in the body of animals.

PHARMACOLOGY Fluoroacetic acid interferes with the Krebs cycle and causes a fatal disruption of cellular respiration.

TOXICOLOGY Monofluoroacetic acid: the lethal oral dose is less than 0.5 mg/kg in humans and most animals.

Dichapetalum cymosum (Hook.) Engl. (Dichapetalaceae); *Giftblatt* (German)

Dictamnus albus

dittany • burning bush

CLASSIFICATION Cell toxin (II). TM: Europe.

USES & PROPERTIES Aerial parts were once used for healing wounds and infections, and for treating epilepsy and convulsions (and to induce abortion).

ORIGIN Europe and Asia. The plant is considered to be the burning bush referred to in the Bible. The volatile oils can be set alight. It is grown in gardens.

BOTANY Evergreen glandular shrub (to 1.2 m); leaves simple, the upper ones pinnately compound; flowers large, in elongated racemes.

CHEMISTRY Furanoquinoline alkaloids: **dictamnine** is the main compound. Also furanocoumarins (e.g. bergapten) and limonoids (e.g. fraxinellon). The essential oil contains mainly limonene.

PHARMACOLOGY The traditional uses suggest antiseptic properties (probably due to the essential oil and the coumarins) but also anticonvulsive effects. Furanocoumarins are phototoxic and mutagenic when activated by prolonged exposure to sunlight. Furanoquinoline alkaloids are cytotoxic.

TOXICOLOGY Dittany is moderately hazardous. Fraxinellon: LD_{50} = 430 mg/kg (mouse, p.o.).

Dictamnus albus L. [=*D. fraxinella* Pers.] (Rutaceae); *dictame blanc*, *fraxinelle* (French); *Diptam* (German); *dittamobianco* (Italian)

Dieffenbachia seguine

spotted dumb cane

CLASSIFICATION Cell toxin, highly hazardous (Ib). TM: South America.

USES & PROPERTIES Stem portions have not only been used for torture but also as contraceptive and as aphrodisiac (and to treat cancer, oedema, skin ailments). Chewing them causes painful swelling of the tongue and throat, and an inability to speak.

ORIGIN South America. Cultivars with attractive leaves are widely grown indoors as pot plants.

BOTANY Perennial herb; stems thick; leaves spotted. Needles of calcium oxalate (raphides) occur in specialised cells and are shot out into skin or mucosal cells when pressure is applied.

CHEMISTRY **Calcium oxalate** raphides in all parts (also cyanogenic glucosides, proteases, saponins).

PHARMACOLOGY Raphides of calcium oxalate cause extreme irritation: they activate the release of histamine, causing swelling and pain. It is likely that other irritant compounds also enter the cells.

TOXICOLOGY Lethal dose in humans: 5–15 g of oxalic acid (3–4 g of leaves). Severe damage to eyes and kidneys (if oxalic acid is deposited in tubules).

Dieffenbachia seguine (Jacq.) Schott [= *D. maculata* (Lodd.) Bunting] (Araceae); *pédiveau vénéneux* (French); *Dieffenbachie* (German)

Digitalis lanata

Grecian foxglove • woolly foxglove

CLASSIFICATION Heart toxin, extremely hazardous (Ia). TM: Europe. Pharm., PhEur8. MM: heart glycosides.

USES & PROPERTIES Leaves (*Digitalis lanatae folium*) have long been used as a heart stimulant to treat oedema (dropsy) and other symptoms of cardiac insufficiency. Carefully controlled doses of pure glycosides are used in modern medicine. Self-medication can have fatal results!

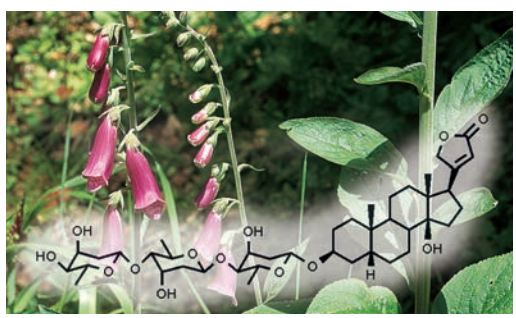
ORIGIN Europe (popular gardens plants).

BOTANY Perennial herb; leaves smooth; flowers yellow and white; bracts and calyx hairy. *D. purpurea* (top right and below) and *D. lutea* have also been used.

CHEMISTRY Cardiac glycosides: digoxin is a main compound in *D. lanata* (**digitoxin** in *D. purpurea*).

PHARMACOLOGY Heart glycosides selectively inhibit Na^+, K^+-ATPase resulting in an increased force of contraction of the heart muscle.

TOXICOLOGY Heart glycosides are very poisonous and have been the cause of human fatalities through accidents, suicide or murder. Lethal dose in humans: 2.5–5 g of dried leaf (2–3 fresh leaves).



Digitalis lanata Ehrh. [Plantaginaceae (formerly Scrophulariaceae)]; *digitale laineuse* (French); *Wolliger Fingerhut* (German); *digitale lanata* (Italian)

Dioscorea villosa

wild yam

CLASSIFICATION Cell toxin (Ib). TM: South America, Africa. Pharm. MM: steroid hormones.

USES & PROPERTIES The tuberous rhizomes (*Dioscoreae tuber*) are used in traditional medicine as expectorant, anti-inflammatory, antispasmodic and cholagogue. They have been used to treat bilious colic and rheumatism. The herb has no contraceptive or steroidal uses but is a source of starting materials to synthesise oral contraceptives (steroidal hormones) which are standardised prescription medicines, used only under medical supervision.

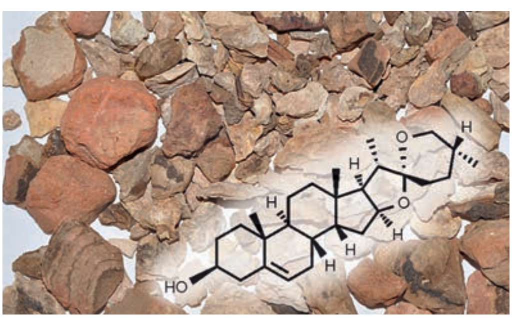
ORIGIN Africa, Asia.

BOTANY Perennial climber; rhizome tuberous; leaves green above, silvery below; flowers small.

CHEMISTRY Steroidal saponins: **diosgenin** as the aglycone (used as starting materials for steroidal hormone semi-synthesis). Alkaloids are also present (possible sedative effects).

PHARMACOLOGY Steroidal hormones have contraceptive and anti-inflammatory activities.

TOXICOLOGY The alkaloids are highly toxic. Dioscorine: LD_{50} = 60 mg/kg (mouse, i.p.).



Dioscorea villosa L. (Dioscoreaceae); *igname sauvage, racines de colique* (French); *Zottige Yamswurzel* (German); *dioscorea* (Italian)

Drimia maritima

sea squill • sea onion

CLASSIFICATION Cell toxin (Ia). TM: Europe. Comm.E+, PhEur8. MM: cardiac glycosides.

USES & PROPERTIES The sliced and dried inner bulb scales (*Scillae bulbus*) are a traditional heart tonic in Europe and have been used as a diuretic and expectorant. In phytotherapy, standardised powder with 0.15–2% cardiac glycosides is used as heart tonic (NYHA I and II) and diuretic (but only under professional supervision).

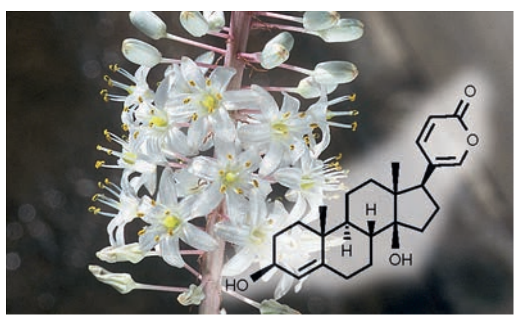
ORIGIN Mediterranean Europe. (Previously known as *Urginea maritima*.)

BOTANY Perennial bulb; leaves broad; flowers white, in multi-flowered racemes.

CHEMISTRY Cardiac glycosides (bufadienolide type): glucoscillaren A and scillaren A are major compounds (glycosides of **scillarenin**).

PHARMACOLOGY Bufadienolides increase the force and efficiency of contraction of the heart muscle. They also have expectorant, diuretic and emetic activity.

TOXICOLOGY The heart glycosides are very poisonous and high doses can lead to coma and death.



Drimia maritima (L.) Stearn [= *Urginea maritima* (L.) Baker] [Asparagaceae (formerly Hyacinthaceae)]; *scille maritime* (French); *Meerzwiebel* (German); *squilla* (Italian)

Drosera rotundifolia

sundew

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES The whole herb (*Droserae herba*) is traditionally used to treat cough (especially dry cough and whooping cough), as well as dyspepsia and stomach cramps. The recommended daily dose is 3 g of the dry herb. Externally it has been applied to treat skin ailments. Sundew is included in some commercial cough syrups.

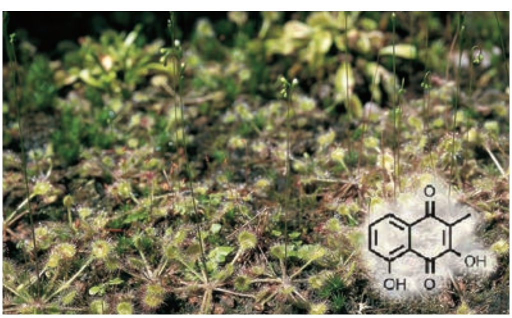
ORIGIN Europe (*D. rotundifolia*). Alternative sources include *D. ramentacea* (Madagascar) and *D. peltata* (China). The source is not always clear.

BOTANY Small perennial herb; leaves with sticky red glandular hairs; flowers small, white.

CHEMISTRY Naphthoquinones (up to 1%): mainly ramentaceone, **droserone** and plumbagin.

PHARMACOLOGY Naphthoquinones: anti-inflammatory, antispasmodic and antitussive effects are known. They are broncholytic and secretolytic and therefore effective for a dry cough. Plumbagin has antibiotic activity at low concentrations.

TOXICOLOGY Naphthoquinones can be mutagenic. Safe to use at recommended doses.



Drosera rotundifolia L. (Droseraceae); *rossolis à feuilles rondes* (French); *Rundblättriger Sonnentau* (German); *rosolida*, *rorella* (Italian)

Duboisia myoporoides

corkwood duboisia

CLASSIFICATION Neurotoxin, hallucinogen, highly hazardous (Ib). TM: Australia. Pharm. MM: pure alkaloids.

USES & PROPERTIES The leaves have been used in Australian traditional medicine to treat pain and were smoked and chewed as stimulant. The plant has become a commercial source of tropane alkaloids, which are extracted from the leaves.

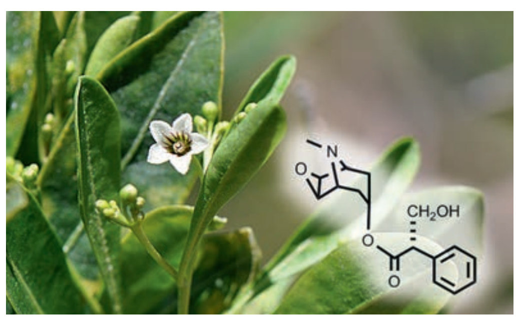
ORIGIN Australia and New Caledonia (commercial cultivation in New South Wales).

BOTANY Small tree (to 12 m); leaves clustered at the branch ends; flowers small, white.

CHEMISTRY Tropane alkaloids (to 2% in leaves): the main compound is **scopolamine** (=hyoscine). Also present are pyridine and piperidine alkaloids (nicotine, nornicotine and anabasine).

PHARMACOLOGY Scopolamine: CNS sedative and depressant at low doses, intoxicating and hallucinogenic at high doses.

TOXICOLOGY The alkaloids are very poisonous and potentially lethal. Scopolamine: lethal dose in humans is 100 mg; LD_{50} = 163 mg/kg (mouse, i.v.).



Duboisia myoporoides R. Br. (Solanaceae); *duboisie* (French); *Duboisia*, *Korkholz* (German)

Ecballium elaterium

squirting cucumber

CLASSIFICATION Cell toxin, highly hazardous (Ib); TM: Europe.

USES & PROPERTIES The fruits have been used in former times as a drastic purgative and anti-inflammatory medicine.

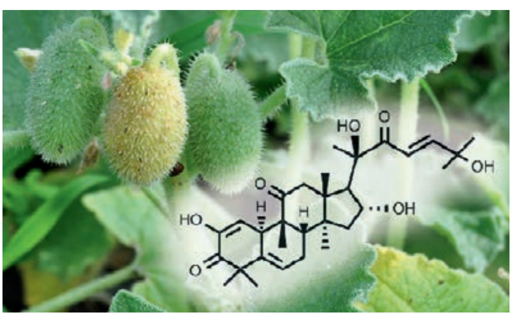
ORIGIN Europe (Mediterranean), Australia and western Asia (introduced to Central America).

BOTANY Trailing perennial herb; leaves hairy; flowers yellow; fruits ellipsoid and bristly. The plant is called squirting cucumber because the content of the fruit comes under pressure as the fruit ripens and is then forcefully ejected.

CHEMISTRY Cucurbitacins (bitter triterpenoids): **cucurbitacin I** and E are examples. The yield is up to 2.2% of fresh weight.

PHARMACOLOGY Cucurbitacins are extremely bitter and very poisonous. Some of them inhibit cell division and are therefore cytotoxic (but too toxic to use for their antitumour activity).

TOXICOLOGY Extremely poisonous: 0.6 ml of fruit juice can be lethal to humans. Cucurbitacin B: LD_{50} = 5 mg/kg (mouse, p.o.).



Ecballium elaterium (L.) A. Rich (Cucurbitaceae); *concombre sauvage* (French); *Spritzgurke* (German); *cocomero asinino* (Italian)

Echinacea pallida

pale purple coneflower

CLASSIFICATION TM: North America, Europe. Comm.E+, ESCOP 6, WHO 1, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES The fresh or dried roots (*Echinaceae pallidae radix*) are used as general tonic and immune stimulant, for supportive treatment of colds and influenza.

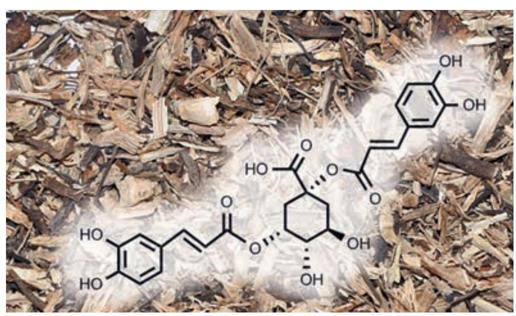
ORIGIN North America (central parts). Roots of *E. angustifolia* (top right) have similar properties.

BOTANY Perennial herb (to 0.8 m); leaves narrow, basal; flower heads pale purple, on long stalks.

CHEMISTRY The roots contain polysaccharides, alkamides (e.g. echinaceine), polyacetylenes (e.g. ponticaepoxide) and antioxidant caffeic acid derivatives (e.g. **cynarin**, unique to *E. pallida*).

PHARMACOLOGY The product is considered to have immune stimulant activity (ascribed to the polysaccharides, based on *in vitro* studies only). Various compounds possibly act in synergy. Clinical studies on flu patients showed a reduction in recovery time.

TOXICOLOGY Safe to use at recommended doses.



Echinacea pallida (Nutt.) Nutt. (Asteraceae); *échinacée* (French); *Blasser Sonnenhut* (German); *rudbeckia, pigna rossa* (Italian)

Echinacea purpurea

echinacea • purple coneflower

CLASSIFICATION TM: North America, Europe. Comm.E+, ESCOP 6, WHO 1, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES The whole herb (*Echinaceae purpureae herba*), root (*Echinaceae purpureae radix*) or juice from fresh herb (6–9 ml per day) are used in supportive treatment of colds and infections of the respiratory and urinary tract. Externally, it is used to treat wounds and ulcers.

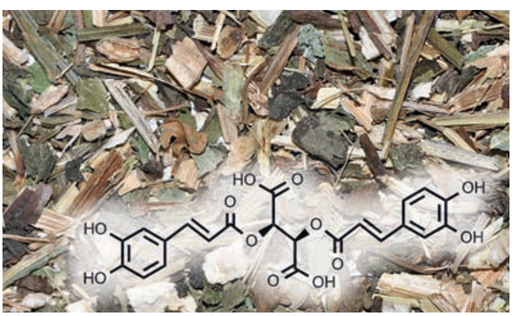
ORIGIN North America (widely cultivated).

BOTANY Perennial herb (to 1 m); leaves broad, bristly; flower heads purple, on short stalks.

CHEMISTRY The products contain characteristic polysaccharides, caffeic acid derivatives (with **cichoric acid** as main compound), polyacetylenes and akylamides (isobutylamides, e.g. echinaceine).

PHARMACOLOGY The immune stimulant activity is ascribed to polysaccharides. Chicoric acid and echinaceine are probably antimicrobial and anti-inflammatory. Clinical studies showed a reduction of infections and cold symptoms.

TOXICOLOGY No serious side effects are known.



Echinacea purpurea (L.) Moench (Asteraceae); *échinacée, rudbeckie poupre* (French); *Purpur-Sonnenhut* (German); *rudbeckia rossa*, *echinacea* (Italian)

Elettaria cardamomum

cardamom

CLASSIFICATION TM: Asia (India), Europe. Pharm., Comm.E+, WHO 4.

USES & PROPERTIES Fruits and seeds (*Cardamomi fructus*) or seed oil (*Cardamomi aetheroleum*) are used, rarely the rhizomes. Seeds are an important spice but also an aphrodisiac in Ayurvedic medicine: used to treat bad breath, respiratory ailments (cough, asthma, bronchitis), digestive problems, as reputed cholagogue (for nausea, griping, stomach pain, flatulence) and urinary complaints.

ORIGIN Asia (India and Sri Lanka). Cultivated in tropical countries (India, Indonesia, Malaysia).

BOTANY Leafy perennial herb; fruit a many-seeded, 3-valved capsule; seeds brown, warty.

CHEMISTRY The seeds contain essential oil (4%) with **1,8-cineole** as main compound.

PHARMACOLOGY The essential oil has antimicrobial and spasmolytic activities. Extracts were shown to stimulate the excretion of bile and gastric juices in animals.

TOXICOLOGY Non-toxic (edible).

Elettaria cardamomum (L.) Maton (Zingiberaceae); *cardamomier* (French); *Grüner Kardamom, Kardamompflanze* (German); *cardamomo* (Italian); *ela* (Sanskrit)

Eleutherococcus senticosus

Siberian ginseng • eleuthero

CLASSIFICATION TM: Asia; Comm.E+, ESCOP, WHO 2, PhEur8, HMPC.

USES & PROPERTIES Dried rhizomes and roots (*Eleutherococci radix*) are used as adaptogenic tonic to reduce stress and fatigue, to improve convalescence and to reverse the symptoms of age-related decreases in physical and mental capacity.

ORIGIN Northeastern Asia (eastern Siberia).

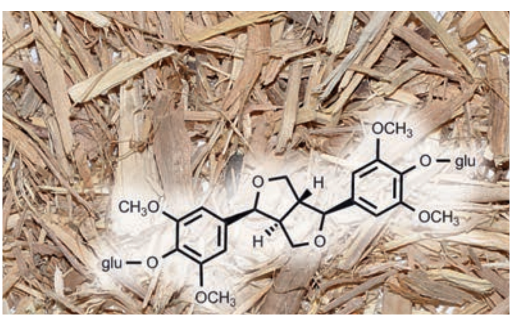
BOTANY Woody shrub; stems spiny; leaves compound; flowers small, arranged in umbels.

CHEMISTRY Complex: coumarins (isofraxidin), lignans and their glycosides (sesamin), phenylpropanoids, triterpene saponins (eleutherosides I–M). An example of a lignan is **eleutheroside D**.

PHARMACOLOGY Animal and human studies indicated improved endurance and stress resistance, similar to real ginseng (see *Panax ginseng*).

TOXICOLOGY Treatment for three months maximum; unsafe for those with high blood pressure.

NOTES An adaptogen has both reducing and increasing biological activities and restores the equilibrium that was disrupted by disease.



Eleutherococcus senticosus (Rupr. & Maxim.) Maxim. (Araliaceae); *éleuthérocoque*, *ginseng de Sibérie* (French); *Stachelpanax*, *Sibirischer Ginseng* (German)

Elymus repens

couchgrass • twitch

CLASSIFICATION TM: Europe. Comm.E+, PhEur8.

USES & PROPERTIES The rhizomes (*Agropyri repentis rhizoma* or *Graminis rhizoma*) are a traditional treatment for inflammation of the respiratory and urinary tracts (to prevent kidney gravel and to alleviate the symptoms of cystitis, urethritis and prostatitis (also gout and rheumatism). Commercial preparations or decoctions (4–9 g of dry rhizome per day) can be taken.

ORIGIN Europe, Asia, North and South America. A cosmopolitan grass and weed.

BOTANY Perennial grass (to 1 m); spikelets small, in two rows on slender unbranched spikes.

CHEMISTRY Polyfructosans: **triticin** as a main compound; essential oil: carvacrol, thymol, carvone); also mucilage, saponins and silica.

PHARMACOLOGY Polysaccharides are often used as diuretics (activity not yet explained). Mucilages have a soothing effect; the essential oil compounds are antimicrobial and perhaps also diuretic.

TOXICOLOGY The herb is safe to use.

Elymus repens (L.) Gould [= *Agropyron repens* (L.) P.Beauv.] (Poaceae); *chiendent officinal* (French); *Gemeine Quecke* (German); *gramigna canina* (Italian)

Ephedra sinica

ephedra • desert tea

CLASSIFICATION Mind-altering, moderately hazardous (II). TM: Asia (China). Pharm., Comm. E+, WHO 1, PhEur8. MM: ephedrine.

USES & PROPERTIES The dried stems (*Ephedrae herba*; *ma huang*) are mostly used, rarely the roots (*Ephedrae radix*; *ma huang gen*). In Chinese traditional medicine, *ma huang* is mainly used to treat bronchitis, asthma and nasal congestion (rhinitis and sinusitis). Nowadays it is a popular ingredient of weight loss products and formulations aimed at improving the performance of athletes.

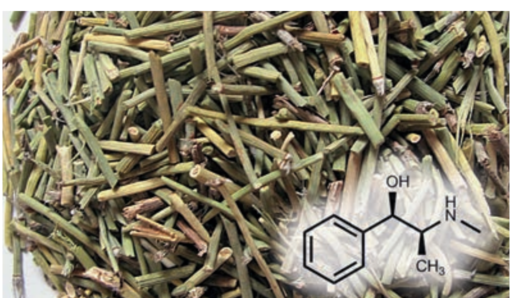
ORIGIN Asia and East Asia (China).

BOTANY Leafless shrub (to 1 m); stems silvery, ribbed; cones fleshy, bright red. Several other species have been used as a source of raw material.

CHEMISTRY Phenylethylalkaloids: **ephedrine** (produced by all *Ephedra* species).

PHARMACOLOGY Ephedrine is a central stimulant; it is also analeptic and bronchodilatory.

TOXICOLOGY Long-term use may lead to dependency. Ephedrine: lethal dose = 4.3 g/kg (mouse, p.o); banned as a dope in sports events.



Ephedra sinica Stapf (Ephedraceae); *ma huang* (Chinese); *ephedra*, *raisin de mer* (French); *Ephedra*, *Meerträubel* (German); *efedra, uva marina* (Italian)

Equisetum arvense

horsetail • field horsetail

CLASSIFICATION TM: Europe, Asia. Pharm.

USES & PROPERTIES Dried stems (*Equiseti herba*) are traditionally used as haemostyptic (to reduce menstrual bleeding) and topically to treat slow healing wounds. Infusions of 2–4 g (6 g per day) are used as diuretic to treat urinary tract infections, kidney gravel and post-traumatic oedema.

ORIGIN Europe, Asia and North America. Raw material (sterile summer branches) are wild-harvested in eastern European countries.

BOTANY Perennial herb with seemingly leafless stems; unbranched fertile stems in early spring; sterile stems with many whorled nodes in summer.

CHEMISTRY The herb contains **silicic acid** (5–8%) and equisetolic acid (a dicarboxylic acid). Also potassium and aluminium salts, and flavonoids (glycosides of quercetin and kaempferol).

PHARMACOLOGY The diuretic and wound-healing activity is ascribed to the silica, potassium salts and the flavonoids.

TOXICOLOGY Safe, except when contaminated with potentially toxic marsh horsetail (*E. palustre*).

Equisetum arvense L. (Equisetaceae); *prêle de champs* (French); *Ackerschachtelhalm* (German); *coda di cavallo*, *equiseto dei campi* (Italian)

Erythroxylum coca

coca plant

CLASSIFICATION Neurotoxin, mind-altering (Ib). TM: South America; MM: alkaloids (derivatives).

USES & PROPERTIES The leaves (*Cocae folium*) are traditionally chewed in the Andean region to counteract fatigue and stress. Source of the alkaloid cocaine (the first commercial anaesthetic, later replaced by synthetic derivatives such as lidocaine). The modern illegal misuse of cocaine is for its stimulant and euphoric effects (thin lines are snorted from a flat surface through a straw).

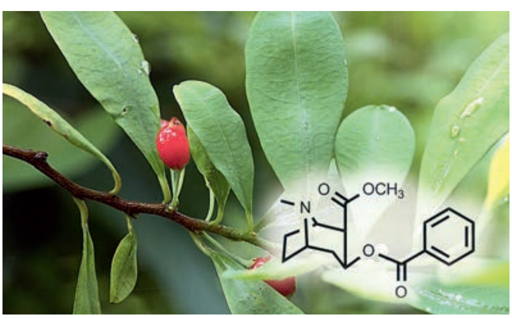
ORIGIN South America (cultivated since ancient times. *E. coca* occurs in Bolivia and Peru; *E. novogranatense* in Colombia, Peru and Venezuela.

BOTANY Woody shrub (to 1 m); leaves simple, glabrous; flower white; fruit a few-seeded drupe.

CHEMISTRY Tropane alkaloids: mainly **cocaine**.

PHARMACOLOGY Cocaine is an illegal intoxicant with local anaesthetic and euphoric effects.

TOXICOLOGY Overdosing on cocaine is often fatal: 1–2 g (p.o.) or 0.2–0.3 g (s.c.); a mere 30 mg can be lethal in sensitive persons. Highly addictive, with strong psychic but no physical dependence.



Erythroxylum coca Lam. (Erythroxylaceae); *cocalier* (French); *Kokastrauch* (German); *coca* (Italian); *cocal* (Spanish)

Eucalyptus globulus

eucalyptus • bluegum

CLASSIFICATION TM: Australia, Europe. Pharm., Comm.E+, ESCOP 6, WHO 2, PhEur8, HMPC.

USES & PROPERTIES Mature (upper) leaves (*Eucalypti folium*) or their essential oil (*Eucalypti aetheroleum*) are mainly used to treat ailments of the respiratory tract (including cough, colds, nasal congestions and bronchial infections). The oil is used topically to treat skin ailments, minor wounds and rheumatism. Small amounts (0.3–0.6 ml per day) can be safely ingested or a tea is made from 1.5–2 g of leaves in 150 ml water.

ORIGIN Australia; commercially cultivated in Spain, Morocco and many other countries.

BOTANY Evergreen tree (to 60 m); mature leaves sickle-shaped, grey; flowers large, solitary, white.

CHEMISTRY Essential oil: **1,8-cineole** is the main compound (also known as eucalyptol). In addition, flavonoids and sesquiterpenes.

PHARMACOLOGY The essential oil is antiseptic and expectorant. The antimicrobial activities of 1,8-cineole and camphor are synergistic.

TOXICOLOGY Safe to use at recommended doses.

Eucalyptus globulus Labill. (Myrtaceae); *eucalyptus* (French); *Eukalyptus*, *Blaugummibaum* (German); *eucalipto* (Italian); *eucalypto* (Spanish)

Eucommia ulmoides

eucommia • Chinese rubber tree

CLASSIFICATION TM: East Asia (China).

USES & PROPERTIES Tea made from the inner bark (*Eucommiae cortex*) is used in Chinese medicine as a kidney and liver tonic and especially as a remedy for high blood pressure. The daily dose is 6–9 g. It is used (often with other Chinese herbs) for pain, sedation and inflammation.

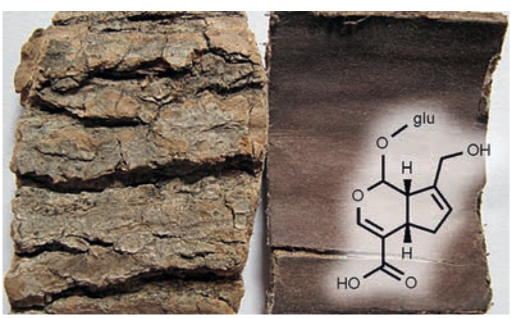
ORIGIN East Asia (endemic to China).

BOTANY Deciduous tree; leaves simple, with latex threads when broken; fruits winged.

CHEMISTRY Iridoid glucosides (especially **geniposidic acid**); lignans (mainly pinoresinol diglucoside), flavonoids and organic acids. The latex/rubber (gutta-percha) content is 6–10%.

PHARMACOLOGY Geniposidic acid reduces blood pressure (and can be used as health food additive for prehypertension). The antioxidant lignan is also claimed to be hypertensive (pinoresinol may be hypoglycaemic). Bark has modest anti-inflammatory activity.

TOXICOLOGY The bark tea is used daily by elderly people in China, with no apparent ill effects.



Eucommia ulmoides Oliv. (Eucommiaceae); *du zhong* (Chinese); *Gummiulme* (German)

Euonymus europaeus

spindle tree • European spindle

CLASSIFICATION Heart toxin, highly hazardous (Ib). TM: Europe, North America.

USES & PROPERTIES Root and stem bark of *Euonymus* species was formerly used to treat ailments of the liver and gall bladder, as well as skin disorders. The timber has many traditional uses (e.g. to make charcoal for gunpowder; violin bows) and the seeds contain a yellow dye (carote-noids) used to colour butter.

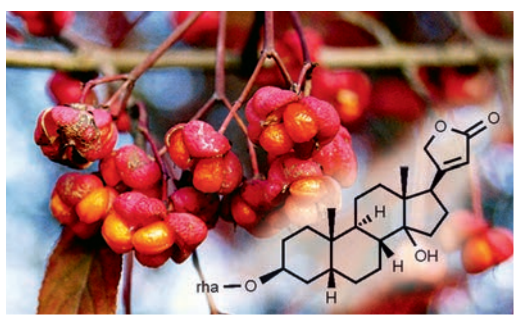
ORIGIN Europe and western Asia.

BOTANY Deciduous shrub or small tree (to 6 m); twigs four-angled; flowers small, greenish-white; fruit a dehiscent capsule; seeds orange, arillate.

CHEMISTRY Cardiac glycosides (cardenolides) such as evonoside, evobioside and **evomonoside**; toxic alkaloids (e.g. evonine); tannins and lectins.

PHARMACOLOGY The cardenolides inhibit Na^+, K^+-ATPase, resulting in cardiac arrhythmia, tachycardia, coma and death.

TOXICOLOGY Evenoside: LD_{50} = 0.84 mg/kg (cat, i.v.). Two fruits can cause severe poisoning in children; 36 are said to be lethal in adults.



Euonymus europaeus L. (Celastraceae); *fusain d'Europe* (French); *Gewöhnliches Pfaffenhütchen* (German); *fusaria commune* (Italian)

Euphorbia peplus

petty spurge • milkweed

CLASSIFICATION Cell toxin (II). TM: Europe, Africa, Asia. MM: diterpene.

USES & PROPERTIES All plant parts contain latex, used to treat skin ailments and cancerous ulcers. A pharmaceutical-grade ingenol mebutate skin gel to treat actinic keratosis has been approved by the US Food and Drug Administration and the European Medicines Agency.

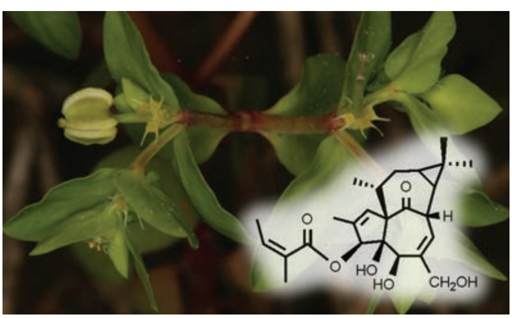
ORIGIN North Africa, Europe and western Asia. A weedy plant of gardens and disturbed places. Naturalised and invasive in many regions, including North America, Australia and New Zealand.

BOTANY Annual herb (to 0.3 m) with white latex; leaves hairless, simple; flowers yellowish green.

CHEMISTRY Diterpene esters (in latex): mainly **ingenol mebutate** (ingenol-3-angelate).

PHARMACOLOGY Ingenol mebutate gel applied for 2–3 days is effective against solar keratoses (premalignant skin lesions caused by the sun).

TOXICOLOGY *Euphorbia* species are potentially lethal (they contain toxic phorbol esters). Topical use may cause irritation which can be severe.



Euphorbia peplus L. (Euphorbiaceae); *euphorbe des jardiniers* (French); *Gartenwolfsmilch* (German)

Euterpe oleracea

acai berry

CLASSIFICATION DS: South America.

USES & PROPERTIES Ripe fruits (and juice) are a traditional Amazon food item, marketed since 2004 as açai, a supplement and health drink (with claims of efficacy in weight loss).

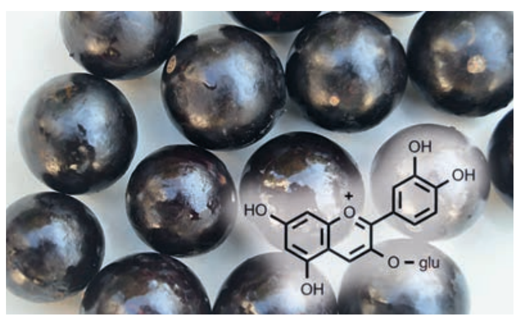
ORIGIN South America (Panama to Brazil). Wild-harvested but also cultivated commercially.

BOTANY Multi-stemmed palm (to 20 m); leaves pinnately dissected (3 m long); fruit a small drupe, purplish black or black (green in one cultivar).

CHEMISTRY The fruit pulp contains moderate quantities of anthocyanins: mainly **cyanidin-3-*O*-glucoside** (with several others). Also present are numerous flavonoids and low levels of resveratrol.

PHARMACOLOGY Anthocyanins: antioxidant and free radical scavenging activity. Convincing scientific evidence for claimed health benefits (and efficacy in weight loss) of açai is not yet available. The antioxidant activity of the juice is lower than that of pomegranate, black grapes and blueberries.

TOXICOLOGY The fruits are used as food and can be safely consumed.



Euterpe oleracea Mart (Arecaceae); *Kohlpalme*, *Açaí-Beere* (German); *açaizeiro* (Portuguese)

Fabiana imbricata

Chilean false heath • pichi

CLASSIFICATION Neurotoxin, mind-altering (II). TM: South America, Europe.

USES & PROPERTIES The twigs and leaves were traditionally used in Chile and in Europe as diuretic and to treat ailments of the kidneys and urinary tract, including cystitis and gonorrhoea. South American Indians inhaled smoke from the dried twigs as an intoxicant.

ORIGIN South America (cultivated as a garden shrub in many parts of the world).

BOTANY Evergreen shrub (to 2 m); leaves ericoid; flowers tubular, pale purple or white.

CHEMISTRY Quinoline alkaloids: **fabianine**. Also present are essential oil, anthraquinones (physcione), sesquiterpenes (3,11-amorphadien and others), coumarins and flavonoids.

PHARMACOLOGY Fabianine can modulate neuroreceptors, resulting in euphoria. Extracts have antibacterial, diuretic and bitter tonic effects.

TOXICOLOGY Fabianine has a very low toxicity (up to 5 g extract per kg body weight had limited effects on rats).

Fabiana imbricata Ruiz & Pav. (Solanaceae); *fabiane imbriquée* (French); *Fabiane* (German); *pichi-pichi* (Italian); *pitchi, pichi romero* (Spanish)

Fagopyrum esculentum

buckwheat

CLASSIFICATION TM: Europe. Pharm., PhEur8. MM: rutin.

USES & PROPERTIES Dried aerial parts (*Fagopyri herba*) are traditionally used to treat the symptoms of capillary and venous insufficiency (bleeding, bruising, haemorrhoids, retinal haemorrhage, varicose veins and poor circulation).

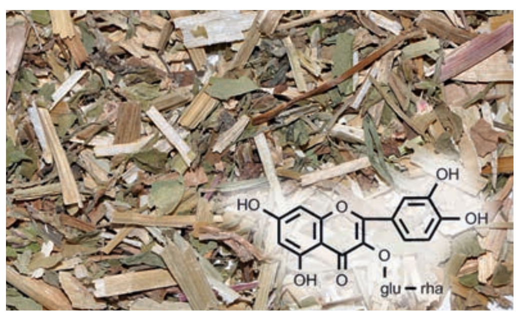
ORIGIN Central and northern Asia. Buckwheat is widely cultivated as a food plant and is also a natural source of rutin (up to 8% in special cultivars).

BOTANY Annual herb (to 0.7 m); leaves heart-shaped; flowers white; fruits small, angular nutlets.

CHEMISTRY Flavonoids (so-called bioflavonoids): mainly **rutin** (quercetin-3-rutinoside). Flowers and seed husks contain fagopyrine (a diathrone).

PHARMACOLOGY Rutin and other antioxidant flavonoids have venotonic and vascular protective activity. They improve the elasticity of veins and enhance circulation.

TOXICOLOGY Aerial parts are non-toxic in small doses. Buckwheat has become popular as a functional food and dietary supplement.



Fagopyrum esculentum Moench (Polygonaceae); *sarrasin* (French); *Echter Buchweizen* (German); *grano saraceno* (Italian)

Ferula assa-foetida

asafoetida • devil's dung

CLASSIFICATION TM: Asia, Europe. Pharm.

USES & PROPERTIES Oleoresin (*Asafoetida*) obtained as solidified secretions from incisions on the upper parts of the roots, is used in traditional medicine to treat colic, dyspepsia and flatulence, as well as bronchitis, coughs and nervous disorders. It is used topically as counter-irritant for relief of pain and itching. The daily dose is 1 g of the powdered gum taken three times per day.

ORIGIN Asia (western Iran). *Ferula foetida* (eastern Iran to Pakistan and India) has perhaps become the main source of gum. It is used as a spice.

BOTANY Robust perennial (monocarpic) herb; leaves grey, deeply lobed; flowers in umbels.

CHEMISTRY The oleoresin is chemically complex, with disulfides, polysulfanes and sesquiterpenes. The powerful odour is ascribed to the sulfur compounds (the *E* and *Z* isomers of ***sec*-butyl propenyl disulfide** are usually main compounds).

PHARMACOLOGY Carminative, antispasmodic and expectorant activities have been described.

TOXICOLOGY Non-toxic in small doses.

Ferula assa-foetida L. (Apiaceae); *férule persique, ase fétide* (French); *Asant, Stinkasant, Teufelsdreck* (German); *assafetida* (Italian)

Filipendula ulmaria

meadowsweet • queen-of-the-meadow

CLASSIFICATION TM: Europe, Asia. Pharm., Comm.E+, ESCOP, PhEur8, HMPC.

USES & PROPERTIES Dried flowering herb (*Spiraeae herba*) or flowers (*Spiraeae flos*) are traditionally used to treat fevers and colds. It is a diuretic used to treat arthritis, rheumatism and many other ailments. The famous aspirin (Aspirin™) is named after *Spiraea ulmaria* (an older name).

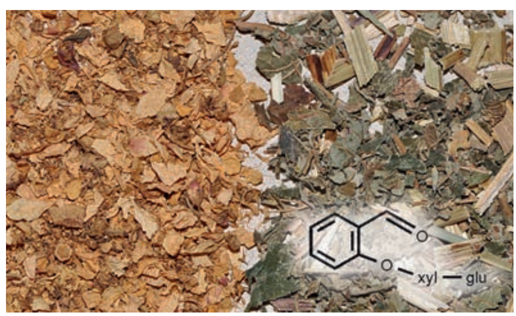
ORIGIN Europe and Asia (wet places); naturalised in North America.

BOTANY Perennial shrub; leaves compound; flowers white, in flat-topped corymbs.

CHEMISTRY Volatile oil is rich in methyl salicylate and salicylaldehyde (present in the intact plant as glycosides: monotropitin and **spiraein**, respectively). Also present are flavonoids (to 6% in flowers; spiraeoside, rutin); gallotannins and ellagitannins.

PHARMACOLOGY Salicylates are anti-inflammatory, analgesic and antirheumatic. Tannins: astringent, antimicrobial and anti-inflammatory.

TOXICOLOGY Side effects may occur (use only under medical supervision).



Filipendula ulmaria (L.) Maxim. [= *Spiraea ulmaria* L.] (Rosaceae); *reine des prés* (French); *Echtes Mädesüß* (German); *regina dei prati, olmaria* (Italian)

Foeniculum vulgare

fennel

CLASSIFICATION TM: Europe, Africa, Asia. Comm.E+, ESCOP 1, WHO 3,5, PhEur8, HMPC.

USES & PROPERTIES The small dry fruits (*Foeniculi fructus*) or essential oil are used against cough, dyspepsia, flatulence, griping and menstrual disorders. Fruits are an ingredient of home-made gripe water to treat flatulence in infants. Fennel syrups alleviate the symptoms of chronic cough and respiratory infections. Externally, extracts are used against skin and eye disorders.

ORIGIN Europe (Mediterranean region); fennel is widely cultivated as a culinary herb and has become naturalised in many parts of the world.

BOTANY Perennial herb (to 1.5 m); leaves feathery; flowers yellow; fruit small, dry, ribbed.

CHEMISTRY Essential oil with ***trans*-anethole** (bitter fennel: 30–75%, with 12–33% fenchone; sweet fennel: 80–90%, with 1–10% fenchone). Also flavonoids and furanocoumarins in the fruits.

PHARMACOLOGY Carminative, expectorant, spasmolytic and stimulant properties.

TOXICOLOGY Anethole is toxic in high amounts.

Foeniculum vulgare Mill. (Apiaceae); *fenouil* (French); *Fenchel* (German); *finocchio* (Italian); *hinojo* (Spanish)

Fragaria vesca

wild strawberry

CLASSIFICATION TM: Europe, Asia. Comm.E+.

USES & PROPERTIES Dried leaves, collected during flowering (*Fragariae folium*) are mainly used, rarely the fruit or rhizomes. Wild strawberry leaf is a mild astringent, traditionally taken orally to treat diarrhoea (or gargled for inflammations in the mouth and throat). Leaves and fruits are used to treat urinary tract infections and rheumatic conditions. They are black tea substitutes, bulking agents and ingredients of herbal teas and liqueurs.

ORIGIN Europe and Asia (cultivated for use).

BOTANY Perennial herb; stem stoloniferous; leaves trifoliate; flowers white; fruit fleshy, edible.

CHEMISTRY Condensed tannins and ellagitannins: **agrimoniin** (see page 70) and pedunculagin. Also present are proanthocyanidins, flavonoids (quercetin, rutin) and phenolic acids (salicylic acid, caffeic acid). Rhizomes are rich in tannins (ca. 10%).

PHARMACOLOGY Tannins and proanthocyanidins bond to proteins and are astringent, antidiarrhoeal and anti-inflammatory.

TOXICOLOGY Leaves are non-toxic; fruits edible.

Fragaria vesca L. (Rosaceae); *fraisier des bois* (French); *Walderdbeere* (German); *fragola di bosco* (Italian); *fresera* (Spanish)

Fraxinus excelsior

common ash • European ash

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (manna only), PhEur8, HMPC.

USES & PROPERTIES The bark of young branches (*Fraxini cortex*) is a traditional tonic to treat fever and rheumatism. Ash leaves (*Fraxini folium*) are used as remedy against bladder complaints, minor joint pains and constipation (sometimes included in slimming products). Manna (*Manna canellata*) is a sugary exudate obtained from the bark of manna ash (*F. ornus*).

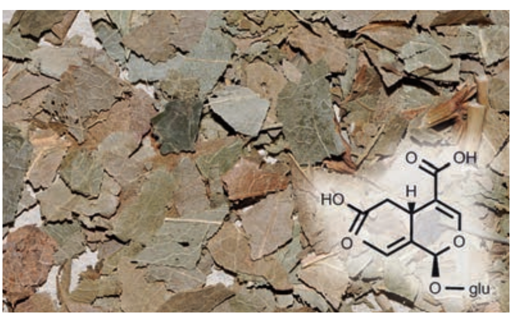
ORIGIN Europe and southwestern Asia.

BOTANY Deciduous tree (to 40 m); buds black; leaves pinnate; flowers small; fruit winged.

CHEMISTRY The bark and leaf are rich in tannins, flavonoids (rutin), coumaroyl glucosides (isofraxidin, aesculin), secoiridoid glucosides (e.g. **oleoside**), triterpenes and phenolic acids (ferulic and sinapic acids). Manna is mainly *D*-mannitol (to 90%).

PHARMACOLOGY The coumarins and iridoids have anti-inflammatory and analgesic activities. Mannitol is an osmotic laxative (retains water).

TOXICOLOGY No harmful side effects are known.



Fraxinus excelsior L. (Oleaceae); *frêne élevé* (French); *Gemeine Esche* (German); *frassino* (Italian); *fresno* (Spanish)

Fumaria officinalis

fumitory

CLASSIFICATION Toxin, mind-altering (II). TM: Europe. Pharm., Comm.E+, ESCOP Suppl., PhEur8, HMPC.

USES & PROPERTIES The dried aboveground parts, collected while flowering (*Fumariae herba*) are traditionally used as diuretic and laxative medicine to treat spasms and discomfort of the gastrointestinal tract, including the gall bladder and bile ducts. An infusion of 2–3 g is taken half an hour before every meal. It can also be used topically against chronic eczema and psoriasis.

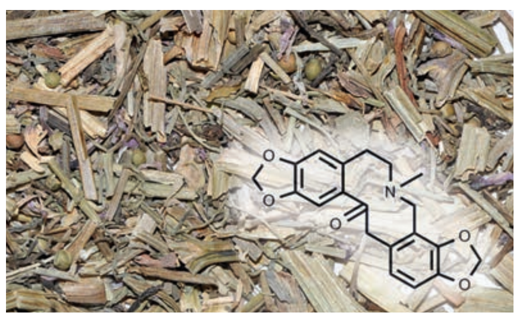
ORIGIN Europe and western Asia.

BOTANY Annual herb; leaves compound, bluish green; flowers pink; fruits small, 1-seeded.

CHEMISTRY Diverse benzylisoquinoline alkaloids (1%): **protopine** (= fumarine) is the main constituent. Also present are fumaric acid and flavonoids.

PHARMACOLOGY Protopine is a cholagogue (but it can apparently reduce or increase bile secretion). Fumaric acid is used as ingredient of preparations to treat psoriasis and eczema.

TOXICOLOGY Safe to use at low doses only.



Fumaria officinalis L. (Papaveraceae); *fumeterre officinale* (French); *Echter Erdrauch* (German); *fumaria*, *cresta di gallo* (Italian)

Galanthus nivalis

common snowdrop • snowdrop

CLASSIFICATION Toxin (II). MM: galanthamine, clinical studies+ (galanthamine).

USES & PROPERTIES The dried and powdered bulb (*Galanthi bulbus*) is used for the extraction of alkaloids. The alkaloid galanthamine and products derived from it is used for treating Alzheimer's disease, one of the most common forms of dementia. Galanthamine also gives symptomatic relief of other neuromuscular conditions such as neuralgia, neuritis, myasthenia gravis and poliomyelitis.

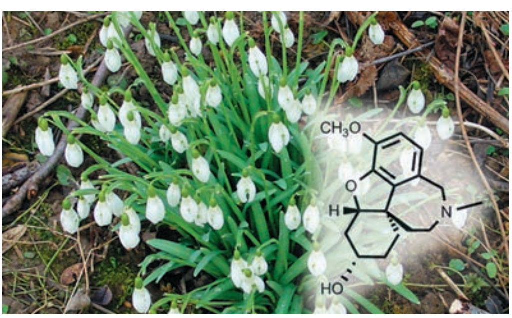
ORIGIN Europe. Naturalised in Britain. An alternative source is *G. woronowii* (western Caucasus).

BOTANY Small bulbous plant; leaves strap-shaped; flowers attractive, white and green, nodding.

CHEMISTRY Amaryllidaceae alkaloids (to 1.6%): **galanthamine** (main compound), occurring with lycorine, galanthine, haemanthamine and others.

PHARMACOLOGY Galanthamine increases the level of acetylcholine, an important neurotransmitter that becomes deficient in some old people.

TOXICOLOGY The alkaloids are very poisonous and can only be used under medical supervision.



Galanthus nivalis L. (Amaryllidaceae); *perce-neige, galanthe des neiges* (French); *Gemeines Schneeglöckchen* (German); *bucaneve, foraneve* (Italian)

Galeopsis segetum

downy hemp-nettle

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES The dried aboveground parts (hemp-nettle herb – *Galeopsidis herba*) are traditionally used as diuretic and for the treatment of cough, bronchitis and catarrh (infusion of 2 g, taken several times a day). The product is incorporated in herbal teas and health care products.

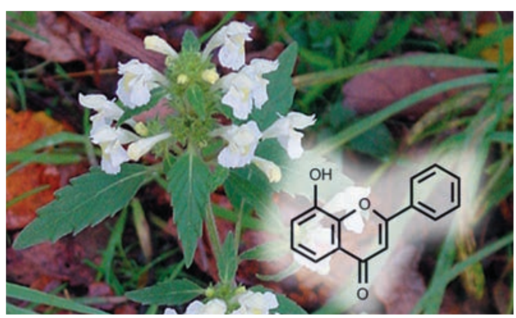
ORIGIN Central and southern Europe.

BOTANY Annual herb (to 0.5 m); leaves opposite, toothed; flowers pale yellow, two-lipped.

CHEMISTRY Large amounts of tannins (5–10%); silicic acid and soluble silicates (1%); **8-hydroxyflavone** and other flavonoids; harpagide and other iridoids.

PHARMACOLOGY The herb has expectorant and astringent activities. The tannins kill microbes by binding to their proteins and enzymes (mucosal cells of the mouth and throat are rapidly replaced). Iridoid glucosides inhibit prostagladin formation and have anti-inflammatory and analgesic effects. Silicic acid is associated with diuretic activity.

TOXICOLOGY The herb is not toxic in low doses.



Galeopsis segetum Necker [= *G. ochroleuca* Lam., *G. dubia* Leers] (Lamiaceae); *galéopsis douteux, chanvre bâtard* (French); *Gelber Hohlzahn* (German); *canapa selvatica* (Italian)

Gaultheria procumbens

wintergreen • checkerberry

CLASSIFICATION TM: North America, Europe.

USES & PROPERTIES Leaves (*Gaultheriae folium*), as infusions or decoctions, and small amounts of essential oil (*Gaultheriae aetheroleum*) are taken orally as tonics and stomachics, but also for rheumatism. Wintergreen oil and ointments are counter-irritants for treating painful joints and muscles. It is also an ingredient of oral hygiene products.

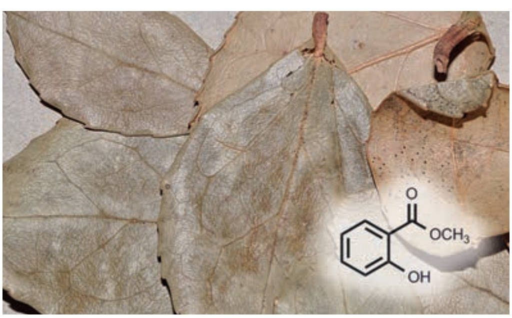
ORIGIN North America (Canada and eastern parts of the USA). The product is mainly wild-harvested.

BOTANY Evergreen, mat-forming shrub; leaves leathery; flowers white or pinkish; fruit edible.

CHEMISTRY Essential oil: almost pure **methyl salicylate** (it occurs in the plant as a glycoside). Leaves contain arbutin and tannins.

PHARMACOLOGY Methyl salicylate, released by hydrolysis of the glycoside in the intestine and liver, has anti-inflammatory and analgesic activities. Arbutin and tannins are also anti-inflammatory.

TOXICOLOGY Use only in small amounts. The lethal dose in adult humans is 30 g of the oil.



Gaultheria procumbens L. (Ericaceae); *gaulthérie du Canada*, *thé des bois* (French); *Niederliegende Scheinbeere*, *Wintergrün* (German); *uva di monte* (Italian)

Gelsemium sempervirens

yellow jasmine

CLASSIFICATION Neurotoxin (Ia). TM: North America. Comm.E.

USES & PROPERTIES Rhizomes and roots (*Gelsemii rhizoma*) are used to extract alkaloids for the treatment of facial and dental neuralgia (intense pain cause by damaged nerves). Included in cough syrups (for asthma and whooping cough) and topically against the pain caused by a pinched nerve. Fresh rhizomes are used in homoeopathy for treating migraine, anxiety and dysmenorrhoea.

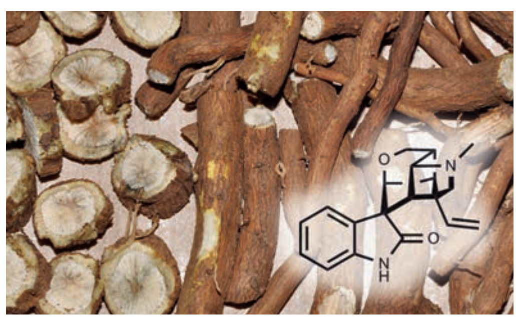
ORIGIN North America (southeastern USA). An attractive and popular ornamental plant.

BOTANY Evergreen climber (vine); leaves opposite, glossy green; flowers bright yellow, tubular.

CHEMISTRY Monoterpene indole alkaloids (0.5%): **gelsemine** (the main compound); also coumarins, iridoids and pregnane-type steroids.

PHARMACOLOGY Gelsemine modulates the glycine receptor (similar to strychnine): it is antispasmodic, analgesic and sedative.

TOXICOLOGY Gelsemine is very poisonous. LD_{50} (mouse) = 4 mg/kg (i.v.) or 1.24 g/kg (p.o.).



Gelsemium sempervirens (L.) J. St-Hil. (Gelsemiaceae); *jasmin sauvage* (French); *Falscher Jasmin*, *Giftjasmin* (German); *gelsemino* (Italian)

Gentiana lutea

yellow gentian

CLASSIFICATION TM: Europe. Comm.E+, ESCOP 4, WHO 3, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES The rhizome and root (*Gentianae radix*) are traditionally used as digestive bitter tonic, cholagogue and stomachic to stimulate appetite and to treat dyspepsia with anorexia. It is used in commercial herbal tinctures, liqueurs and roborants, and in homeopathic preparations.

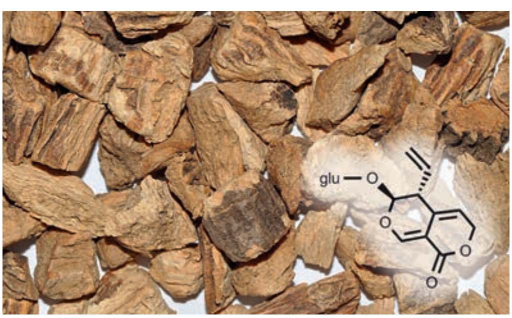
ORIGIN Europe (usually at high elevations).

BOTANY Deciduous perennial herb (to 1.5 m); leaves with prominent veins; flowers yellow, in clusters on a long stalk.

CHEMISTRY Bitter secoiridoids: mainly gentiopicroside (=**gentiopicrin**) (2–3%). The bitter taste is due to a minor compound, amarogentin (bitterness value of 50 000 000). Xanthones (gentisin, gentioside) give the yellow colour to the roots.

PHARMACOLOGY The bitter compounds stimulate (via the *nervus vagus*) the flow of saliva, gastric juices and bile. Gentian root also has antimicrobial, anti-stress and immune-modulatory activities.

TOXICOLOGY Non-toxic at low doses.



Gentiana lutea L. (Gentianaceae); *gentiane jaune* (French); *Gelber Enzian* (German); *genziana maggiore* (Italian)

Ginkgo biloba

ginkgo • maidenhair tree

CLASSIFICATION TM: Asia (China). Comm.E+ (extracts only), ESCOP, WHO 1, PhEur8, clinical studies+.

USES & PROPERTIES The leaves (and seeds) have many traditional uses but special leaf extracts (120–240 mg/day) are nowadays used for treating cerebrovascular insufficiency and symptoms of old age (e.g. sleep disturbances, memory loss, dementia and peripheral arterial occlusive disease).

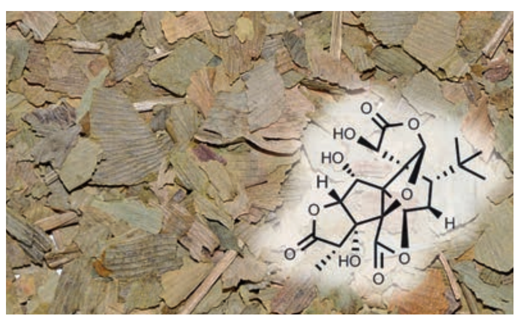
ORIGIN Eastern Asia (China). A popular street tree, commercially cultivated for leaves and nuts.

BOTANY Large tree (to 35 m); leaves bilobed, with striate venation; fruit fleshy; seed (nut) edible.

CHEMISTRY Special extracts are almost devoid of ginkgolic acids but rich in flavonoids (flavonol glycosides and biflavonoids), unique diterpene lactones (**ginkgolide B** and others), a sesquiterpenoid (bilobalide) and oligomeric proanthocyanidins.

PHARMACOLOGY Clinical studies support the efficacy of ginkgo extracts in treating circulatory disorders, tinnitus and dementia.

TOXICOLOGY Safe at prescribed doses.



Ginkgo biloba L. (Ginkgoaceae); *ginkgo* (French); *Ginkgo* (German); *ginkgo biloba* (Italian); *arbol de los escudos* (Spanish)

Gloriosa superba

flame lily • climbing lily

CLASSIFICATION Cell toxin, extremely hazardous (Ia). MM: source of colchicine.

USES & PROPERTIES The rhizomes have been used in traditional medicine (e.g. as abortifacient) but are nowadays mainly used for the extraction of colchicine. The pure alkaloid is used in cytological research and to treat inflammatory conditions (e.g. gout, see *Colchicum autumnalis*).

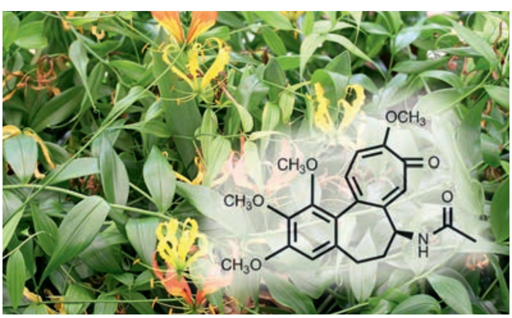
ORIGIN Africa (southern and eastern parts) to South Asia (India). An attractive garden plant.

BOTANY Geophyte; rhizomes fleshy; leaves with climbing tendrils; flowers spectacular, in shades of yellow and red; fruit a capsule; seeds orange.

CHEMISTRY Phenethylisoquinoline alkaloids: **colchicine** is the main compound (2.4% in leaves).

PHARMACOLOGY Colchicine is a well-known spindle poison that disrupts cell division. It has anti-inflammatory and analgesic activities.

TOXICOLOGY Colchicine is extremely poisonous: oral intake of more than 40 mg of the alkaloid results in death within three days, due to fatal respiratory and cardiovascular arrest.



Gloriosa superba L. (Colchicaceae); *superbe de Malabar*, *lis de Malabar* (French); *Ruhmeskrone* (German)

Glycine max

soybean

CLASSIFICATION TM: Europe, Asia (China). Pharm., Comm.E+, PhEur8. DS: lecithin.

USES & PROPERTIES Soy seeds (*Sojae semen*), lecithin and oil (*Lecithinum ex soja*; *Sojae oleum*) are popular dietary supplements used to reduce cholesterol and the symptoms of menopause. Soy lecithin is used for appetite loss, chronic hepatitis, inflammatory bowel disease and acne. It is linked to the low incidence of cancer in East Asian people.

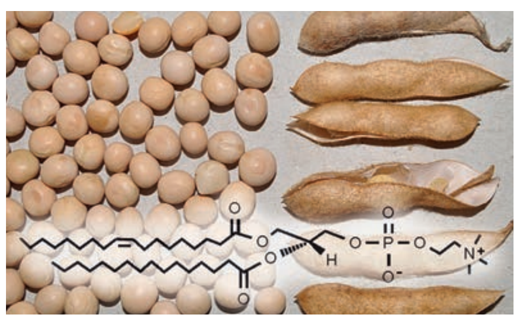
ORIGIN Asia. An old Chinese cultigen.

BOTANY Erect annual herb; leaves trifoliate; flowers minute, pink; fruit a few-seeded pod.

CHEMISTRY Soybean lecithin is a mixture of phospholipids (mainly **phosphatidylcholine**). Soy also has isoflavonoids (3 mg/g, genistein and daidzein), saponins (soyasaponins), omega-3 fatty acids (α-linolenic acid) and lunasin (a peptide).

PHARMACOLOGY Lecithin is a source of choline, an essential nutrient. It lowers blood lipids. Isoflavonoids are phytoestrogenic. Soyasaponins may be antithrombotic and liver-protectant.

TOXICOLOGY Allergy to soy is quite common.



Glycine max (L.) Merr. (Fabaceae); *fève de soja* (French); *Sojabohne* (German); *soia* (Italian)

Glycyrrhiza glabra

liquorice • licorice

CLASSIFICATION TM: Europe, Asia (India). Pharm., Comm.E+, ESCOP, WHO 1, PhEur8, HMPC.

USES & PROPERTIES Dried rhizomes (*Liquiritiae radix*) are traditionally used (as an infusion of 1–1.5 g in 150 ml water) for coughs, catarrh, gastritis, flatulence and chronic gastric and duodenal ulcers. Externally it is applied for relief of sunburn, insect bites, pruritus and piles. It is included in products as active ingredient and as sweetener.

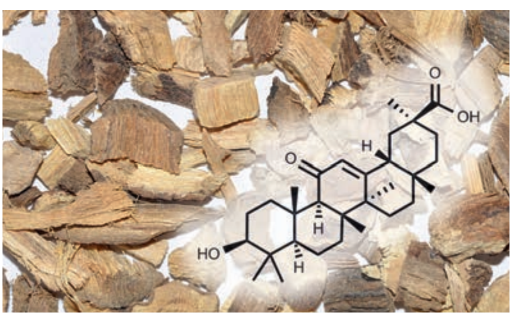
ORIGIN Mediterranean to Central Asia. *Gan cao* or Chinese liquorice (*G. uralensis*) is also used.

BOTANY Perennial herb (to 1 m); rhizomes and stems woody; leaves pinnate; flowers white/purple.

CHEMISTRY Flavonoids (mainly liquiritin); triterpene saponins: glycyrrhizic acid (2–15%), and its aglycone, **glycyrrhetinic acid**.

PHARMACOLOGY The saponins are expectorant, secretolytic and anti-inflammatory. Numerous other activities are associated with liquorice.

TOXICOLOGY Chronic use of large doses: mineralocorticoid effects and high blood pressure.



Glycyrrhiza glabra L. (Fabaceae); *réglisse officinale* (French); *Süßholz*, *Lakritze* (German); *liquirizia* (Italian); *regalicia* (Spanish)

Griffonia simplicifolia

griffonia

CLASSIFICATION TM: West Africa. AHP, clinical studies+.

USES & PROPERTIES Roots, stems and leaves are used in African traditional medicine as poultices for wounds and as anti-emetics, aphrodisiacs and to treat kidney ailments. The main interest is in the seeds: a rich source of 5-hydroxytryptophan. It is used for treating neurological and psychiatric disorders (mostly depression, but also anxiety, insomnia, headaches, migraine and eating disorders). Initial dose: 50 mg, 3 × per day with meals.

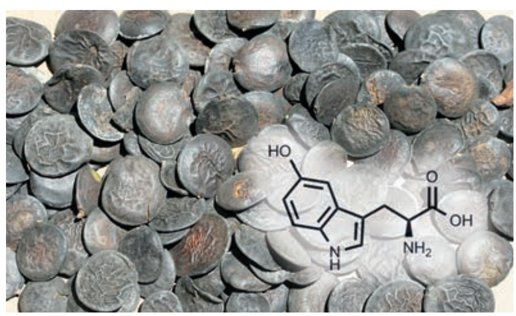
ORIGIN West tropical Africa (mainly Ghana).

BOTANY Woody climber (vine); fruit an inflated pod; seeds disc-shaped, black, 15–20 mm in diam.

CHEMISTRY Seeds contain several indole alkaloids (14 –17% of dry weight), of which **5-hydroxytryptophan** (5-HTP) is the dominant compound.

PHARMACOLOGY 5-HTP increases the levels of serotonin in the brain and central nervous system.

TOXICOLOGY Low toxicity. 5-HTP: LD_{50} = 243 mg /kg (rat, p.o.). Not suitable for self-medication, due to the possibility of severe side effects.



Griffonia simplicifolia (DC.) Baill. (Fabaceae); *griffonia* (French); *Griffonia* (German)

Grindelia squarrosa

curly-cup gumweed • scaly grindelia

CLASSIFICATION TM: North America. Pharm., Comm.E+, ESCOP Suppl., HMPC.

USES & PROPERTIES The dried flowering tops and leaves (gumweed herb – *Grindeliae herba*) are traditionally used to treat coughs, catarrh of the upper respiratory tract, asthma and bronchitis. Externally it is applied for relief of eczema, wounds and skin ailments.

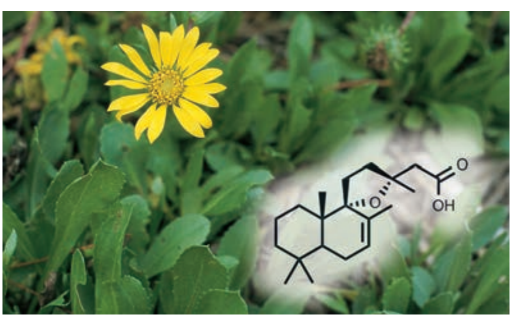
ORIGIN North America (NW parts of the USA). It has become a weed in Britain and Australia.

BOTANY Perennial herb; leaves oblong, toothed; flower heads yellow. *G. camporum* (SW USA and Mexico) is an acceptable alternative source.

CHEMISTRY **Grindelic acid** and other labdane-type diterpenes. Also phenolic acids, essential oil (with borneol, camphor), flavonoids, tannins, polyacetylenes and triterpene saponins.

PHARMACOLOGY The terpenoids are associated with antitussive and spasmolytic effects. Tannins, saponins and the volatile oil probably all contribute to the medicinal value and observed benefits.

TOXICOLOGY Safe to use at appropriate doses.



Grindelia squarrosa (Pursh) Dunal (Asteraceae); *grindélia* (French); *Sperrige Grindelie*, *Gummikraut* (German); *grindelia* (Italian)

Guaiacum officinale

guaiac • lignum vitae

CLASSIFICATION Toxin (II–III). TM: Central and South America, Europe. Comm.E+ (guaiacol).

USES & PROPERTIES The heartwood and sapwood, usually in the form of wood shavings (*Lignum vitae*, *Guaiaci lignum*) are used to treat chronic rheumatism and rheumatoid arthritis. Resin obtained by heating the wood (*Guaiaci resina*) and its essential oil are applied as a circulatory stimulant and for treating painful joints.

ORIGIN Central and South America.

BOTANY Evergreen tree (to 10 m); leaves compound (paripinnate); flowers blue; fruit a capsule.

CHEMISTRY The resin comprises many lignans (α-guaiaconic acid and others), phenolics (guaiacol), volatile oil (mainly guaiol) and triterpenoid saponins. Guaiol is converted to bright blue **guaiazulene** (valuable, used in aromatherapy).

PHARMACOLOGY The resin has anti-inflammatory, antimicrobial and antioxidant activities. Guaiazulene is antiphlogistic (like chamazulene).

TOXICOLOGY Topical use is safe but one of the lignans is suspected of causing renal lithiasis.

Guaiacum officinale L. (Zygophyllaceae); *bois de gaïac*, *bois de vie* (French); *Guajakholzbaum*, *Schlangenholz* (German); *guaiaco*, *legno santo* (Italian); *guajacum*, *palosanto* (Spanish)

Gypsophila paniculata

baby's breath • gypsophila

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES Dried underground parts, known as white soapwort root (*Saponariae albae radix*; *Gypsophilae radix*), are traditionally taken in the form of an infusion (30–150 mg of the herb or 3–15 mg saponins per day) to treat coughs and catarrh of the upper respiratory tract (often also as an ingredient of commercial cough medicines). Topical use is against skin ailments.

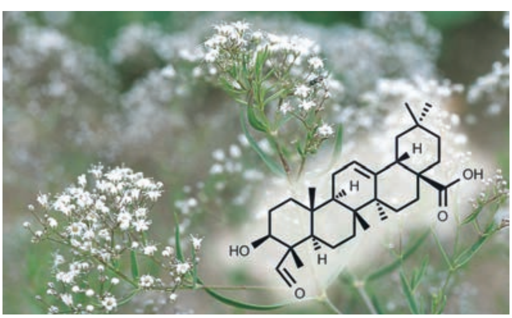
ORIGIN Central Europe to Central Asia.

BOTANY Perennial herb; taproot fleshy; leaves narrow, bluish green; flowers in large panicles.

CHEMISTRY Triterpene saponins (to 20%): mainly saponasides A and D. Hydrolysis of both these bidesmosides yields **gypsogenin** as only aglycone.

PHARMACOLOGY The saponins have secretolytic and antitussive activity: stimulation of the *nervus vagus* in the mucosa of the stomach promotes the secretion of water in bronchia. Because of their haemolytic effect (biomembranes become leaky), they are antimicrobial, spermicidal and cytotoxic.

TOXICOLOGY Oral use is safe at low doses.



Gypsophila paniculata L. (Caryophyllaceae); *gypsophile*, *brouillard* (French); *Schleierkraut*, *Rispiges Gipskraut* (German); *gypsophila* (Italian)

Hamamelis virginiana

witch hazel

CLASSIFICATION TM: North America, Europe. Pharm., Comm.E+, ESCOP 5, WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES The leaves, bark and twigs (*Hamamelidis folium et cortex*) are used against diarrhoea. An infusion of 0.1–1 g of dry herb is taken several times a day. It is also an ingredient of gargles and mouth rinses used for inflammation of the throat and gums, and suppositories to treat haemorrhoids. Ointments and lotions are used for skin and venous disorders (bleeding wounds, bruises, varicose veins and haemorrhoids).

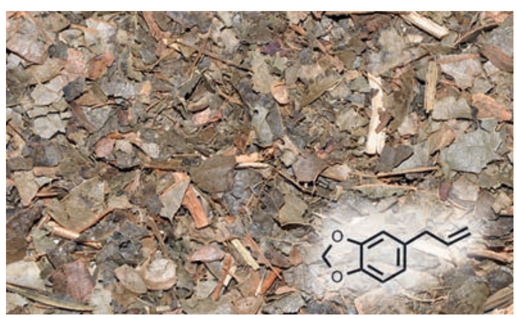
ORIGIN North America (eastern USA, Canada).

BOTANY Shrub/small tree (2–8 m); stems in a zig-zag pattern; flowers yellow; fruit a woody capsule.

CHEMISTRY Tannins (10%): hamamelitannins and catechins in bark, proanthocyanidins, ellagitannins and essential oil (**safrole**, ionone) in leaves.

PHARMACOLOGY The tannins have proven astringent, antiseptic, antihaemorrhagic, anti-inflammatory and antihaemorrhoidal effects.

TOXICOLOGY Saffrole is mutagenic.



Hamamelis virginiana L. (Hamamelidaceae); *hamamélis de Virginie* (French); *Hamamelis*, *Zaubernuss* (German); *amamelide*, *nocciolo delle streche* (Italian)

Harpagophytum procumbens

devil's claw

CLASSIFICATION TM: Africa, Europe. Pharm., Comm.E+, ESCOP 2, WHO 3, PhEur8, HMPC, AHP, clinical studies+.

USES & PROPERTIES Sliced and dried secondary roots (*Harpagophyti radix*) are used against rheumatism, arthritis, muscle pains, low back pain and labour pains. An infusion of 1–3 g is taken up to three times per day. It is a general tonic and stomachic that stimulates appetite and alleviates the symptoms of indigestion. Ointments made from devil's claw are applied to wounds, sores and boils.

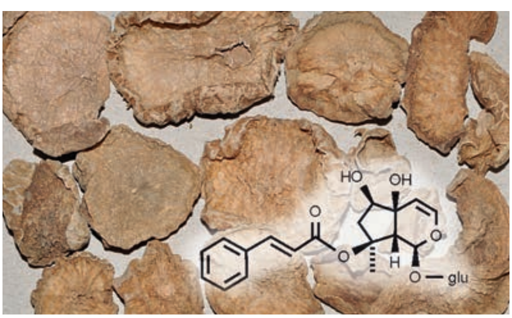
ORIGIN Southern Africa (Kalahari region).

BOTANY Weedy perennial herb; leaves deeply lobed; flowers pink or purple; fruits characteristic, with finger-like thorny projections (the "claw").

CHEMISTRY Iridoid glucosides (3%): mainly harpagoside (0.5–2%), with **harpagide**, procumbide and their cinnamic and coumaric acid esters.

PHARMACOLOGY Bitter tonic, anti-inflammatory and weak analgesic activities are ascribed to the iridoid glucosides (they inhibit cyclooxygenase).

TOXICOLOGY Non-toxic (clinically tested).



Harpagophytum procumbens DC. ex Meissn. (Pedaliaceae); *griffe du diable* (French); *Afrikanische Teufelskralle* (German); *artiglio del diavolo*, *arpagofito* (Italian)

Harungana madagascariensis

haronga

CLASSIFICATION TM: Africa, Europe. Comm.E, AHP.

USES & PROPERTIES Bark and leaves (haronga bark and leaf – *Harunganae madagascariensis cortex et folium*) are used to treat stomach ailments (to stimulate the flow of gastric and pancreatic juices and bile). The daily dose is 7.5–15 mg of dried ethanolic extract (= 25–50 mg of the herb). Commercial preparations are available. Externally it is applied to bleeding wounds, skin diseases, itchy skin and leprosy.

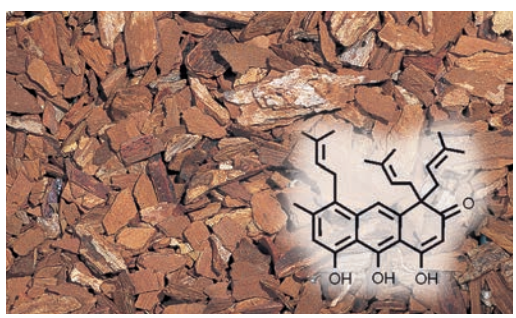
ORIGIN Southern and eastern Africa, Madagascar.

BOTANY Evergreen shrub or small tree (4–7 m); stem sap orange; flowers white; fruit a red drupe.

CHEMISTRY Anthracene derivatives (1,8-dihydroxyanthracenes): **harunganin** and madagascin in the bark, hypericin in leaves. Also tannins (proanthocyanidins, epicatechins), phytosterols.

PHARMACOLOGY The bark and leaves have secretolytic, choleretic, cholekinetic activity. The drug exhibits anthelmintic and abortive properties.

TOXICOLOGY Not safe during pregnancy.



Harungana madagascariensis Lam. ex Poiret (= *Haronga madagascariensis*) (Hypericaceae); *harongana* (French); *Haronga*, *Drachenblutbaum* (German); *aronga* (Italian)

Hedera helix

ivy • common ivy

CLASSIFICATION Cell toxin (II). TM: Europe. Pharm., Comm.E+, ESCOP, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Dried leaves (*Hederae folium*) or extracts: coughs, bronchitis and chronic catarrh. Wood extracts are used in lotions and shampoos for itchy skin and skin disorders and in homoeopathic and anticellulitis products.

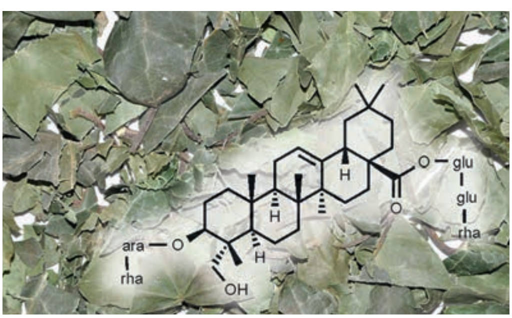
ORIGIN Europe and western Asia.

BOTANY Woody climber; stems with aerial climbing roots; leaves 3–5-lobed, upper ones entire; flowers small, yellow; fruit a small purple berry.

CHEMISTRY Bidesmosidic saponins (5–8%), with **hederacoside C** as main compound (up to 7%). In dried leaves they are converted to monodesmosides. Also polyacetylenes (e.g. falcarinol).

PHARMACOLOGY The saponins are expectorant, spasmolytic and secretolytic (supported by clinical studies). Falcarinol is a well-known skin irritant.

TOXICOLOGY Few or no side effects in adults with doses of up to 400 mg of crude drug per day. Cytotoxic and haemolytic in higher concentrations.



Hedera helix L. (Araliaceae); *lierre grimpant*, *lierre commun* (French); *Efeu* (German); *edera* (Italian); *hiedra* (Spanish)

Helichrysum arenarium

sandy everlasting

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES The flower heads, collected and dried before they open (*Helichrysi flos*) are traditionally used as diuretic tea (3–4 g, 3 × a day) for treating cholecystitis and spasms of the gall bladder and urinary tract. It is also used as a bitter tonic, believed to be useful for dyspepsia. The herb is often added to commercial tea mixtures simply to enhance their appearance.

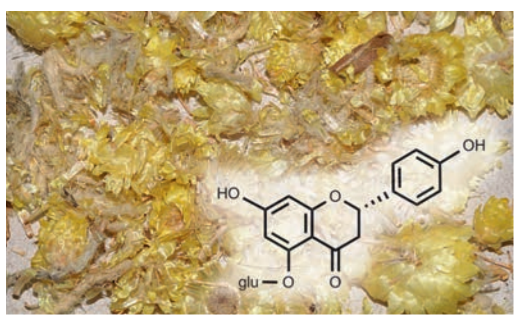
ORIGIN Central, eastern and southern Europe.

BOTANY Small perennial herb; leaves narrow, silver-hairy; flower heads yellow, in cymes.

CHEMISTRY Rich diversity of flavonoids (chalcones, flavanes and flavanols). **Helichrysin A** is a main compound. Isosalipurposide (a chalcone) gives the bright yellow colour. Also arenarin (unidentified, antibacterial) and bitter substances.

PHARMACOLOGY Antibacterial, mild choleretic and spasmolytic effects have been demonstrated. Bitter tonic effects (increased gastric and pancreatic secretions) seem plausible.

TOXICOLOGY No serious side effects are known.



Helichrysum arenarium (L.) Moench. (Asteraceae); *immortelle des sables* (French); *Sand-Strohblume*, *Gelbes Katzenpfötchen* (German); *semprevivo*, *elicriso arenario* (Italian)

Heliotropium arborescens

heliotrope • cherry pie

CLASSIFICATION Liver toxin, neurotoxin, mutagen, moderately hazardous (II).

USES & PROPERTIES All parts of the plant contain pyrrolizidine alkaloids that may cause acute and more often chronic poisoning when ingested. Contamination of cereals with the seeds of *Heliotropium* species and related plants has been the cause of fatal human poisoning.

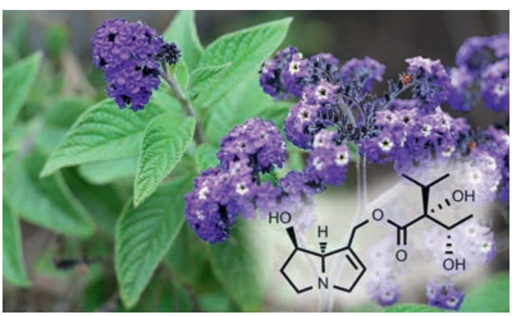
ORIGIN South America (Peru and Ecuador). Widely cultivated as garden shrub for the strong vanilla-like fragrance of the flowers.

BOTANY Perennial shrub (to 2 m); leaves hairy; flowers blue/purple, in scorpioid racemes.

CHEMISTRY The level of pyrrolizidine alkaloids (PAs) in aerial parts is about 0.9% of dry weight: **indicine** (main compound), with smaller amounts of acetylindicine, heliotropine and cynoglossine. Heliotropine is dominant in many species.

PHARMACOLOGY PAs with an unsaturated necine base are activated in the liver, causing damage.

TOXICOLOGY PAs are cumulative liver poisons; they are mutagenic, carcinogenic and teratogenic.



Heliotropium arborescens L. [= *H. peruvianum* L.] (Boraginaceae); *héliotrope*, *fleur des dames* (French); *Vanilleblume*, *Heliotrop* (German); *girasole del Peru* (Italian)

Helleborus viridis

green hellebore

CLASSIFICATION Heart toxin, extremely hazardous (Ia). TM: Europe (obsolete).

USES & PROPERTIES The roots and/or leaves were once used in traditional medicine to treat nausea, constipation, intestinal worms and nephritis. It was also employed as abortifacient. Powdered herb was formerly used in central Europe as sneezing powder (now banned).

ORIGIN Western and central Europe. Several species are cultivated ornamentals, including *H. niger*.

BOTANY Small perennial herb; rhizomes fleshy; leaves compound; flowers nodding, green (white in *H. niger*, photo below); seeds with arils.

CHEMISTRY Heart glycosides of the bufadienolide type (up to 1.5%): **hellebrin** is the main compound. Also present are alkaloids and saponins (and irritant ranunculin in *H. niger*).

PHARMACOLOGY In high doses, bufadienolides can cause fatal cardiac and respiratory arrest. The alkaloids resemble aconitine in their activity.

TOXICOLOGY The LD_{50} of helleborin is 8.4 mg/kg (mouse, i.p.) or a mere 0.1 mg/kg (cat, i.v.).

Helleborus viridis L. (Ranunculaceae); *hellébore vert* (French); *Grüne Nieswurz* (German); *elleboro verde* (Italian)

Herniaria glabra

smooth rupturewort • herniary

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES The dried, aboveground parts (rupturewort herb – *Herniariae herba*) is a traditional diuretic medicine, used to treat bladder and kidney ailments, including chronic cystitis, and urethritis. A decoction of 1.5 g is taken two or three times per day. It is a "blood purifier" that has also been used for respiratory tract infections, arthritis and rheumatism. The generic name suggests that the herb can heal hernias.

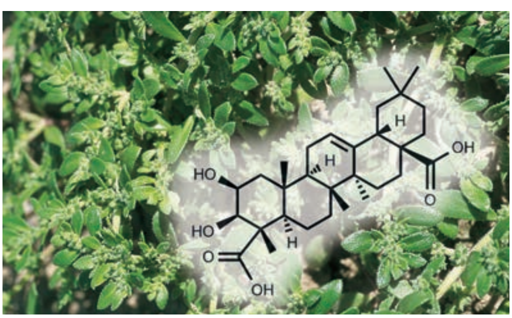
ORIGIN Europe and Asia (*H. glabra*) or the Mediterranean region and North Africa (*H. hirsuta*). Both species are acceptable as sources of the herb.

BOTANY Short-lived perennial herbs; stems mat-forming; leaves green, glabrous (or bluish green and hairy in *H. hirsuta*); flowers inconspicuous.

CHEMISTRY Mainly saponins (up to 9%): glycosides of **medicagenic acid** and gypsogenic acid. Also flavonols (1.2%), tannins and coumarins.

PHARMACOLOGY Weak spasmolytic activity is ascribed to the saponins and flavonoids.

TOXICOLOGY There is no evidence of side effects.



Herniaria glabra L. (Caryophyllaceae); *herniaire* (French); *Kahles Bruchkraut* (German); *erniaria* (Italian)

Hibiscus sabdariffa

hibiscus • red-sorrel • roselle

CLASSIFICATION TM: Africa, Europe. Pharm., Comm.E+, PhEur8, AHP. DS: functional food.

USES & PROPERTIES The dried calyces and epicalyces (hibiscus flowers – *Hibisci flos*) are used as a tasty, caffeine-free health tea and as a colourful additive to health tea mixtures. It has been used in traditional medicine as a general tonic to treat appetite loss, colds and catarrh. Externally it is said to help with skin ailments and allergic eczema.

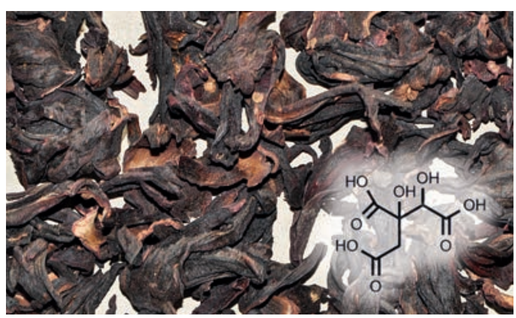
ORIGIN Africa (Angola). Cultivated commercially in warm regions.

BOTANY Erect annual (to 4 m); leaves lobed; flowers white, epicalyx green, calyx fleshy, bright red (purple when dry), edible, with a sweet-sour taste.

CHEMISTRY Polysaccharides, pectins, organic acids (e.g. **hibiscus acid**), sugars, anthocyanins.

PHARMACOLOGY Some health benefits have been proposed. The anthocyanins are antioxidants, the organic acids are mild laxatives and the polysaccharides may have an immune-modulatory action and a soothing effect on inflamed mucosa.

TOXICOLOGY Non-toxic and edible.



Hibiscus sabdariffa L. (Malvaceae); *karkadé* (French); *Hibiscus*, *Sabdariffa-Eibisch* (German); *carcade* (Italian)

Hippophae rhamnoides

buckthorn

CLASSIFICATION TM: Europe. WHO 5, clinical studies+. DS: functional food.

USES & PROPERTIES Ripe fruits (*Hippophae fructus*) have been used to treat asthma, gastric ulcers, and disorders of the lungs, liver and skin. Oil from the seeds and fruit pulp (*Hippophae oleum*) has become popular as a dietary supplement.

ORIGIN Europe and Asia.

BOTANY Deciduous, dioecious shrub or small tree (2–5 m); stems spiny; leaves narrow, with silver scales; fruit a bright orange drupe.

CHEMISTRY Fruits: vitamins C and E, carotenoids (lycopene and β-carotene), flavonoids and mannitol. Seed oil: linolenic and linoleic acids. Mesocarp oil: **palmitoleic acid** and palmitic acid (65%).

PHARMACOLOGY Clinical studies showed efficacy in reversing liver damage. Antioxidant, anti-inflammatory, hepatoprotective, neuroprotective, wound-healing, anti-ulcer, anticarcinogenic and antimutagenic activities have been recorded.

TOXICOLOGY No side effects are known.

Hippophae rhamnoides L. (Eleagnaceae) *argousier* (French); *Sanddorn* (German); *olivello spinoso* (Italian); *espino cerval de mar* (Spanish)

Hoodia gordonii

hoodia • ghaap

CLASSIFICATION TM: Africa. AHP. DS: functional food, clinical studies.

USES & PROPERTIES Pieces of stem were eaten by Khoi-San hunters and herders in South Africa and Namibia as a functional food and masticatory to suppress hunger and thirst. It became popular as a dietary supplement with claimed appetite-suppressant and anti-obesity activity.

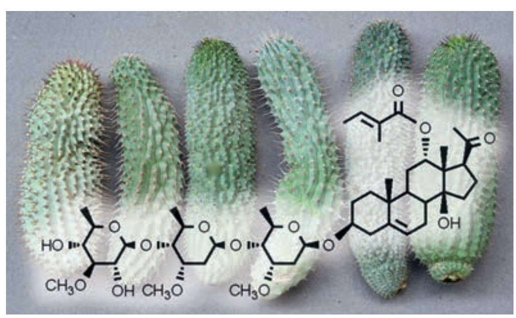
ORIGIN Southern Africa. Found in arid regions.

BOTANY Leafless succulent (to 0.5 m); stems cactus-like, spiny; flowers flesh-coloured, foetid.

CHEMISTRY The main active compound is a pregnane glycoside called **P57**.

PHARMACOLOGY Appetite-suppressant activity was shown in animal experiments. Human clinical studies indicated an unfavourable risk to benefit ratio. The traditional method of administration (as masticatory) bypasses the stomach and the food aversion effect appears to be centred in the mouth (associated with an intense bitter taste).

TOXICOLOGY Side effects (at therapeutic doses) include nausea and hypertension.



Hoodia pilifera (L.f.) Plowes [= *Trichocaulon piliferum* L.f.] [Apocynaceae (formerly Asclepiadaceae)]; *hoodia* (French); *Hoodia* (German); *hoodia* (Italian)

Hordeum vulgare

barley

CLASSIFICATION TM: Europe, Asia (China). DS: functional food, clinical studies+.

USES & PROPERTIES Barley is traditionally used to treat inflammation of the digestive tract. The grains and dried juice from seedlings (known as barley green) have become popular health food items for controlling diabetes, hyperlipidaemia, hypertension, coronary heart disease and gastro-intestinal disorders. Promoting weight loss e.g. with pure hordenine) is not yet convincing.

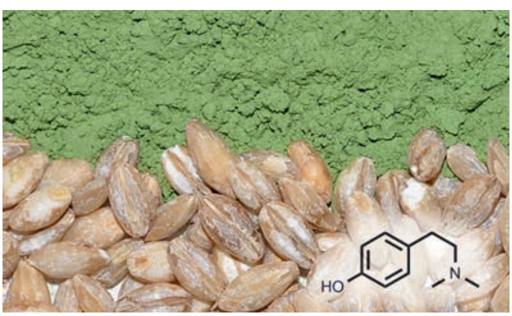
ORIGIN Middle East. Barley was domesticated in Mesopotamia some 10 000 years ago.

BOTANY Annual grass (to 1 m); spikelets mostly in three rows; husk usually adhering to the grain.

CHEMISTRY Dietary fibre (β-glucans in the husk); essential nutrients, e.g. vitamin B5, B9 (folic acid), lysine; alkaloids (**hordenine**) in seedling roots.

PHARMACOLOGY Clinical evidence supports the use of barley (> 3 g β-glucans per day) in reducing serum (LDL) cholesterol and controlling diabetes.

TOXICOLOGY Non-toxic (edible). Hordenine has a low toxicity: LD_{50} = 299 mg/kg (mouse, i.p.).



Hordeum vulgare L. (Poaceae); *mai ya* (Chinese); *orge* (French); *Gerste* (German); *orzo* (Italian); *cebada* (Spanish)

Hovenia dulcis

Japanese raisin tree

CLASSIFICATION TM: Asia (China). DS: alcohol antagonist.

USES & PROPERTIES The edible fruit stalks have been used in Chinese traditional medicine as a hangover cure. Extracts and health drinks have become popular to counteract the effects of alcoholism and damage to the liver.

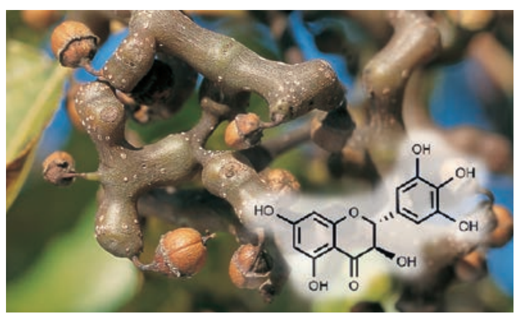
ORIGIN East Asia (China, Japan, Korea and the Himalayas). It is cultivated as an ornamental tree and source of commercial product.

BOTANY Deciduous tree (to 10 m); leaves simple, glossy; flowers small, white; fruit small, dry, inedible, fruit stalks branched, fleshy, juicy, edible.

CHEMISTRY Stalks contain flavonoids: **ampelopsin** (a flavanol) is a major compound. Hodulcine 1 (a triterpenoid glycoside in leaves) inhibits sweet taste perception (less active than gymnemic acid).

PHARMACOLOGY Animal studies have shown that ampelopsin has hepatoprotective activity and counteracts the effects of alcohol.

TOXICOLOGY The fruit stalks are edible and no side effects have been reported.



Hovenia dulcis Thunb. (Rhamnaceae); *kouai tsao* (Chinese); *raisin de chine* (French); *Japanischer Rosinenbaum* (German); *ovenia dolce* (Italian); *kemponashi* (Japanese)

Humulus lupulus

hop plant

CLASSIFICATION Sedative (III). TM: Europe. Comm.E+, ESCOP 4, WHO 3, PhEur8, HMPC.

USES & PROPERTIES Hops are the dried, cone-like female flower clusters (*Lupuli strobulus*), while hops grains are small resinous glands obtained by sieving (*Lupuli glandula*). Both are used in traditional medicine as bitter tonics and diuretics. In recent years, hops has become popular as an ingredient of natural sedative mixtures and sleep-promoting teas.

ORIGIN Asia, Europe and North America. Widely cultivated for hops (used mainly in beer brewing).

BOTANY Perennial creeper (vine) (to 10 m); leaves deeply lobed; female flowers in cone-like clusters.

CHEMISTRY A C5 alcohol (**2-methyl-3-buten-2-ol**) forms in hops during storage. The bitter taste and antibacterial activity of hops are due to lupulone and humulone (phloroglucinol derivatives).

PHARMACOLOGY Experiments showed that 2-methyl-3-buten-2-ol has strong sedative activity. It may be formed from lupulone after oral intake.

TOXICOLOGY No side effects are known.

Humulus lupulus L. (Cannabaceae); *houblon* (French); *Hopfen* (German); *luppolo* (Italian); *lupulo* (Spanish)

Hydrastis canadensis

goldenseal

CLASSIFICATION Neurotoxin, mind-altering (Ib–II). TM: North America, Europe. PhEur8, Homeopathy.

USES & PROPERTIES The dried rhizome and root (*Hydrastis rhizoma*), taken as an infusion of 0.5–1 g three times per day, are traditionally used to stop bleeding and diarrhoea. It is a general medicine and bitter tonic, digestive stimulant, mild laxative and antihaemorrhagic. Extracts are used in washes and gargles for mouth infections and in eye drops.

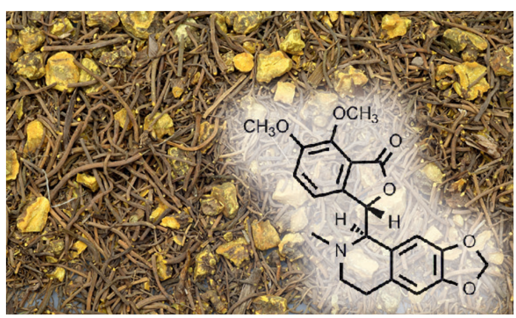
ORIGIN North America. Wild-harvesting is not sustainable but alternative sources can be used.

BOTANY Deciduous perennial herb; leaves lobed; flowers solitary, white; fruits fleshy, red, inedible.

CHEMISTRY Isoquinoline alkaloids: mainly **hydrastine** (1.5–4%) and berberine (to 6%).

PHARMACOLOGY Antibacterial activity is due to the alkaloids. They affect many different receptors, enzymes and DNA (berberine).

TOXICOLOGY The alkaloids are toxic is large doses and may cause vomiting, digestive disturbances, uterus contraction, hallucinations and delirium.



Hydrastis canadensis L. (Ranunculaceae); *hydrastis* (French); *Kanadische Gelbwurzel* (German); *sigillo d'oro* (Italian)

Hyoscyamus niger

henbane

CLASSIFICATION Neurotoxin, mind-altering, extremely hazardous (Ia). TM: Europe. Pharm., Comm.E+. MM: alkaloids, clinical studies+.

USES & PROPERTIES Mainly the leaves (*Hyoscyami folium*) but also the seeds (*Hyoscyami semen*) or roots (*Hyoscyami radix*) are traditionally used to treat nervous disorders, pain and toothache. It was once smoked to treat asthma, applied as narcotic in surgery (and as hallucinogen in witchcraft).The daily dose of standardised henbane powder (0.5–0.7 mg/g alkaloid) is 3 g, with a maximum single dose of 1 g. It is also a mind-altering drug.

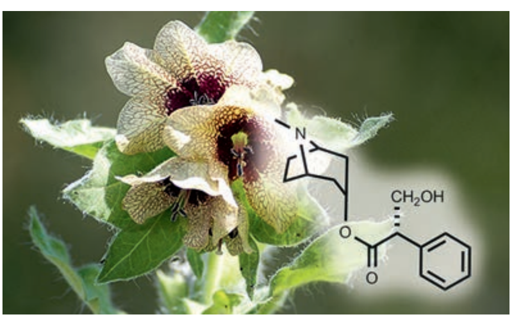
ORIGIN Europe and Asia (a weed of disturbed sites, naturalised in North America and Australia).

BOTANY Annual or biennial herb (to 0.5 m); leaves lobed, hairy; flowers pale yellow, veined purple.

CHEMISTRY Tropane alkaloids: **hyoscyamine** is the main compound (or atropine, its racemate) and scopolamine.

PHARMACOLOGY The alkaloids have antispasmodic, sedative and narcotic effects.

TOXICOLOGY Lethal dose in children: 15 seeds.



Hyoscyamus niger L. (Solanaceae); *jusquiame noire* (French); *Bilsenkraut* (German); *giusquiamo nero* (Italian): *veleño negro* (Spanish)

Hypericum perforatum

St John's wort

CLASSIFICATION TM: Europe. Comm.E+, ESCOP 1, WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Dried flowering tops (St. John's wort – *Hyperici herba*) have a long tradition as medicinal product but are used in modern times mainly to treat mild depression, anxiety and mood disturbances. A bright red oil (infusion in vegetable oil) is used for treating wounds and burns.

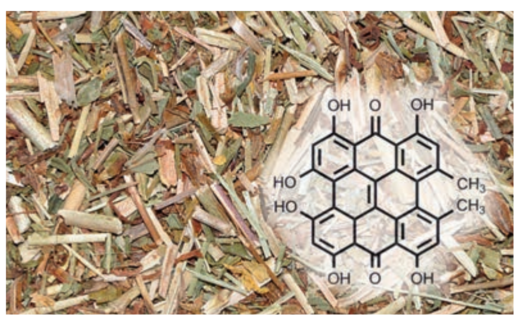
ORIGIN Europe and Asia. Naturalised in North America, Australia and South Africa.

BOTANY Perennial shrublet (to 0.6 m); leaves small, gland-dotted; flowers bright yellow.

CHEMISTRY The main active compounds are hypericin (a dianthrone), hyperforin (a phloroglucinol derivative) and flavonoids.

PHARMACOLOGY The drug functions as a reuptake inhibitor, hence the antidepressant activity (shown in clinical studies). It has antimicrobial and antiviral activities.

TOXICOLOGY Hypericin is phototoxic and may cause severe blistering of the skin at high doses. It interacts with pharmaceutical medicines.



Hypericum perforatum L. (Hypericaceae); *millepertuis perforé* (French); *Echtes Johanniskraut*, *Tüpfel-Johanniskraut* (German); *iperico*, *erba di San Giovanni* (Italian)

Hypoxis hemerocallidea

hypoxis • star flower

CLASSIFICATION TM: Africa, Europe. AHP, dietary supplement, clinical studies (–).

USES & PROPERTIES Fresh or dried (often sliced and dried) corms are used as general tonics and to treat prostate hyperplasia. Some of the commercial products no longer contain any hypoxis extract but rather isolated phytosterols from industrial sources.

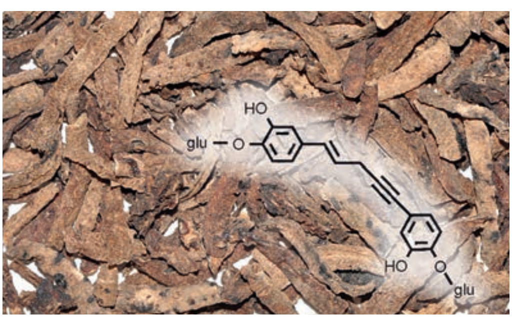
ORIGIN Southern Africa.

BOTANY Tuberous perennial herb; corms black, fibrous, bright yellow inside; leaves strap-shaped; flowers star-shaped, yellow.

CHEMISTRY Phytosterols (β-sitosterol and phytosterol glycosides). Also present is **hypoxoside** (rooperol is obtained by hydrolysis of hypoxoside).

PHARMACOLOGY Phytosterols may inhibit 5α-reductase and aromatase or they may prevent the binding of dihydrotestosterone in the prostate. Rooperol shows anti-inflammatory and anticancer activity *in vitro* but there is no convincing support for immune-boosting activity.

TOXICOLOGY No side effects are known.



Hypoxis hemerocallidea Fisch. & C.A.Mey. [= *H. rooperi* S.Moore] (Hypoxidaceae); *hypoxis* (French); *Hypoxis* (German); *hypoxis* (Italian); *inkomfe* (Zulu)

Ilex paraguariensis

maté

CLASSIFICATION Stimulant, mind-altering (III). TM: Europe, Central and South America. Pharm., Comm.E+, HMPC.

USES & PROPERTIES Dried leaves (*Mate folium*) are used as a diuretic and stimulant tea to counteract mental and physical fatigue. It is considered to be a useful general tonic and slimming ingredient. In Argentina, Brazil, and Paraguay, maté is enjoyed every day in much the same way as tea or coffee (but the infusion is sucked up through a special silver straw from a small gourd).

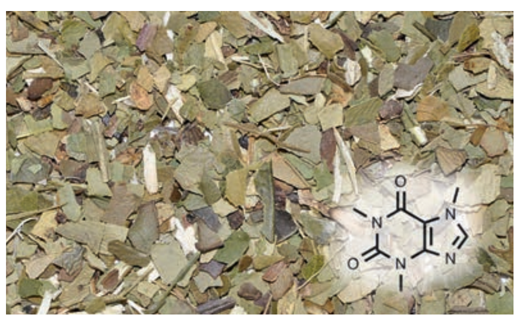
ORIGIN South America.

BOTANY Evergreen shrub or tree; leaves leathery; flowers small, white; fruit a small red berry.

CHEMISTRY **Caffeine** (2%) is the main stimulant compound. Also present are condensed catechins (4–16%), chlorogenic acid (12%), flavonoids, triterpene glycosides and essential oil (0.3%).

PHARMACOLOGY Caffeine is well known for its stimulant activity (see page 84).

TOXICOLOGY High doses can lead to anxiety, heart palpitations and insomnia.



Ilex paraguariensis A.St.-Hil. (Aquifoliaceae); *maté* (French); *Mate* (German); *matè* (Italian); *yerba mate* (Spanish)

Illicium anisatum

Japanese anise • shikimi

CLASSIFICATION Neurotoxin (Ib). TM: China.

USES & PROPERTIES Shikimi (bastard star anise) is an adulterant of star anise (*Illicium verum*) and may cause human poisoning or even death. Both species have been a source of shikimic acid, a starting material for the semisynthesis of Tamiflu (a commercial antiviral agent against influenza).

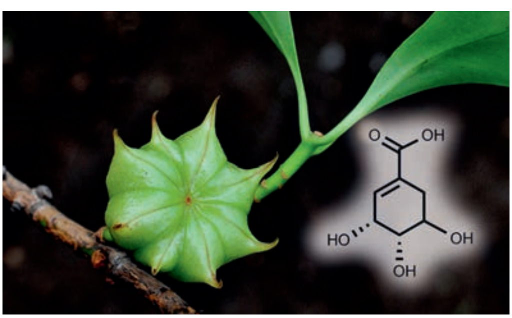
ORIGIN Eastern Asia (Japan, Korea and Taiwan). It is an ornamental shrub that is traditionally planted at Buddhist shrines and graveyards.

BOTANY Evergreen shrub or small tree (to 8 m); flowers pale yellow; fruit irregularly star-shaped, the follicle tips sharp and curved.

CHEMISTRY The fruits and seeds contain anisatin, neoanisatin and other sesquiterpene dilactones. Also present are **shikimic acid** (named after the Japanese name for the plant) and oil with myristicin.

PHARMACOLOGY Anisatin and other lactones are convulsive poisons (causing spasms, seizures).

TOXICOLOGY A dose of 1.5 g of fruits can cause poisoning in humans. Anisatin: LD_{50} = 0.7–1.0 mg/kg (mouse, i.p.).



Illicium anisatum L. [= *I. japonicum* Sieb., *I. religiosum* Sieb. et Zucc.] [Schisandraceae (formerly Illiciaceae)]; *badiane du Japon* (French); *Shikimibaum*, *Japanischer Sternanis* (German)

Illicium verum

star anise • Chinese anise

CLASSIFICATION TM: Asia (China), Europe. Pharm., Comm. E+, PhEur8.

USES & PROPERTIES The ripe fruit (syncarp), known as star anise fruit (*Anisi stellati frutus*), is used to treat ailments of the respiratory tract (inflammation, catarrh) and the digestive system (dyspepsia, indigestion, bloating). The daily dose is 3 g of fruit or 0.3 g of essential oil.

ORIGIN Asia (northeastern Vietnam and southeastern China). Widely cultivated in Asia.

BOTANY Evergreen tree (to 10 m); flowers solitary, yellowish; fruit an 8-locular, star-shaped capsule, the follicle tips straight (curved in *I. anisatum*).

CHEMISTRY Fruits produce essential oil (ca. 8%, located in oil cells in the pericarp), dominated by ***trans*-anethole** (80–90%).

PHARMACOLOGY The fruits have antispasmodic, carminative and tonic effects.

TOXICOLOGY An important Chinese spice. Adulteration with similar-looking but toxic fruits of shikimi is possible. *Trans*-anethole may be mutagenic and carcinogenic in high doses.

Illicium verum Hook.f. (Schisandraceae); *ba jiao xian* (Chinese); *badiane de Chine, anis étoilé* (French); *Echter Sternanis* (German); *anice stellato* (Italian)

Inula helenium

elecampane • elfdock

CLASSIFICATION TM: Europe, Asia. Pharm., Comm.E+.

USES & PROPERTIES Dried rhizomes and roots of two- or three-year-old plants (elecampane; *Helenii rhizoma*) are traditionally used as expectorant in cases of cough, pertussis and bronchial catarrh but also as a bitter tonic, carminative, stomachic, diuretic, diaphoretic and urinary tract disinfectant. It is also used against skin ailments.

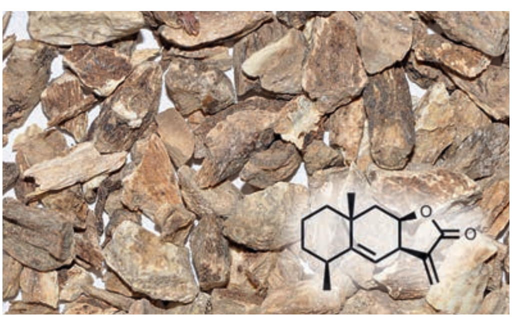
ORIGIN Asia Minor and southeastern Europe.

BOTANY Robust perennial herb (2.5 m); leaves broad, margins dentate; flower heads large, yellow.

CHEMISTRY A mixture of sesquiterpene lactones, (called helenin or elecampane camphor) that is also present in the essential oil (1–3%). The main compound is **alantolactone**. Also present: inulin, polyacetylenes, phytosterols and triterpenoids.

PHARMACOLOGY Alantolactone and other lactones can bind to SH-groups of proteins; they appear to be responsible for the secretolytic, diuretic, choleretic and antibiotic activities.

TOXICOLOGY Allergic skin reactions are possible.



Inula helenium L. (Asteraceae); *aunée* (French); *Echter Alant* (German); *enula campana* (Italian, Spanish)

Ipomoea tricolor

morning glory

CLASSIFICATION Neurotoxin, mind-altering, highly hazardous (Ib). TM: Central America.

USES & PROPERTIES Mexican shamans used an ergot alkaloid containing product called *ololiuqui* (probably *Ipomoea* or *Turbinia* species) as a hallucinogen for ritual and religious purposes. The seeds have been used as an intoxicant, sometimes with fatal consequences due to overdosing.

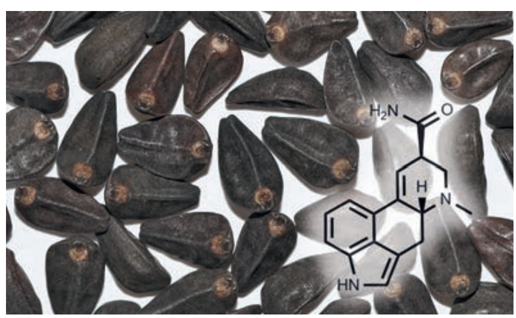
ORIGIN Central America (Mexico). Nowadays found on all continents as an ornamental plant.

BOTANY Climber (vine); stems twining; flowers large, short-lived, distinctive (blue, white, yellow).

CHEMISTRY Indole alkaloids: **ergine** (*d*-lysergic acid amide or LSA) and other lysergic acid derivatives. They are structurally related to lysergic acid diethylamide (the well-known LSD).

PHARMACOLOGY Central stimulants and powerful hallucinogens (similar to LSD but weaker). They modulate the activity of serotonin, dopamine and noradrenalin receptors.

TOXICOLOGY Only the seeds are highly toxic and hallucinogenic in humans.



Ipomoea tricolor Cav. [= *I. violacea* auct. non L.] (Convolvulaceae); *ipomée* (French); *Prachtwinde* (German)

Jatropha curcas

physic nut

CLASSIFICATION Cell toxin, co-carcinogen, skin irritant; highly hazardous (Ib). TM: Central and South America, Europe (now obsolete).

USES & PROPERTIES The seeds are rich in oil (ca. 35%) that was once used as a purgative medicine to treat constipation.

ORIGIN Tropical America. Grown in Central America, India and Africa as live fences and nowadays on a commercial scale for biofuel production.

BOTANY Shrub/small tree (to 6 m); leaves lobed; fruit a 3-seeded capsule; seeds ca. 20 mm long.

CHEMISTRY Diterpenoids of the tigliane (phorbol) type, mainly **curcusone A** and C. The seed contains a very poisonous lectin (toxic protein/toxalbumin) known as curcin or jatrophin. It is absent from oil (not fat-soluble). Curcanoleic acid is present in the oil (cf. ricinoleic acid in castor oil).

PHARMACOLOGY The purgative action is due to the irritant phorbol esters and curcanoleic acid. The toxicity is due to phorbol esters and curcin.

TOXICOLOGY Lethal when injected but relatively low oral toxicity: 5 to 20 seeds cause toxic effects.

Jatropha curcas L. (Euphorbiaceae); *pignon d'Inde* (French); *Purgiernuss* (German); *giatrofa catartica* (Italian)

Juglans regia

walnut • English walnut

CLASSIFICATION TM: Europe. Pharm., Comm. E+, HMPC.

USES & PROPERTIES Walnut leaf (*Juglandis folium*) or the fruit husks (*Juglandis fructus cortex*) are used against skin ailments (including acne, eczema, infections, inflammation, itchy scalp and skin ulcers). Infusions (of 1.5 g) are taken orally to treat diarrhoea and stomach ailments and may be gargled for infections of the mouth and throat.

ORIGIN Asia Minor (widely cultivated for its nuts). American walnut (*J. nigra*) has similar uses.

BOTANY Deciduous tree (to 25 m); leaves compound; flowers small; fruit a large drupe; seed an edible nut, surrounded by a bony endocarp.

CHEMISTRY Leaves are rich in tannins (10%), flavonoids (3%) and organic acids. The leaves and fruit husks contain pro-oxidant **juglone**, a naphthoquinone; also essential oil with germacrene D.

PHARMACOLOGY The tannins are astringent, antimicrobial and anti-inflammatory. Juglone and germacrene D are both strongly antimicrobial.

TOXICOLOGY Juglone has mutagenic properties.

Juglans regia L. (Juglandaceae); *noyer royal* (French); *Walnuss* (German); *noce* (Italian)

Juniperus communis

juniper

CLASSIFICATION Cell toxin (II–III). TM: Europe. Pharm., Comm.E+, ESCOP 3, PhEur8, HMPC.

USES & PROPERTIES The ripe, fleshy female cones, mostly dried (*Juniperi fructus*) are widely used as a spice and also as a diuretic and urinary antiseptic (and to treat stomach complaints). An infusion of 0.5 g crushed fruits is taken 3 × per day. Wood extracts are ingredients of diuretic and urological teas. Essential oil is used, or juniper spirits (0.5 % oil in 50% ethanol, with 0.1% camphor).

ORIGIN Northern temperate zone (Europe, Asia and North America).

BOTANY Evergreen small tree (to 5 m); leaves crowded, needle-like; cones fleshy, blue or black.

CHEMISTRY Essential oil (2%): α- and β-pinene as main compounds (80%), with small amounts of **terpinen-4-ol**, sabinene and others; also flavonoids, catechin tannins and proanthocyanidins.

PHARMACOLOGY The volatile oil (especially terpinen-4-ol) has diuretic and antiseptic activity.

TOXICOLOGY The oil is irritant and not considered to be a safe diuretic: it may cause haematuria.

Juniperus communis L. (Cupressaceae); *geniévrier* (French); *Gewöhnlicher Wacholder* (German); *ginepro* (Italian); *enebro común* (Spanish)

Juniperus sabina

savin

CLASSIFICATION Cell toxin and neurotoxin, mind-altering, extremely hazardous (Ia).

USES & PROPERTIES The plant is well known as a traditional abortifacient and was once used as an insecticide. Oil was employed to treat warts and condylomata.

ORIGIN Southern and central Europe to western Asia. Commonly grown in gardens and parks.

BOTANY Woody shrub/small tree (to 4 m); leaves reduced to scales; cones small, fleshy, dark blue, with a white waxy bloom.

CHEMISTRY Essential oil (3–5%), with **sabinene**, sabinyl acetate and thujone as main compounds. A non-volatile diterpene, isocupressic acid, is found in *Juniperus* (also *Cupressus* and *Pinus* species).

PHARMACOLOGY Sabinene and thujone are reactive molecules and probably responsible for most of the cytotoxic and neuotoxic effects. Isocupressic acid causes premature parturition in cattle and probably enhances the abortifacient activity.

TOXICOLOGY Very poisonous: the lethal oral dose in adults is 6 drops of the oil or 5–20 g of leaves.

Juniperus sabina L. (Cupressaceae); *sabine, genévrier sabine* (French); *Sadebaum* (German); *sabina* (Italian)

Justicia adhatoda

Malabar nut

CLASSIFICATION TM: Europe, Asia (India). Pharm., HPMC.

USES & PROPERTIES Dried leaves (*Adhatodae vasicae folium*) are traditionally used in the Ayurvedic, Siddha and Unani systems of medicine to treat tuberculosis, asthma and other respiratory ailments (coughs, catarrh of the upper respiratory tract, bronchitis). It is also used to treat fever, hepatitis, infections, allergies and intestinal parasites.

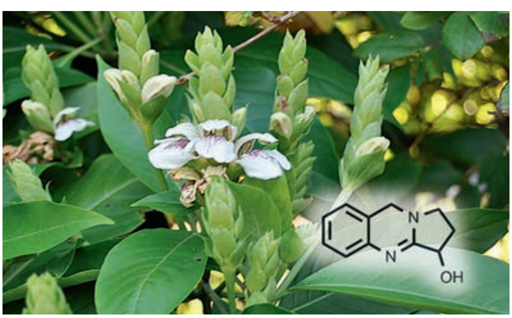
ORIGIN Asia (Himalaya region). Widely cultivated as an ornamental shrub.

BOTANY Shrub (to 2.5 m); leaves opposite; flowers white with purple; fruit a 4-seeded capsule.

CHEMISTRY Quinazoline alkaloids: **vasicine** (= peganine) is the main compound. The leaves contain essential oil with an unpleasant smell.

PHARMACOLOGY The alkaloids are respiratory stimulants. They show bronchodilatory and expectorant properties. Anthelmintic and antimicrobial activities have also been documented.

TOXICOLOGY The drug and vasicine are known for their abortifacient activities.



Justicia adhatoda L. [= *Adhatoda vasica* Nees] (Acanthaceae); *Malarbar-Nuss*, *Indisches Lungenkraut* (German); *sinhapuri*, *vasaka* (Sanskrit)

Kigelia africana

sausage tree

CLASSIFICATION TM: Africa.

USES & PROPERTIES The large sausage-shaped fruits are mostly used, but sometimes the bark. Powdered fruits are applied to sores and ulcers; bark decoctions are used to treat stomach ailments and dysentery. The main interest is in the antiseptic and wound-healing properties of fruit extracts when applied externally. Commercial skin care products are used to treat sunburn, keratoses, eczema, psoriasis and skin pigmentation. It is claimed to be of benefit in certain types of cancer.

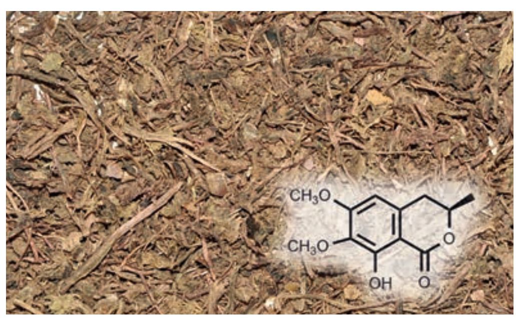
ORIGIN Tropical Africa. A popular garden tree.

BOTANY Tree (to 12 m). Leaves compound; flowers maroon-purple; fruit hard, fibrous, to 1 m long.

CHEMISTRY Main compounds: **kigelin** (a dihydroisocoumarin), lapachol (a naphthoquinone) and norviburtinal (derived from iridoids); also catalpol-type iridoids and phytosterols.

PHARMACOLOGY Benefits in skin care (and against melanoma) attributed to kigelin, norviburtinal and antiseptic activity to naphthoquinones.

TOXICOLOGY No side effects are known.



Kigelia africana (Lam.) Benth. (Bignoniaceae); *kigelia* (French); *Leberwurstbaum* (German); *kigelia* (Italian)

Krameria lappacea

rhatany • Peruvian rhatany

CLASSIFICATION TM: Europe, Central and South America. Pharm., Comm.E+, ESCOP, PhEur8.

USES & PROPERTIES The dried root (*Ratanhiae radix*) is traditionally used to treat diarrhoea and infections of the mouth and throat. A decoction is made of 1.5–2 g of the root or commercial tinctures can be used (5–10 drops in a glass of water, 3 × per day). Undiluted tincture can be applied directly to the tongue, throat or gums. Rhatany root has been used as a venotonic to alleviate the symptoms of capillary fragility and haemorrhoids, and to treat burns and bleeding wounds.

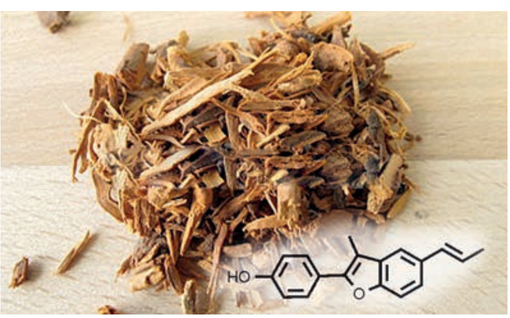
ORIGIN South America (Bolivia, Ecuador, Peru).

BOTANY Shrub (to 1 m); leaves small, silky-hairy; flowers purplish red, with four petals.

CHEMISTRY Condensed tannins (15%) and neolignans (ratanhia phenols), with **ratanhiaphenol II** and (+)-conocarpan as main compounds.

PHARMACOLOGY The tannins are antimicrobial, astringent and antidiarrhoeal. Topical anti-inflammatory activity is due to the lignans.

TOXICOLOGY Low doses have no side effects.



Krameria lappacea (Domb.) Burd. & Simp. [= *K. triandra* Ruíz & Pavón] (Krameriaceae); *ratanhia* (French); *Ratanhia* (German); *ratania* (Italian); *ratania* (Spanish)

Laburnum anagyroides

golden chain • golden rain

CLASSIFICATION Neurotoxin, highly hazardous (Ib). TM: Europe.

USES & PROPERTIES The tree is a popular ornamental plant, commonly grown in gardens and parks. Young children are attracted to the fruits, which superficially resemble those of beans and peas. As a result, *Laburnum* is a leading cause of intoxications reported to poison centres in Europe.

ORIGIN Central and southeast Europe.

BOTANY Long-lived shrub or small tree (usually 5–10 m); leaves trifoliate; flowers yellow, showy, in long pendulous clusters; fruit an oblong, flat, 4–6-seeded pod; seeds black.

CHEMISTRY **Cytisine** and other quinolizidine alkaloids (3% in seeds, 0.3% in leaves).

PHARMACOLOGY Symptoms of cytisine poisoning set in after 15–60 minutes and include nausea, vomiting, cold sweat, confusion and spasms. Cytisine is an AChR agonist and affects the nervous system.

TOXICOLOGY Three to four pods (15 to 20 seeds) can cause serious poisoning in children.

Laburnum anagyroides (L.) Medikus (Fabaceae); *aubour*, *cytise faux ébénier* (French); *Goldregen* (German); *avorniello* (Italian)

Lamium album

white dead nettle

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (flowers only).

USES & PROPERTIES The dried flowering tops (white dead nettle herb – *Lamii albi herba*) or the dried petals (white dead nettle flower – *Lamii albi flos*) are traditionally used as an expectorant to dissolve phlegm in catarrh of the upper respiratory tract, as well as for gastrointestinal complaints. The daily dose is 3 g. Other uses that have been recorded include menopausal and urogenital disorders, and leucorrhoea. Poultices have been applied to bruises, swellings and varicose veins.

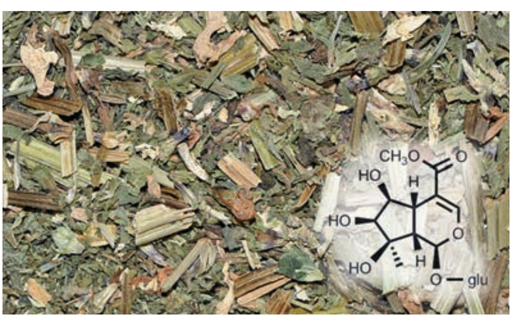
ORIGIN Europe and Asia.

BOTANY Perennial herb (to 0.5 m), leaves opposite, resembling nettle; flowers 2-lipped, white.

CHEMISTRY Iridoid glucosides (mainly **lamalbide**); also tannins, triterpene saponins and acids.

PHARMACOLOGY Anti-inflammatory, weak diuretic and antiseptic activities are ascribed to the iridoids, tannins and saponins.

TOXICOLOGY No contraindications or side effects are known.



Lamium album L. (Lamiaceae); *ortie blanche* (French); *Weiße Taubnessel* (German); *ortica bianca* (Italian); *ortiga blanca* (Spanish)

Lathyrus sativus

grass pea • chickling vetch

CLASSIFICATION Cell toxin (II).

USES & PROPERTIES Grass pea seeds are apparently not toxic when consumed in combination with other staple foods. However, during times of famine, when people have nothing else to eat, it causes lathyrism (paralysis of the lower limbs, with the knees often locked in a bent position). Outbreaks were recorded in France in 1700–1701 and 1856. Grass pea flour was banned in Germany in 1671.

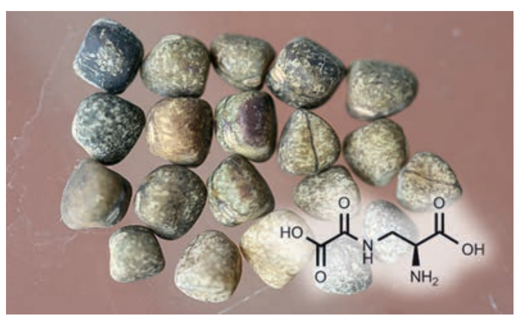
ORIGIN Eastern Mediterranean. Still an important food source in Ethiopia, Pakistan, India and Bangladesh despite efforts to discourage its use. It is highly resistant to drought and will provide at least some harvest when all other crops fail.

BOTANY Annual herb; stems winged, with climbing tendrils; leaves trifoliate; flowers blue; fruit a 3–5-seeded pod; seeds mottled.

CHEMISTRY Seeds contain a toxic non-protein amino acid, **oxalyldiaminopropionic acid** (ODAP).

PHARMACOLOGY ODAP is an analogue of the neurotransmitter glutamate and causes lathyrism.

TOXICOLOGY Cooking removes 90% of the toxin.



Lathyrus sativus L. (Fabaceae); *ou zhou xiang wan dou* (Chinese); *gesse blanche* (French); *Saatplatterbse* (German); *khesari* (Hindi); *cicerchia* (Italian); *almorta* (Spanish)

Lavandula angustifolia

lavender

CLASSIFICATION TM: Europe. Comm.E+, ESCOP, PhEur8, HMPC.

USES & PROPERTIES Flowers, stripped from their stalks (*Lavandulae flos*) are used as mild sedative to treat nervous conditions, excitement and sleep disturbances. It is taken for digestive ailments (as cholagogue, spasmolytic, carminative and diuretic). It is a popular ingredient of calming teas, sedative preparations, tonics and cholagogues. Lavender oil (*Lavandulae aetheroleum*) is used on the skin for antiseptic, soothing and wound-healing effects; in aromatherapy, for relief of nervous tension, emotional upsets, headache and migraine.

ORIGIN Western Mediterranean. Widely cultivated (ornamental, source of essential oil).

BOTANY Aromatic shrublet (to 1 m); leaves silvery; flowers purple-blue, in elongated spikes.

CHEMISTRY Essential oil, dominated by **linalyl acetate** and linalool.

PHARMACOLOGY Sedative, spasmolytic and mild antimicrobial activities (due to terpenoids).

TOXICOLOGY The oil is toxic when ingested.

Lavandula angustifolia Mill. [= *L. officinalis* Chaix, *L. vera* DC.] (Lamiaceae); *lavande* (French); *Echter Lavendel* (German); *lavanda* (Italian); *lavanda* (Spanish)

Lawsonia inermis

henna

CLASSIFICATION TM: Asia (India).

USES & PROPERTIES The powdered leaf (*Hennae folium*) is used in Ayurvedic medicine to treat burns, wounds and other skin ailments and may be taken orally as antidiarrhoeal, anti-epileptic and abortifacient. It is used to colour hair and nails, and for traditional body art (intricate decorations on hands and feet).

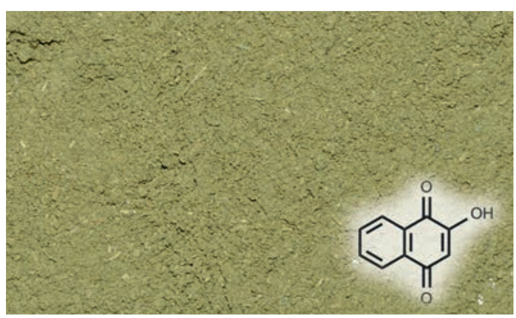
ORIGIN South Asia, Middle East and Mediterranean region. It is widely cultivated.

BOTANY Evergreen shrub (5 m); leaves opposite; flowers white; fruit a small, many-seeded capsule.

CHEMISTRY The active compound is **lawsone**, a 2-hydroxy-1,4-naphthoquinone that occurs in the intact plant as glycoside (1% in dry leaf powder) but also as free aglycone. Also present are tannins (10%), coumarins, flavonoids, phenolic acids, sterols and xanthones.

PHARMACOLOGY Astringent and antiseptic activities are due to tannins and lawsone.

TOXICOLOGY There are some indications that lawsone may be mutagenic.



Lawsonia inermis L. (Lythraceae); *henné* (French); *Hennastrauch* (German); *hennè* (Italian)

Leonurus cardiaca

motherwort

CLASSIFICATION Mild narcotic and sedative (III). TM: Europe. Pharm., Comm.E+., WHO 5, PhEur8, HMPC.

USES & PROPERTIES The aboveground parts (*Leonuri herba*) are traditionally used to treat nervous heart conditions (reflected in *cardiaca*) and anxiety during childbirth (hence "motherwort"). It is also used as spasmolytic and hypotensive, and in supportive treatment of an overactive thyroid.

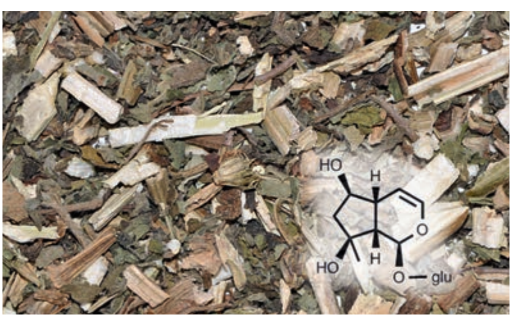
ORIGIN Central Europe, northern Europe and Asia. The herb is commonly grown in gardens.

BOTANY Erect perennial herb (to 1.5 m); leaves toothed, drooping; flowers pink, hairy. Chinese- (*L. heterophyllus*) and Siberian motherwort (*L. sibirica*) have been used in the same way.

CHEMISTRY Iridoid glucosides (**ajugol**, ajugoside), alkaloids (stachydrine, leonurine), diterpenes (leocardin, marrubiaside), flavonoids, tannins and phenolic acids.

PHARMACOLOGY Demonstrated cardiotonic and uterotonic activities are not yet explained.

TOXICOLOGY Considered safe to use at 4.5 g/day.



Leonurus cardiaca L. (Lamiaceae); *agripaume* (French); *Herzgespann* (German); *cardiaco* (Italian); *agripalma* (Spanish)

Lepidium sativum

garden cress • cress

CLASSIFICATION TM: Africa, Arabia, Asia, Europe, North America. DS: functional food.

USES & PROPERTIES Seeds are traditionally used in African, Arabian and Asian medicine for many ailments, including asthma, coughs and bronchitis (also as antiseptic, diuretic, expectorant, aphrodisiac, stomachic and laxative). In Europe and North America, the herb is used as food (formerly as diuretic, anthelmintic and antiscorbutic).

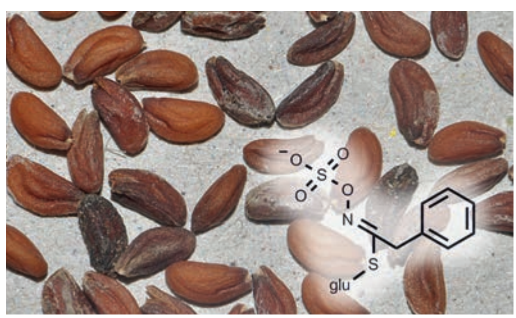
ORIGIN Uncertain: western Asia (Iran) or Africa (Ethiopia). Used in ancient Egypt as food. It is cultivated in Europe, Asia and North America.

BOTANY Annual herb (to 0.6 m); leaves compound; flowers white; fruit a bilocular capsule.

CHEMISTRY **Glucotropaeolin** and other glucosinolates; lepidine and other imidazole alkaloids; flavonoids, mucilages, fatty acids, vitamin C.

PHARMACOLOGY Diuretic, airway relaxant, antihypertensive, anti-inflammatory, antirheumatic, analgesic, antispasmodic, aphrodisiac, hypoglycaemic, antibacterial and many other activities.

TOXICOLOGY Non-toxic (edible).



Lepidium sativum L. (Brassicaceae); *jia du xing cai* (Chinese); *cresson alénois* (French); *Gartenkresse* (German); *crescione* (Italian); *mastruco* (Portuguese); *berro de huerta* (Spanish)

Lessertia frutescens

sutherlandia • cancer bush

CLASSIFICATION TM: Africa. AHP.

USES & PROPERTIES Dried twigs and leaves (1–3 g/day) are a traditional bitter tonic and adaptogen to treat many ailments. The main uses are against stress, diabetes and cancer (as treatment and prophylaxis) but also colds, influenza, cough, asthma, bronchitis, fever, indigestion, heartburn, poor appetite, gastritis, peptic ulcers, diarrhoea, liver conditions, rheumatism, urinary tract infections, tuberculosis, and topically for skin disorders.

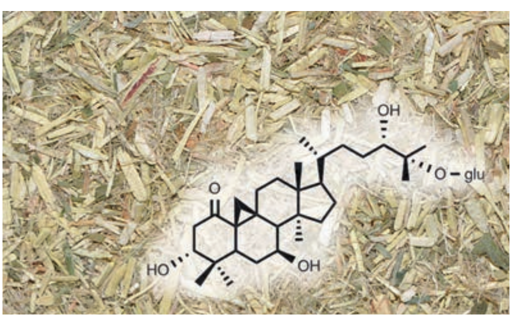
ORIGIN Southern Africa. Cultivated as a garden plant and also commercially for medicinal use.

BOTANY Perennial shrub (to 2 m); leaves pinnate; flowers red; fruit an inflated, many-seeded pod.

CHEMISTRY Triterpenoid saponins (**SU1**); NPAAs, *L*-canavanine; flavonoids; pinitol.

PHARMACOLOGY The triterpenoids have bitter tonic, anticancer and possible corticomimetic effects. Canavanine has anticancer and antiviral activity. Pinitol is an antidiabetic and is potentially useful to treat wasting in cancer and AIDS.

TOXICOLOGY No serious side effects are known.



Lessertia frutescens (L.) P.Goldblatt & J.C.Manning [= *Sutherlandia frutescens* (L.) R.Br.] (Fabaceae); *sutherlandia* (French); *Sutherlandia* (German); *sutherlandia* (Italian)

Levisticum officinale

lovage

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8, HMPC.

USES & PROPERTIES The dried rhizome and roots (*Levistici radix*) are used as diuretic to treat oedema, inflammation of the lower urinary tract and to prevent kidney gravel. The dose is 1.5–3 g, taken 3 × per day as tea (or half an hour before meals, when used as stomachic, carminative, expectorant and emmenagogue). Lovage root is an ingredient of commercial urological and cardiotonic preparations. Fruits and leaves are also used.

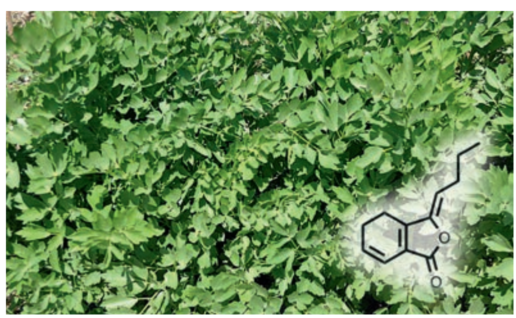
ORIGIN Eastern Mediterranean. Cultivated (and naturalised) in Europe and North America as a popular spice and ingredient of bitter liqueurs.

BOTANY Perennial herb (to 2 m); leaves compound, aromatic; flowers small; fruit a schizocarp.

CHEMISTRY Essential oil (1%) with alkylphthalides (e.g. 3-butylphthalide, **ligustilide**, sedanolide).

PHARMACOLOGY The phthalides are antispasmodic, carminative and sedative. They also increase the flow of saliva and gastric juices.

TOXICOLOGY Edible (the tea has no side effects).



Levisticum officinale Koch [= *Ligusticum levisticum* L.] (Apiaceae); *livèche* (French); *Liebstöckel*, *Maggikraut* (German); *levistico* (Italian); *ligustico* (Spanish)

Linum usitatissimum

flax • linseed

CLASSIFICATION Cell toxin (II). TM: Europe. Pharm., Comm. E+, ESCOP 1, PhEur8, HMPC, clinical studies+. DS: functional food.

USES & PROPERTIES Ripe, dried seeds (linseed; *Lini semen*) are used for ongoing constipation, gastritis, enteritis, diverticulitis, irritable colon, ulcerative colitis and diarrhoea. Whole or cracked seeds (1 tablespoon in 150 ml water, 3 × per day).

ORIGIN Mediterranean and western Europe.

BOTANY Erect annual herb (to 1 m); leaves small; flowers pale blue; fruit a few-seeded capsule.

CHEMISTRY Oil (35–45%): linoleic and α-linolenic acids; mucilage (6–10%), in the outer layer of the seed coat; cyanogenic glucosides (1%), mainly **linamarin**; lignans: secoisolariciresinol (SDG); proteins (25%); fibre (25%).

PHARMACOLOGY Bulk laxative. Clinical evidence for benefits in high cholesterol and diabetes. SDG: possibly anticarcinogenic and phytoestrogenic.

TOXICOLOGY The seeds are edible and safe to consume. Linamarin and other cyanogenic glucosides should not pose a health risk in therapeutic doses.

Linum usitatissimum L. (Linaceae); *lin* (French); *Lein*, *Flachs* (German); *lino* (Italian); *lino* (Spanish)

Lobelia inflata

Indian tobacco • asthma weed

CLASSIFICATION Neurotoxin, mind-altering (Ib).TM: Europe, North America. Pharm. MM: alkaloid (lobeline).

USES & PROPERTIES Stems and leaves (*Lobeliae herba*) are used to treat asthma, bronchitis and whooping cough. An infusion or decoction of 0.2–0.6 g of the herb is taken 3 × per day. Extracts and tinctures are also taken (sometimes as commercial mixtures). Isolated lobeline is an ingredient of oral preparations to treat nicotine withdrawal. Injection of extracts to resuscitate babies with asphyxia and apnoea is no longer considered safe.

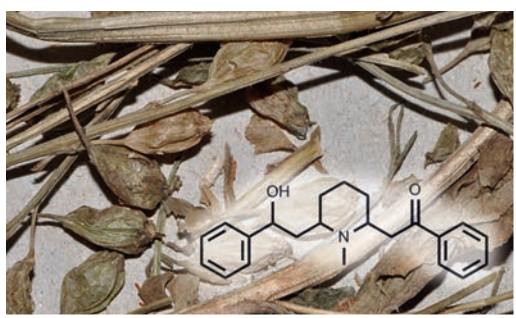
ORIGIN North America.

BOTANY Annual herb (to 0.5 m); leaves sessile; flowers pale blue, calyx inflated; fruits a capsule.

CHEMISTRY Piperidine alkaloids (0.5%): **lobeline** is the main compound in this and other species.

PHARMACOLOGY Lobeline activates nicotinic acetylcholine receptors and acts as a respiratory stimulant and bronchodilator.

TOXICOLOGY Safe in low doses only. The alkaloids are very poisonous when used in large amounts.



Lobelia inflata L. (Campanulaceae); *lobélie enflée* (French); *Aufgeblasene Lobelie*, *Indianertabak* (German); *lobelia* (Italian)

Lophophora williamsii

mescal • peyote

CLASSIFICATION Neurotoxin, hallucinogen, mind-altering (Ib–II). TM: Central America.

USES & PROPERTIES About 10 to 12 dried tops of the stems ("mescal buttons") are chewed to produce intoxicating and hallucinogenic effects. Drug users apply pure alkaloid by injection. The drug has a long history of use by the Aztecs (as *peyotl*) and the isolated mescaline by artists and authors.

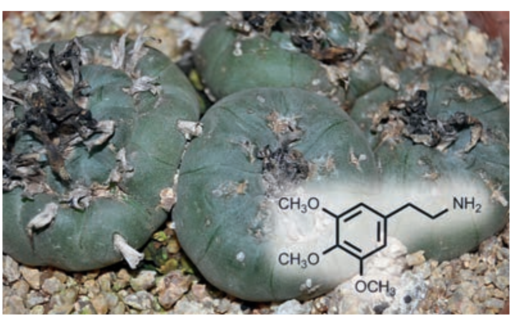
ORIGIN Central America.

BOTANY Globular cactus (to 100 mm in diameter), bluish green; thorns absent; flowers pink.

CHEMISTRY Phenylpropylamines: **mescaline** is the main alkaloid (4.5–7%). Modern designer drugs such as Ecstasy resemble mescaline in chemical structure and in psychedelic effects.

PHARMACOLOGY Mescaline is a serotonin agonist, a stimulant and hallucinogen. Doses above 400 mg cause paralysis of the central nervous system (with low blood pressure, weakness, liver damage and vomiting).

TOXICOLOGY Mescaline has a relatively low toxicity. LD_{50} = 212 mg/kg (mouse, i.p.).



Lophophora williamsii (Lem. ex Salm-Dyck) J.M.Coult. (Cactaceae); *peyote*, *peyoti* (French); *Meskalkaktus*, *Peyotekaktus* (German)

Lycium chinense

Chinese wolfberry • goji berry

CLASSIFICATION TM: Asia (China). DS: functional food.

USES & PROPERTIES Fresh or more often dried berries of both *Lycium chinense* and *L. barbarum* (*gou qi zi* – *Lycii fructus*) are a traditional tonic in China, used to improve eyesight, protect the liver and treat wasting diseases. Dried roots (*Lycii radicis cortex*): fever and high blood pressure.

ORIGIN Eastern Asia (*L. chinense*) and China (Ningxia Province, *L. barbatum*). Both are naturalised in North America (*L. barbarum* in Europe).

BOTANY Woody shrub (1 m); stems spiny; leaves lanceolate; flowers purple, tube 1.5 mm long; fruit a drupe, 10 mm long (*L. barbarum*: leaves ovate, flower tube 2.5 mm, fruit to 20 mm long).

CHEMISTRY Amino acids (to 5%), proteoglycan polysaccharides (30% of fruit pulp), antioxidant carotenoids (high levels of **zeaxanthin** and β-carotene), triterpenes and saponins.

PHARMACOLOGY The health benefits are linked to the nutrients, polysaccharides and carotenoids.

TOXICOLOGY Fruits are edible (non-toxic).

Lycium chinense Mill. (Solanaceae); *lyciet* (French); *Chinesischer Bocksdorn* (German); *licio* (Italian)

Lycopersicon esculentum

tomato

CLASSIFICATION Cytotoxin and neurotoxin (II) (green fruits). DS: lycopene.

USES & PROPERTIES The red pigment in ripe fruits (lycopene) is an important dietary supplement. Cooked and processed tomato is second only to gac fruit (*Momordica cochinchinensis*) as a source. The latter is sold as soft capsules and juice blends with high levels of lycopene and β-carotene. Lycopene is fat-soluble.

ORIGIN South and Central America. Early domestication may have occurred in Mexico.

BOTANY Short-lived perennial (grown as annual); leaves aromatic; flowers yellow; fruit a large berry.

CHEMISTRY Carotenoid pigments: mainly **lycopene** (ca. 40 μg/g in raw tomatoes, 60–130 μg/g in tomato sauce and ketchup).

PHARMACOLOGY Lycopene is a powerful antioxidant but not a vitamin A precursor. Lycopene is claimed to reduce the risk of prostate cancer.

TOXICOLOGY Lycopene is an approved natural food colouring (non-toxic). Green tomatoes may contain toxic levels of steroidal alkaloids.

Lycopersicon esculentum Mill. or ***Solanum lycopersicum*** *L.* (Solanaceae); *fan qie* (Chinese); *tomate* (French); *Tomate* (German); *pomodoro* (Italian); *tomate* (Portuguese, Spanish)

Lycopodium clavatum

common clubmoss

CLASSIFICATION Neurotoxin, mind-altering (II). TM: Europe, Asia.

USES & PROPERTIES The whole herb (*Lycopodii herba*) is traditionally used as a diuretic for the treatment of inflammations of the bladder and urinary tract, as well as menstrual ailments. The daily dose is 4.5 g. It is used as a tonic in Chinese Traditional Medicine. Pure alkaloids such as huperzine A show potential for treating Alzheimer's disease.

ORIGIN Arctic region (Eurasia, North America).

BOTANY A clubmoss (Lycopodiales, Pteridophyta) with creeping and branching stems (to 1 m); leaves small, linear, spirally arranged.

CHEMISTRY Quinolizidine alkaloids: **lycopodine** (the main compound), with dehydrolycopodine and others; also triterpenes, flavonoids and acids.

PHARMACOLOGY The alkaloids are sedative and antispasmodic. Huperzine A inhibits acetylcholinesterase but clinical use for dementia is still experimental.

TOXICOLOGY High doses of alkaloids can cause nausea, dizziness, staggering and coma.

Lycopodium clavatum L. [= *L. vulgare*] (Lycopodiaceae); *lycopode en massue, jalousie* (French); *Keulen-Bärlapp* (German); *licopodio clavato* (Italian)

Lycopus europaeus

bugleweed • gipsywort

CLASSIFICATION TM: Europe, North America. Comm. E+, clinical studies+.

USES & PROPERTIES The dried aboveground parts, harvested from flowering plants (*Lycopi herba*), are traditionally used to treat an overactive thyroid gland, heart palpitations and mastodynia. Daily dose (adapted to individual need): 1–2 g, as infusion. Extracts are ingredients of commercial preparations. In Chinese medicine, *L. lucidus* (top right) is used to treat gynaecological ailments.

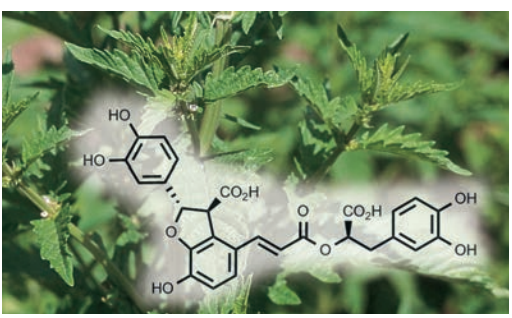
ORIGIN Europe and Asia.

BOTANY Erect perennial herb (to 0.5 m); leaves opposite, toothed; flowers small, subsessile.

CHEMISTRY Phenolic acids (hydroxycinnamic acid derivates): **lithospermic acid** and rosmarinic acid; flavonoids; terpenes and essential oil.

PHARMACOLOGY Depsides of the hydrocinnamic acids are linked to the antithyrotropic activity, which is supported by clinical evidence.

TOXICOLOGY High doses and continued use may lead to thyroid hypertrophy. Contraindicated for persons with thyroid insufficiency.



Lycopus europaeus L. (Lamiaceae); *pied-de-loup* (French); *Gemeiner Wolfstrapp* (German); *marrubio d'acqua* (Italian); *manta de lobo* (Spanish)

Mahonia aquifolium

Oregon grape

CLASSIFICATION Cell toxin and neurotoxin (II). TM: Europe, North America.

USES & PROPERTIES The root and root bark are used as bitter tonic and general medicine for digestive ailments, liver complaints and psoriasis. It is also used as cholagogue, diuretic and laxative. Similar to *Berberis* species and used in much the same way. Extracts are active ingredients of commercial preparations for treating psoriasis. The efficacy is sometimes questioned, despite clinical studies that show benefits.

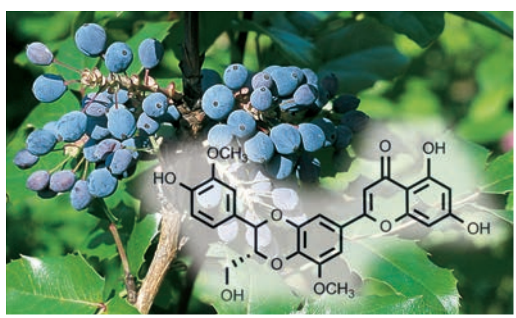
ORIGIN North America. A popular and attractive garden subject, found in many parts of the world.

BOTANY Evergreen shrub; leaves compound, spiny; flowers yellow; fruit a small purple drupe.

CHEMISTRY Isoquinoline alkaloids: mainly berberine. Also **5'-methoxyhydnocarpin** (shown to potentiate the antimicrobial action of berberine).

PHARMACOLOGY The alkaloids have antimicrobial, cytotoxic, hypotensive and cholekinetic activities; possible benefits in treating psoriasis.

TOXICOLOGY Toxic dose of berberine: >0.5 g.



Mahonia aquifolium (Pursh) Nutt. or ***Berberis aquifolium*** Pursh (Berberidaceae); *mahonie a feuilles de houx* (French); *Gewöhnliche Mahonie* (German); *maonia commune* (Italian)

Malva sylvestris

mallow • common mallow

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP, PhEur8.

USES & PROPERTIES The dried leaves (*Malvae folium*) or flowers (*Malvae flos*) are traditionally used against colds, catarrh, inflammation of the mouth and throat, as well as gastroenteritis. Both are used as poultice to treat wounds. The flowers (of subsp. *mauritiana*) are a traditional diuretic in folk medicine and are also used as a natural dye to colour teas and foodstuffs.

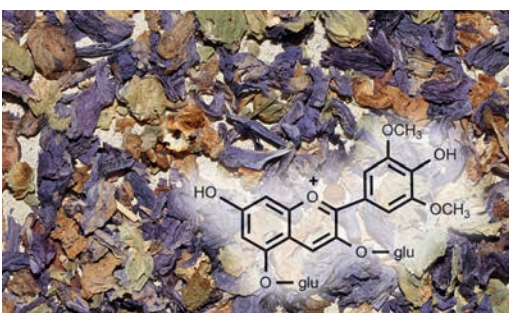
ORIGIN Europe and Asia. Naturalised in many parts of the world.

BOTANY Biennial herb (to 1 m); leaves deeply lobed; flowers pink (purple in subsp. *mauritiana*).

CHEMISTRY Mucilage (8–10%); flavonoids sulfates in the leaves; anthocyanins – mainly **malvin** (malvidin 3,5-diglucoside) in the flowers (petals).

PHARMACOLOGY The mucilage is demulcent, forming a protective layer over inflamed mucosa. Anthocyanins provide colour but are also mildly astringent, antioxidant and anti-inflammatory.

TOXICOLOGY No side effects are known.



Malva sylvestris L. (Malvaceae); *mauve sauvage* (French); *Wilde Malve*, *Große Käsepappel* (German); *malva riondela* (Italian); *malva* (Spanish)

Mandragora officinarum

mandrake

CLASSIFICATION Neurotoxin, hallucinogen, mind-altering (Ia). TM: Europe.

USES & PROPERTIES Mandrake has been used since ancient times as anthelmintic, analgesic, hypnotic, aphrodisiac and narcotic for surgery. It is mentioned in the Ebers Papyrus (1500 BC) and in the famous *Materia Medica* written by Dioscorides between 50 and 70 BC. It is associated with Greek mythology and medieval witchcraft and sorcery.

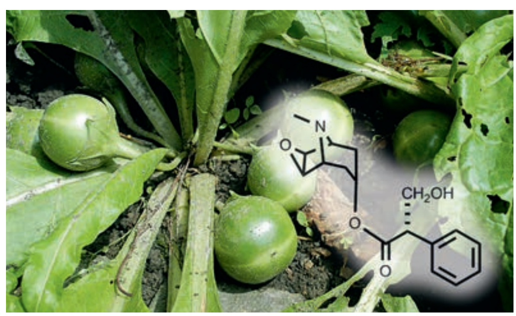
ORIGIN Southern Europe.

BOTANY Small perennial herb; taproot up to 0.6 m long (according to tradition it resembles a human body); flowers purple; fruit fleshy, many-seeded.

CHEMISTRY Tropane alkaloids: mainly **scopolamine** (hyoscine), with hyoscyamine and others.

PHARMACOLOGY Scopolamine is an antagonist at the muscarinic acetylcholine receptor and acts as a parasympatholytic. It is depressant and sedative at low doses but euphoric and hallucinogenic at high doses (causes a feeling of flying).

TOXICOLOGY The lethal dose of scopolamine is 100 mg in adults and 2–10 mg in children.



Mandragora officinarum L. (Solanaceae); *mandragore* (French); *Alraune* (German); *mandragora primaverile* (Italian)

Marrubium vulgare

white horehound

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8, HMPC.

USES & PROPERTIES Fresh or dried aboveground parts (*Marrubii herba*) are traditionally used for menstrual disorders and inflammations of the skin and mucosa. It is nowadays used for digestive ailments (indigestion, flatulence, biliary complaints and lack of appetite) and dry coughs associated with chronic bronchitis. The daily dose is 4.5 g, taken as tea. Commercial expectorants and digestive medicines sometimes contain horehound.

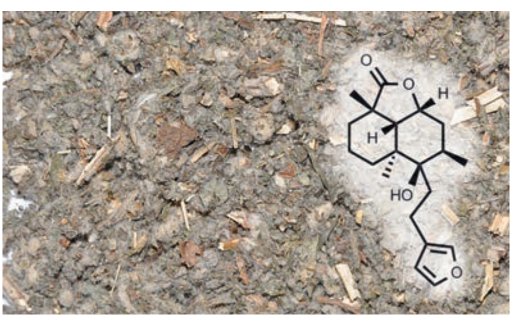
ORIGIN Southern Europe and Asia. It has become a weed in many warm parts of the world.

BOTANY Perennial herb (to 0.5 m); stems square; leaves prominently veined; flowers small, two-lipped, white, in rounded clusters.

CHEMISTRY Diterpene lactones (**marrubiin**, 1%); also flavonoids, tannins, acids and essential oil.

PHARMACOLOGY Marrubiin has choleretic and expectorant activities (it stimulates secretions).

TOXICOLOGY High doses can be cardioactive and uterine stimulant (dosage should be controlled).



Marrubium vulgare L. (Lamiaceae); *marrube blanc* (French); *Gemeiner Andorn* (German); *marrobio* (Italian); *marrubio* (Spanish)

Matricaria chamomilla

chamomile • German chamomile

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 6, WHO 1, PhEur8, HMPC.

USES & PROPERTIES Dried flower heads (*Matricariae flos*): flatulent nervous dyspepsia in adults and children, as well as diarrhoea, gastritis, mild anxiety and travel sickness. Essential oil (*Matricariae aetheroleum*) or liquid extracts: applied to wounds and inflammations of the skin and mucous membranes. Oil can be inhaled: nasal catarrh and infections of the respiratory tract.

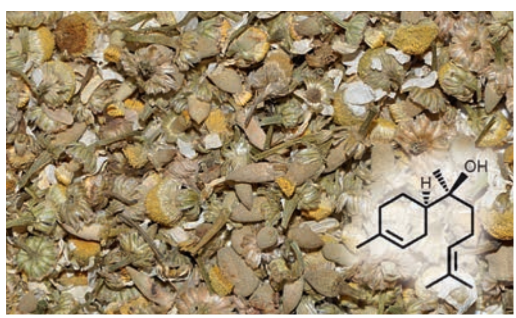
ORIGIN Eastern Europe and the Near East. It is cultivated on a large commercial scale.

BOTANY Annual herb; leaves compound, feathery; flower heads yellow, ray florets white, the disc hollow (solid in Roman chamomile – *Chamaemelum*).

CHEMISTRY Essential oil (deep blue colour), with sesquiterpenes: **α-bisabolol** (50%) and chamazulene (15%). Also present are flavonoids, coumarins, polyacetylenes and polysaccharides.

PHARMACOLOGY Sesquiterpenoids: anti-inflammatory, antispasmodic, carminative, antiseptic.

TOXICOLOGY Safe to use (allergies may occur).



Matricaria chamomilla L. [= *Chamomilla recutita* (L.) Rausch.; = *M. recutita* L.] (Asteraceae); *camomille* (French); *Echte Kamille* (German); *camomilla* (Italian); *camomilla* (Spanish)

Medicago sativa

alfalfa • lucerne

CLASSIFICATION DS: functional food.

USES & PROPERTIES Stems and leaves (*Medicago sativae herba*) or seeds and sprouts (germinated seeds) are used as health food and general tonic to improve health, to aid in the recovery of convalescents and to help maintain cholesterol levels. No more than 5–10 g of dry herb or 40 g of seeds/sprouts can be taken 3 × per day with meals.

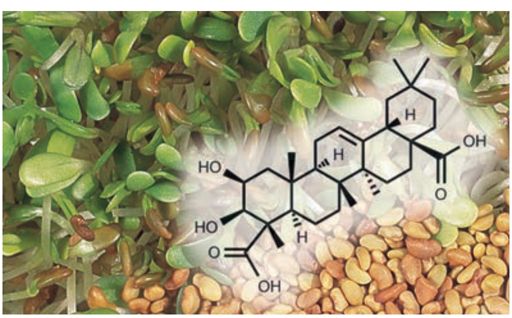
ORIGIN Southwestern Asia (Turkey). Alfalfa or lucerne is an important pasture and fodder crop.

BOTANY Perennial herb (to 1 m); leaves trifoliate, serrate; flowers usually blue; fruit a coiled pod.

CHEMISTRY Saponins (glycosides of **medicagenic acid**, hederagenin and soyasapogenols), steroids (β-sitosterol), isoflavonoids, coumarins, non-protein amino acids (canavanine), proteins.

PHARMACOLOGY Saponins seem to block the intestinal absorption of cholesterol.

TOXICOLOGY In the USA, alfalfa is "generally regarded as safe" but excessive quantities of seeds or sprouts in the diet can lead to systemic *lupus erythromatosus* (SLE) or reversible pancytopenia.



Medicago sativa L. (Fabaceae); *luzerne* (French); *Luzerne* (German); *alfa-alfa* (Italian)

Melaleuca alternifolia

tea tree

CLASSIFICATION TM: Europe, Australia. Pharm., ESCOP Suppl., WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Essential oil (*Melaleucae aetheroleum*), extracted from stems and leaves by steam distillation, is used in creams and ointments to treat a wide range of skin ailments (including abrasions, wounds, acne, itches, infections, athlete's foot and thrush). Dilute oil can be used as gargle and mouthwash to treat inflammation of the mouth and throat, sinusitis and catarrh.

ORIGIN Australia (New South Wales). Commercially cultivated but also grown in herb gardens.

BOTANY Medium-sized tree; leaves linear; flowers without petals, white; fruit a small capsule.

CHEMISTRY Essential oil: the main monoterpenoids in high-quality oil are **terpinen-4-ol** (at least 30%), α- and γ-terpinene (40%) and 1,8-cineole (= eucalyptol; up to 15% maximum).

PHARMACOLOGY Efficacy in treating acne and fungal infections is supported by clinical studies.

TOXICOLOGY External use is safe.

Melaleuca alternifolia Cheel. (Myrtaceae); *melaleuca* (French); *Teebaum* (German); *melaleuca* (Italian)

Melilotus officinalis

sweet clover • common melilot

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 4, PhEur8, HMPC.

USES & PROPERTIES Fresh or dried flowering tops of *M. officinalis* or *M. alba* (below) (*Meliloti herba*) are used to treat varicose veins, pruritus, acute haemorrhoids and other symptoms of venous or lymphatic insufficiency. Preparations are used for minor sleep disturbances and stomach ailments. Effective dose: the equivalent of 3–30 mg of coumarin (oral use) or 1–7.5 mg (parenteral use).

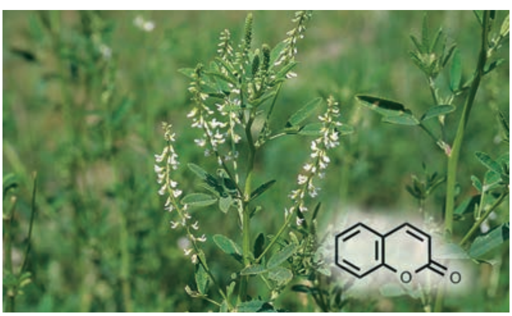
ORIGIN Europe, Asia and North Africa.

BOTANY Erect herb (to 1.2 m); leaves trifoliate, serrate; flowers yellow; fruit small, indehiscent.

CHEMISTRY The glucoside melilotoside is enzymatically converted to **coumarin**, the main ingredient of the drug; also phenolic acids, isoflavonoids and triterpenoid saponins.

PHARMACOLOGY Coumarin acts as a venotonic and decreases capillary permeability; it has anti-oedemic and anti-exudative activities.

TOXICOLOGY Anticoagulant dicoumarols may be formed; do not use while taking anticoagulants.



Melilotus officinalis (L.) Medikus (Fabaceae); *mélilot officinal* (French); *Echter Steinklee* (German); *meliloto*, *trifoglio cavallino* (Italian)

Melissa officinalis

lemon balm • sweet balm

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 2, WHO 2, PhEur8, HMPC.

USES & PROPERTIES The dried leaves of *Melissa officinalis* subsp. *officinalis* (*Melissae folium*) and essential oil (*Melissae aetheroleum*) are used mainly to treat nervous stomach disorders and minor sleep disturbances in adults and children. Extracts and essential oil are used topically for minor skin ailments and are included as ingredients in many commercial preparations (teas, creams, lotions).

ORIGIN Eastern Mediterranean and the Near East.

BOTANY Perennial herb (to 0.9 m); leaves opposite, prominently veined; flowers small, sessile.

CHEMISTRY Essential oil: **citronellal** (30–40%) and citral A and B (10–30%) are main compounds. Also rosmarinic acid (4%), phenolic acids, monoterpene glycosides, triterpenes and flavonoids.

PHARMACOLOGY Essential oil: sedative, carminative, spasmolytic. Ointments with essential oil and rosmarinic acid are active against *herpes simplex* and have antihormonal activity.

TOXICOLOGY No serious side effects are known.

Melissa officinalis L. (Lamiaceae); *mélisse* (French); *Zitronenmelisse* (German); *melissa*, *cedronella* (Italian); *melissa* (Spanish)

Mentha ×piperita

peppermint

CLASSIFICATION TM: Europe. Comm.E+, ESCOP 3, WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Fresh or dried leaves (*Menthae piperitae folium*) and essential oil (*Menthae piperitae aetheroleum*) are used to treat digestive ailments and catarrhs of the respiratory tract. It is used against irritable bowel syndrome and ailments of the gall bladder and bile duct. Peppermint oil is applied topically to reduce pain and headache and as mouthwash/gargle for inflammation of the mouth and throat. It has many uses as flavourant.

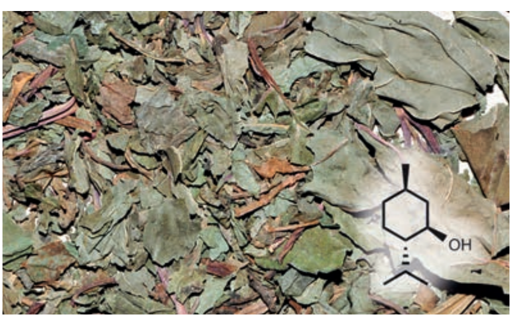
ORIGIN Sterile hybrid, garden origin (England).

BOTANY Perennial herb (to 0.9 m) with rhizomes; stems purple; flowers lilac-pink. Many other species are used in traditional medicine worldwide.

CHEMISTRY Essential oil with the monoterpene **menthol** as the main active ingredient (40% or more).

PHARMACOLOGY The oil is antimicrobial, mildly analgesic, carminative, spasmolytic and choleretic. Menthol activates cold receptors to give a cooling sensation. Clinical data support the stated uses.

TOXICOLOGY The oil is unsafe to use in children.



Mentha ×piperita L. (Lamiaceae); *menthe poivrée* (French); *Pfefferminze* (German); *menta piperina* (Italian); *la menta* (Spanish)

Menyanthes trifoliata

bogbean

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8.

USES & PROPERTIES The dried leaves (*Menyanthidis folium*) are used to stimulate appetite and to treat dyspeptic complaints. It is an ingredient of preparations used for liver and bile ailments and inflammatory conditions, mainly rheumatism. Unsweetened tea made from 0.5–1 g of dried leaves is taken half an hour before meals. The daily dose is 1.5–3 g. Extracts are used in topical anti-inflammatory products for skin disorders and rheumatism, and as bittering agent in liqueurs.

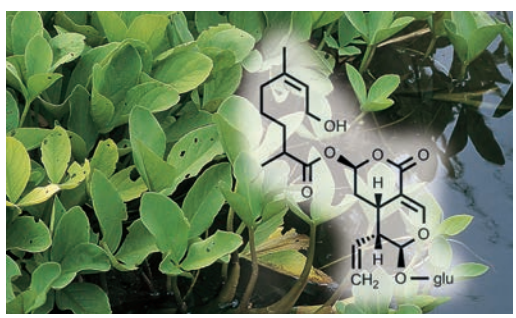
ORIGIN Northern temperate zone (North America, Europe and Asia), in lakes and marshes.

BOTANY Perennial, mat-forming herb; leaves trifoliate (like common bean); flowers white.

CHEMISTRY Bitter-tasting secoiridoid glucosides: mainly **dihydrofoliamenthin**. Coumarins (e.g. scopoletin), tannins, flavonoids and triterpenes.

PHARMACOLOGY *Amarum* (appetite stimulating) effects. Scopoletin: choleretic and cholagogic.

TOXICOLOGY There are no known side effects.



Menyanthes trifoliata L. (Menyanthaceae); *trèfle d'eau* (French); *Bitterklee*, *Fieberklee* (German); *trifoglio d'acqua* (Italian); *trébol acuático* (Spanish)

Mondia whitei

White's ginger • tonic root

CLASSIFICATION TM: Africa. AHP.

USES & PROPERTIES The fleshy roots are widely used across Africa as an aphrodisiac and to treat erectile dysfunction. It is used in African Traditional Medicine for many ailments, including lack of appetite, anorexia, stress and tension, nausea, indigestion, gastrointestinal disorders, constipation, diabetes, post-partum bleeding and gonorrhoea.

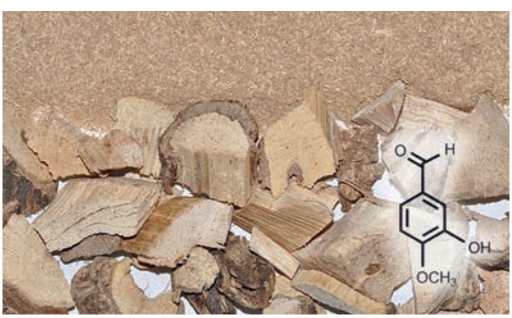
ORIGIN Tropical Africa (South Africa to Congo and East Africa). It is easily cultivated.

BOTANY Woody climber (vine), to 6 m; roots fleshy; leaves with frilly stipules; flowers yellow or maroon; fruit a paired follicle; seeds silky-hairy.

CHEMISTRY Simple benzaldehyde derivates: mainly 2-hydroxy-4-methoxybenzaldehyde and **isovanillin** (hence the vanilla-like smell).

PHARMACOLOGY Roots are androgenic but also show reversible antispermatogenic and antifertility effects. 2-Hydroxy-4-methoxybenzaldehyde is a specific and potent inhibitor of tyrosinase.

TOXICOLOGY Available data indicate a very low toxicity. Aldehydes are potential mutagens.



Mondia whitei (Hook.f.) Skeels (Apocynaceae); *mkombela* (Kenya); *citumbulo* (Malawi); *umondi*, *mundi* (Zulu); *mungurawu* (Shona)

Morinda citrifolia

noni tree • Indian mulberry

CLASSIFICATION TM: Polynesia. DS: functional food.

USES & PROPERTIES Juice from ripe fruits is used as general health drink. Traditional uses include the treatment of fever, diabetes, stomach and liver ailments, menstrual cramps and urinary tract ailments. Possible health benefits of the juice are difficult to evaluate because of the influence of commercial interests and marketing materials.

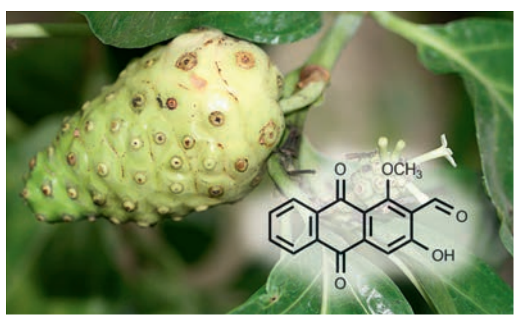
ORIGIN India, Southeast Asia and Pacific Islands (a traditional famine food and medicine).

BOTANY Evergreen shrub or tree (to 6 m); leaves glossy; flowers small, in dense heads; fruit a white compound drupe, resembling a large mulberry.

CHEMISTRY The fruit and fruit juice contain high levels of minerals and vitamins B and C. **Damnacanthal** (an anthraquinone) is present in the roots.

PHARMACOLOGY Damnacanthal is an inhibitor of tyrosine kinase and has anticancer activity. An alkaloid, xeronine, was said to be the active compound (but the structure is still unknown).

TOXICOLOGY Noni is not toxic (used as food).



Morinda citrifolia L. (Rubiaceae); *hai ba ji* (Chinese); *nono* (French); *Indische Maulbeere*, *Nonibaum* (German); *bengkudu* (Malay); *nonu* (Polynesian); *mora de la India* (Spanish)

Moringa oleifera

ben tree • drumstick tree

CLASSIFICATION TM (DS): Europe, Africa, Asia.

USES & PROPERTIES Leaves, fruits and seeds are edible, while seeds, flowers and roots have been used in traditional medicine to treat a wide range of ailments (e.g. in Ayurvedic medicine, to lower blood pressure and blood glucose). Leaves are used for malnutrition relief. The seed oil, called ben or behen oil, is used as a dietary supplement and has cosmetic and industrial uses. Powdered seeds have been used to treat asthma.

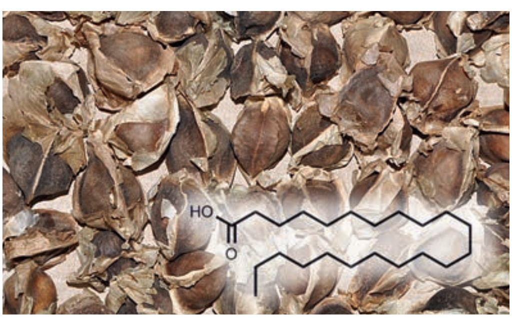
ORIGIN Northwestern India; widely cultivated.

BOTANY Tree (5–15 m); leaves 2–4-pinnate; flowers creamy white; fruits to 1 m; seeds winged.

CHEMISTRY The seed oil (ben/behen oil) contains a saturated fatty acid, **behenic acid**. Antibiotic benzyl isothiocyanates are present.

PHARMACOLOGY The medicinal properties (e.g. anti-asthmatic effect) are not yet clearly explained. Benefits are derived from the high levels of nutrients (minerals, vitamins and protein) and glucosinolates. The oil has cosmetic uses.

TOXICOLOGY Leaves, fruits and seeds are edible.



Moringa oleifera Lam. (Moringaceae); *la mu* (Chinese); *ben oléifère* (French); *Meerrettichbaum* (German); *been* (Italian); *arbol de las perlas*, *ben* (Spanish)

Myristica fragrans

nutmeg tree

CLASSIFICATION Neurotoxin, mind-altering (II). TM: Europe, Asia. Pharm., PhEur8.

USES & PROPERTIES Dried seeds (*Myristicae semen*) and/or the dried seed arils (mace, *Myristicae arillus*) are used to treat digestive ailments and catarrh of the respiratory tract. The essential oil (*Myristicae aetheroleum*) is used topically for relief of aches and pains. Nutmeg is also an intoxicating and addictive drug.

ORIGIN Southeast Asia (Amboine Island). Cultivated in tropical regions for nutmeg and mace.

BOTANY Evergreen tree (to 20 m); flowers small, yellow; fruits (on female trees) fleshy; seed a large nut, surrounded by a bright red aril.

CHEMISTRY Essential oil: sabinene, pinene and **myristicin** with phenylpropanoids (elemicin, eugenol, isoeugenol, safrol and others).

PHARMACOLOGY Myristicin and elemicin are addictive and hallucinogenic (potentially cytotoxic, mutagenic and abortive). The oil has strong antimicrobial and anti-inflammatory activity.

TOXICOLOGY Doses exceeding 5 g are dangerous.

Myristica fragrans Houtt. (Myristicaceae); *noix muscade* (French); *Muskatnussbaum* (German); *noce moscata* (Italian); *nuez moscada* (Spanish)

Myroxylon balsamum

Tolu balsam tree

CLASSIFICATION TM: Central and South America. Pharm., Comm.E+, PhEur8.

USES & PROPERTIES The oleoresin obtained from damaged bark is called Tolu balsam (*Balsam tolutanum*), while smoked wood of the var. *pereirae* yields Peruvian balsam. Tolu balsam is used in cough syrups (also for asthma and whooping cough) and friar's balsam (a traditional inhalant for catarrh and colds). Peruvian balsam is applied externally to wounds, burns and bruises.

ORIGIN South and Central America.

BOTANY Tall evergreen trees (to 19 m); leaves compound; flowers white or pale blue; fruit a pod.

CHEMISTRY Balsams are oleoresins containing benzoic acid, cinnamic acid and their esters (especially **benzyl benzoate**).

PHARMACOLOGY Benzyl benzoate has vasodilating and spasmolytic effects (and is active against scabies). Benzoic acid is antibacterial; Peruvian balsam stimulates granulation in wounds.

TOXICOLOGY Benzyl benzoate has a very low oral toxicity: LD_{50} = 1700 mg/kg (rat, p.o.).

Myroxylon balsamum (L.) Harms (Fabaceae); *baumier de Tolu* (French); *Tolubalsambaum* (German); *balsamo del Tolù* (Italian)

Narcissus pseudonarcissus

wild daffodil • lent lily

CLASSIFICATION Cell toxin, highly hazardous (Ib–II). TM: Europe, Asia.

USES & PROPERTIES The bulbs have been used in traditional Roman and Japanese (Kampo) medicine as emollient to treat wounds. Daffodils are popular garden plants and poisoning may occur when the bulbs are confused with onions.

ORIGIN Western Europe. Widely naturalised and cultivated as a spring flower and cut flower.

BOTANY Perennial bulbous plant; leaves strap-shaped; flower dark or pale yellow, with a large, bell-shaped corona.

CHEMISTRY Isoquinoline alkaloids: **lycorine** and galanthamine.

PHARMACOLOGY Lycorine: inhibitor of protein biosynthesis, cytotoxic, virustatic, emetic, diuretic. Galanthamine blocks cholinesterase and is used to treat Alzheimer's disease and other memory impairments (see *Galanthus nivalis*).

TOXICOLOGY Lycorine is very poisonous. LD_{50} = 41 mg/kg (dog, p.o.). Symptoms of poisoning include nausea, vomiting and slowing of heartbeat.

Narcissus pseudonarcissus L. (Amaryllidaceae); *narcisse jaune, bonhomme, chaudron* (French); *Osterglocke, Gelbe Narzisse* (German); *narciso trombone* (Italian)

Nelumbo nucifera

lotus • sacred lotus

CLASSIFICATION TM: Asia (China, India).

USES & PROPERTIES The leaves (*he ye*, *Folium Nelumbinis*), rhizomes (*ou jie*), seeds (*lian zi*) and seed embryos (*lian zi xin*) are all used in Chinese traditional medicine. The leaves and flowers are used to treat menorrhagia and haemorrhoids, fever, diarrhoea and nervous conditions. Seeds are a functional food, eaten to reduce nausea, indigestion, nervous conditions and insomnia.

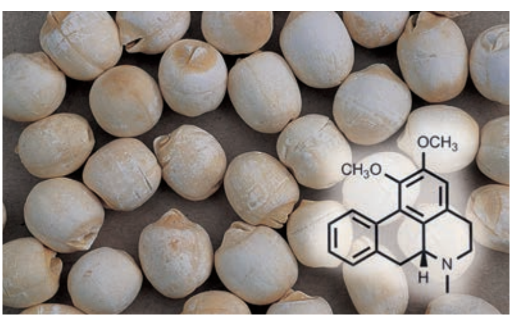
ORIGIN Southern Asia (India and China to Australia). Widely cultivated in ponds and lakes.

BOTANY Aquatic plant; rhizome fleshy; leaves large, umbrella-shaped; flowers large, waxy, white or pink; fruit cup-shaped; seed a one-seeded nut.

CHEMISTRY Alkaloids: especially **nuciferine**. Also flavonoids in leaves and flowers.

PHARMACOLOGY Nuciferine has CNS-depressant effects (through dopamine receptor blocking) and is sedative and hypothermic. Also anti-inflammatory, hypoglycaemic and antipyretic effects.

TOXICOLOGY Nuciferine: LD_{50} = 289 mg/kg (mouse, p.o.).



Nelumbo nucifera Gaertner [Nelumbonaceae (formerly Nymphaeaceae)]; *lian* (Chinese); *nelumbo* (French); *Lotosblume* (German); *kanwal* (Hindi); *nelumbo* (Italian); *kamala* (Sanskrit)

Nerium oleander

oleander • rose laurel

CLASSIFICATION Heart poison, extremely hazardous (II). TM: Europe. Pharm.

USES & PROPERTIES Infusions of the leaves (*Oleandri folium*) have been used in European medicine as a heart tonic to treat cardiac insufficiency. It has also been used for abortion and externally to treat skin rashes and scabies. Accidental and deliberate deaths have occurred after drinking extracts or eating only a few leaves.

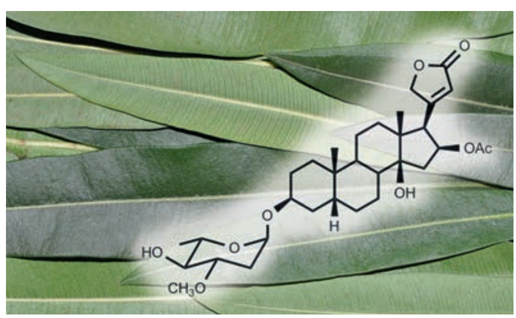
ORIGIN Europe (Mediterranean region). A popular garden shrub in all warm parts of the world.

BOTANY Shrub or small tree (to 5 m); all parts exude milky latex when broken; leaves leathery; flowers in many colours; fruit oblong; seeds hairy.

CHEMISTRY Heart glycosides (cardenolides): at least 30 compounds (**oleandrin** as the main toxin).

PHARMACOLOGY Cardenolides inhibit Na^+, K^+-ATPase, leading to an increase in the force of contraction of the heart. They are also diuretic.

TOXICOLOGY The lethal oral dose for domestic animals is 0.5 mg/kg. A single leaf can cause intoxication in humans.



Nerium oleander L. (Apocynaceae); *laurier rose* (French); *Oleander* (German); *oleandro* (Italian); *adelfa* (Spanish)

Nicotiana glauca

tree tobacco • tobacco tree

CLASSIFICATION Neurotoxin, mutagen, highly hazardous (Ib). TM: South America.

USES & PROPERTIES The plant has been used in traditional medicine and as insecticide. Human fatalities have often been recorded, where young plants were misidentified as other plants traditionally eaten as cooked spinach (*marog*). Since a bitter taste in vegetables is often appreciated, this warning sign may not be heeded before it is too late.

ORIGIN South America (Bolivia to Argentina); an invasive weed in many parts of the world.

BOTANY Shrub or small tree (ca. 3 m); leaves fleshy, bluish-green; flowers tubular, yellow; fruit a dehiscent, many-seeded capsule.

CHEMISTRY All aboveground parts contain high levels of **anabasine** (a piperidine alkaloid) as practically the only alkaloid.

PHARMACOLOGY Anabasine is a nicotinic acetylcholine receptor antagonist that can block nerve transmission and cause death by cardiac arrest.

TOXICOLOGY Anabasine: LD_{50} = 11–16 mg/kg (mouse, p.o.).

Nicotiana glauca Graham (Solanaceae); *tabac en arbre* (French); *Baumtabak, Blaugrüner Tabak* (German); *tabacco glauco*, *tabacco orecchiuto* (Italian)

Nicotiana tabacum

tobacco

CLASSIFICATION Neurotoxin, mind-altering, highly hazardous (Ib). TM: South America.

USES & PROPERTIES Tobacco has been smoked since pre-Columbian times. Despite health warnings, smoking has remained popular. Tobacco may be chewed or taken as snuff. Powdered tobacco was once popular as insecticide. Pure nicotine is used in chewing gum and slow-release plasters.

ORIGIN South America; a cultigen developed from three wild species in pre-Columbian times.

BOTANY Robust annual (ca. 2 m); leaves large, soft, glandular; flower tubular, pink.

CHEMISTRY Pyridine alkaloids (to 9%): **nicotine** is the main constituent.

PHARMACOLOGY Nicotine is a potent parasympathomimetic (mAChR antagonist) that is stimulant at low doses but sedative at higher doses. It is highly addictive and may cause heart and lung ailments (especially lung carcinoma and emphysema).

TOXICOLOGY Nicotine: LD_{50} = 3 mg/kg for mice (p.o.). A dose of 0.5–1.0 mg/kg (or 50–60 mg) may be lethal for adult humans.

Nicotiana tabacum L. (Solanaceae); *tabac de Virginie* (French); *Tabak*, *Virginischer Tabak* (German); *tabacco Virginia* (Italian); *tabaco de Virginia* (Spanish)

Nigella sativa

black seed • kalonji

CLASSIFICATION TM (DS): Asia.

USES & PROPERTIES The ripe seeds or seed oil are important in Arabian and Islamic folk medicine. The seeds are ingested daily as general tonic and preventive medicine; also stomach ailments, colic, spasms, asthma, headache and intestinal parasites. A popular spice in the Middle East and India (often called black cumin but the latter more correctly refers to *Bunium persicum*).

ORIGIN Southern Europe, North Africa and western Asia. Cultivated since ancient times in Mesopotamia, Egypt, Arabia, Pakistan and India.

BOTANY Annual herb; leaves deeply dissected; flowers white or pale blue; fruit a many-seeded capsule; seeds black, oblong, angular.

CHEMISTRY Chemically diverse, with phytosterols, triterpene saponins, quinones, flavonols and alkaloids (nigelline). The essential oil has **thymoquinone** as main compound.

PHARMACOLOGY Immune stimulation, antispasmodic. Large doses: diuretic, stimulate lactation.

TOXICOLOGY The seeds are edible.

Nigella sativa L. (Ranunculaceae); *nigelle, poivrette* (French); *Schwarzkümmel* (German); *nigella* (Italian)

Ocimum tenuiflorum

holy basil • sacred basil

CLASSIFICATION TM: Asia (India). WHO 2.

USES & PROPERTIES Fresh or dried aboveground parts (*Ocimi sancti herba*) are used in Ayurvedic medicine as a general medicine and tonic (for an exceptionally wide diversity of ailments), as well as for wound healing. Infusions of the leaves or fresh leaf juice are used against cough, upper respiratory tract infections, indigestion and stress-related skin ailments. Dose: 2–4 g, three times per day.

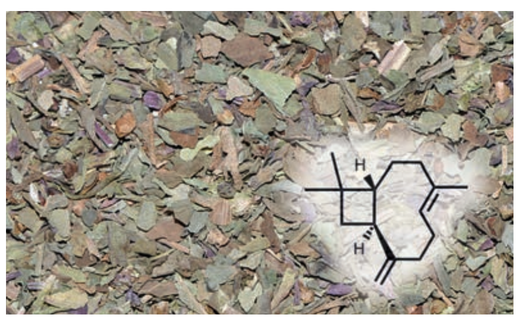
ORIGIN Western Asia to Arabia, India, Sri Lanka, Malaysia and Australia. Widely cultivated. *Ocimum basilicum* is a popular spice.

BOTANY Short-lived perennial herb (to 1 m); leaves hairy; flowers purple, lilac or white.

CHEMISTRY Essential oil (to 2%): eugenol and methyleugenol (the main compounds), also α- and **β-caryophyllene**; tannins (4.6%) and flavonoids.

PHARMACOLOGY Tonic and wound-healing activities. Clinical data show anti-asthmatic, anti-diabetic and cholesterol-lowering activity.

TOXICOLOGY Do not use for prolonged periods. Contraindicated: pregnant women and children.



Ocimum tenuiflorum L. (Lamiaceae); *sheng luo le* (Chinese); *Basilic sacré* (French); *Indisches Basilikum* (German); *tulsi, talasi* (Gujarati); *tulasii* (Hindi)

Oenothera biennis

evening primrose

CLASSIFICATION TM: North America, Europe. WHO 2, HMPC, clinical studies+. DS: seed oil.

USES & PROPERTIES Seed oil (evening primrose oil, *Oenotherae biennis oleum*) is a dietary supplement for symptomatic relief of skin disorders: atopic eczema, pruritus and inflammation. Possible benefits: irritable bowel syndrome and menopausal, circulatory and rheumatic disorders.

ORIGIN North America (Florida to Mexico and Canada). It has become a weed in many countries.

BOTANY Biennnial or short-lived perennial herb (to 1.5 m); leaves in a basal rosette in 1st year; flowers in 2nd year, large, yellow; fruit an oblong, multi-seeded capsule (150 000 seeds per plant).

CHEMISTRY The seed oil contains high levels of **γ-linolenic acid** (gamma-linolenic acid or GLA).

PHARMACOLOGY GLA is an essential fatty acid (prostaglandin pathway). Some people are apparently unable to convert linoleic acid to GLA. Clinical studies support the use for eczema.

TOXICOLOGY The seed oil is safe to consume in recommended doses (2–3 g per day, up to 5 g).

Oenothera biennis L. (Onagraceae); *onagre bisannuelle* (French); *Gemeine Nachtkerze* (German); *enothera* (Italian)

Olea europaea

olive tree

CLASSIFICATION TM: Africa, Europe, Asia. Pharm., PhEur8, Comm.E+, HMPC.

USES & PROPERTIES Dried leaves (*Oleae folium*) are traditionally used to lower blood pressure (also as diuretic). The daily dose is about 1–2 g. Cold-pressed fruit oil (*Olivae oleum*) is taken with meals (15–30 ml) as mild laxative and cholagogue and applied externally as demulcent and emollient.

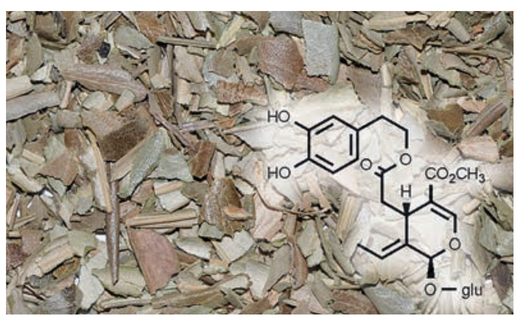
ORIGIN Mediterranean Europe, western Asia and North Africa. The tree is widely cultivated for the production of olives. African wild olive (subsp. *cuspidata*) is an alternative source of raw material.

BOTANY Evergreen tree (to 10 m); leaves opposite; flowers small, white; fruit a fleshy, oily drupe.

CHEMISTRY Bitter sesquiterpenoids: **oleuropein**, with ligustroside and oleacein. Also triterpenoids, sterols and flavonoids. Oil: oleic and linoleic acids.

PHARMACOLOGY Oleuropein lowers blood pressure by increasing coronary flow; it also has antispasmodic, antioxidant and lipid-lowering effects. Oleacein inhibits the ACE.

TOXICOLOGY Non-toxic at recommended doses.



Olea europaea L. (Oleaceae); *olivier* (French); *Ölbaum* (German); *olivo*, *ulivo* (Italian); *olivo* (Spanish)

Ononis spinosa

spiny restharrow

CLASSIFICATION TM: Europe. Pharm., PhEur8, Comm.E+.

USES & PROPERTIES The dried roots, harvested in autumn (*Ononidis radix*) are traditionally used as a mild diuretic to treat rheumatism and gout. In modern phytotherapy it is mainly used for irrigation therapy: inflammation of the lower urinary tract and to prevent and treat kidney gravel. It is taken as an infusion of 2.5 g of root, taken several times per day (recommended daily dose: 6–12 g).

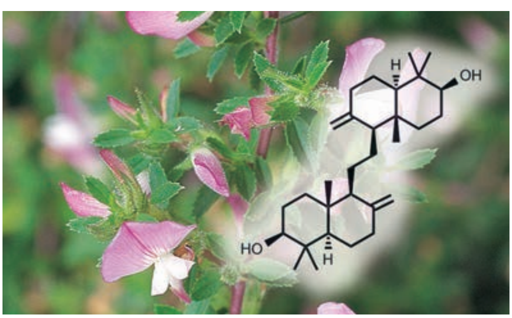
ORIGIN Europe, western Asia and North Africa.

BOTANY Shrub (to 0.8 m); stems spiny; leaves trifoliate at base, upper simple; flowers pink.

CHEMISTRY Triterpenes: mainly **α-onocerin** (onocol); sterols (mainly sitosterol); phenolic acids; isoflavones: ononine, formononetin, genistein.

PHARMACOLOGY Diuretic activity may be due to α-onocerin. Isoflavones have oestrogenic activity.

TOXICOLOGY Non-toxic (but sufficient fluids should be taken). Contraindicated for persons suffering from oedema due to cardiac or renal insufficiency.



Ononis spinosa L. (Fabaceae); *bugrane épineuse, arrête-boeuf* (French); *Dornige Hauhechel* (German); *bonaga, ononide* (Italian); *gatună* (Spanish)

Origanum vulgare

oregano

CLASSIFICATION TM: Europe. Pharm. Comm. E+. (*O. dictamnus*: WHO 5, HMPC).

USES & PROPERTIES The dried flowering herb (*Origani vulgaris herba*) is taken as infusion (1–2 g, three times per day) to treat respiratory ailments (bronchitis, catarrh, colds, influenza) and indigestion (colic and dyspepsia). It can be applied to itchy skin. Oregano oil (*Origani vulgaris aetheroleum*) is used in aromatherapy and in dilute form for mouth hygiene and nasal congestion.

ORIGIN Europe to central Asia. Cultivated on a large scale for use as a culinary herb spice (mainly to flavour pizzas).

BOTANY Perennial herb (to 0.9 m); leaves hairy, opposite; flowers white or pink. *Origanum dictamnus* (dittany), *O. syriacum* (zatar) and *O. majorana* (marjoram) also have essential oil and similar uses.

CHEMISTRY Essential oil with **carvacrol** (40–70%), *p*-cymene and terpinene.

PHARMACOLOGY The oil has proven antimicrobial, spasmolytic and anti-inflammatory activity.

TOXICOLOGY The plant is non-toxic.

Origanum vulgare L. (Lamiaceae); *origan* (French); *Echter Dost* (German); *origano* (Italian); *orégano* (Spanish)

Orthosiphon aristatus

long-stamened orthosiphon

CLASSIFICATION TM: Europe, Asia. Comm.E+, ESCOP 1, PhEur8, HMPC.

USES & PROPERTIES Dried leaves (*Orthosiphonis folium*) are used to treat urological ailments in the form of a diuretic tea known as Java tea. It is used to treat inflammation of the bladder and kidneys. It may also be used with other herbs in urological preparations. Recommended daily dose: 6–12 g (taken as infusion, in doses of 2–3 g in 150 ml water).

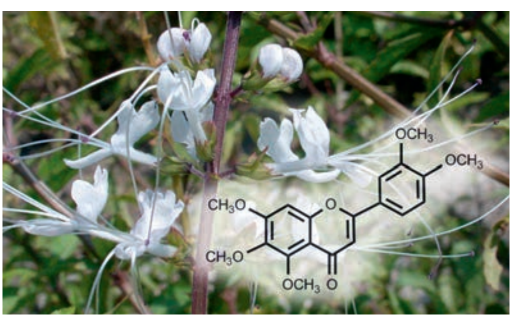
ORIGIN Southeast Asia, Malaysia and Australia.

BOTANY Perennial herb (to 0.8 m); leaves opposite, hairy; flowers white/lilac; stamens protruding.

CHEMISTRY The herb is chemically complex, with methoxylated flavonoids (**sinensetin**, scutellarein), flavonol glycosides, organic acids (rosmarinic acid, tartaric acid) and diterpenes (orthosiphol A–C), potassium salts (3%) and essential oil (borneol, limonene, thymol and sesquiterpenoids).

PHARMACOLOGY Diuretic, antimicrobial, antioxidant and anti-inflammatory activity.

TOXICOLOGY No serious side effects are known.



Orthosiphon aristatus (Blume) Miq. [= *O. stamineus* Benth.] (Lamiaceae); *moustache de chat* (French); *Katzenbart* (German); *kumis kutjing* (Indonesian); *tè de Giava* (Italian)

Paeonia lactiflora

white peony

CLASSIFICATION TM: Asia (China). Pharm., WHO 1. (*P. officinalis*: Pharm.).

USES & PROPERTIES Dried roots (*Paeonia radix*) are used in Chinese traditional medicine to treat digestive ailments (stomach cramps, liver problems), menstrual disorders (amenorrhoea, dysmenorrhoea) and also headache, dementia and vertigo. The daily dose is up to 15 g. Dried roots of the southern European *P. officinalis* (*Paeoniae radix rubra*) are no longer used to any extent but the petals (*Paeoniae flos*) are still included in herbal teas to provide colour.

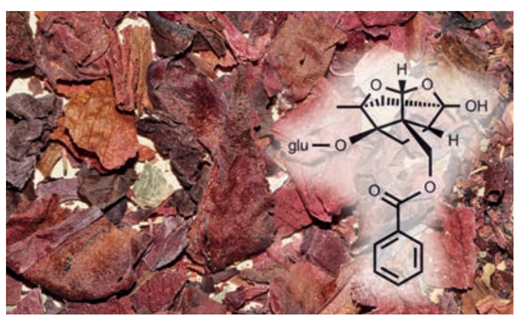
ORIGIN Asia (China, Japan and India).

BOTANY Deciduous perennial herb (to 0.8 m); roots fleshy; leaves compound; flowers large, showy, usually white.

CHEMISTRY Roots contain a monoterpenoid glucoside called **paeoniflorin** (up to 5% of dry weight).

PHARMACOLOGY Paeoniflorin has analgesic, antipyretic, anti-inflammatory, sedative, uterus-contractant and vasodilatory activities.

TOXICOLOGY Non-toxic at recommended doses.



Paeonia lactiflora Pallas [= *P. albiflora*] (Paeoniaceae); *bai shao yao* (Chinese); *pivoine* (French); *Chinesische Pfingstrose*, *Päonie* (German); *peonia* (Italian)

Panax ginseng

ginseng • Asian ginseng

CLASSIFICATION TM: Asia (China), Europe. Comm.E+; WHO 1, 5; PhEur8, HMPC; clinical studies+. (*P. quinquefolius*: WHO 4).

USES & PROPERTIES Fresh or mostly dried roots (*Ginseng radix*, *ren shen*) have a long history of use in China as an adaptogenic tonic aimed at treating general weakness, fatigue, lack of stamina and declining concentration. *Panax quinquefolius* (American ginseng) is used in the same way.

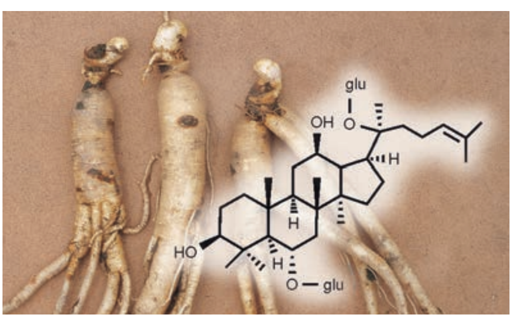
ORIGIN East Asia (China). American ginseng: USA and Canada. Both cultivated on a large scale.

BOTANY Perennial herb; roots fleshy; leaves compound; flowers small, white; fruits fleshy, red.

CHEMISTRY Triterpenoid saponins, so-called ginsenosides, in a complex mixture: **ginsenoside Rg$_1$**, Rc, Rd, Rb$_1$, Rb$_2$ and Rb$_0$ are the main compounds. Also present are polyacetylenes.

PHARMACOLOGY Controlled clinical trials have proven that ginseng elevates and enhances mood, performance (physical and intellectual), immune response and convalescence.

TOXICOLOGY No serious side effects are known.



Panax ginseng C. A. Mey. (Araliaceae); *ginseng* (French); *Ginseng* (German); *ginseng* (Italian)

Papaver somniferum

opium poppy

CLASSIFICATION Neurotoxin, mind-altering, highly hazardous (Ib). TM: Asia, Europe. Pharm., PhEur8. MM: pure alkaloids.

USES & PROPERTIES Dried latex from unripe fruits (*Opium*) is traditionally used as intoxicant and nowadays as source of pure alkaloids for treating visceral spasms and intense pain, as well as cough, congestion, and the pain associated with colds and flu. Usual doses are 10–40 mg per day (morphine) and 30 mg every four hours (codeine).

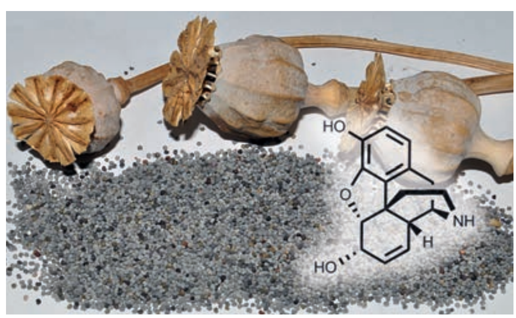
ORIGIN Southwestern Asia.

BOTANY Annual (ca. 1.5 m); leaves grey; flowers large, terminal; fruit a multi-seeded capsule.

CHEMISTRY Raw opium contains isoquinoline alkaloids: **morphine** (10–12%), codeine (2.5–10%) and noscapine (= narcotine, 2–10%). Morphine is chemically converted to heroin (highly addictive).

PHARMACOLOGY Analgesic and euphoric (hallucinogenic). Morphine is converted to the less addictive codeine (antitussive, analgesic).

TOXICOLOGY Lethal dose: 50–75 mg heroin, 200–400 mg morphine (or 100–200 mg, parenteral).



Papaver somniferum L. (Papaveraceae); *pavot somnifère* (French); *Schlafmohn* (German); *pavot officinal*, *papavero domestico* (Italian)

Passiflora incarnata

passion flower • apricot vine

CLASSIFICATION Sedative, mind-altering (III). TM: North America, Europe. Comm.E+ ESCOP, WHO 3, PhEur8, HMPC.

USES & PROPERTIES Dried leaves and thin stems (*Passiflorae herba*) are used as mild sedative to treat restlessness, nervousness, sleeplessness and nervous gastrointestinal disorders, especially in children. The seed arils are juicy and edible.

ORIGIN North America (eastern and southern).

BOTANY Woody climber; stems with coiled tendrils; leaves deeply lobed; flowers white or violet, showy; fruit a many-seeded berry.

CHEMISTRY The herb contains numerous compounds: γ-pyrones (**maltol** and ethylmaltol), flavonoids (*C*-glycosides such as vitexin and isovitexin; apigenin and luteolin), a polyacetylene (passicol) and a cyanogenioc glucoside (gynocardin).

PHARMACOLOGY CNS sedating and anticonvulsant properties are ascribed to maltol and ethylmaltol. (Presence of alkaloids uncertain.)

TOXICOLOGY Cyanogenic glucosides are toxic but the herb is safe to use at doses of up to 8 g/day.

Passiflora incarnata L. (Passifloraceae); *passiflore, fleur de la passion* (French); *Fleischfarbene Passionsblume* (German); *passiflora* (Italian); *pasiflora* (Spanish)

Paullinia cupana

guaraná • Brasilian cocoa

CLASSIFICATION Stimulant (III). TM: South America. Pharm., HMPC. DS: caffeine.

USES & PROPERTIES Ripe seeds or guaraná (a dried paste made from roasted, powdered seeds) are used as stimulant tonics to reduce fatigue, and as antidiarrhoeal and diuretic medicines. Guaraná is used in soft drinks and weight loss preparations.

ORIGIN South America. Cultivated in Brazil.

BOTANY Woody climber; stems with coiled tendrils; leaves compound; flowers small, yellowish; fruit a bright red capsule; seeds dark brown / black.

CHEMISTRY Seeds (and guaraná) contain three to five times more **caffeine** (3–8%) than coffee. Also present are phenolic compounds in high yields (12%), including catechin, epicatechin and proanthocyanidins.

PHARMACOLOGY Caffeine is a central stimulant with diuretic activity (see *Coffea*); high doses cause intoxication with headaches, nausea, vomiting and diarrhoea. The tannins have antidiarrhoeal effects.

TOXICOLOGY Caffeine is safe but high doses may cause sleeplessness and heart palpitations.

Paullinia cupana Kunth (Sapindaceae); *guarana* (French); *Guarana-Strauch* (German); *cupana* (Spanish)

Pausinystalia johimbe

yohimbe tree

CLASSIFICATION Neurotoxin, hallucinogen, highly hazardous (Ib); TM: Africa. MM: pure alkaloid (aphrodisiac).

USES & PROPERTIES The bark (*Yohimbe cortex*) is traditionally used for treating urinary ailments and as aphrodisiac and male tonic. The dose ranges from 3 to 10 g per day. In modern phytotherapy it has become a popular remedy for micturition, impotence and frigidity (dose: 10 mg of yohimbine).

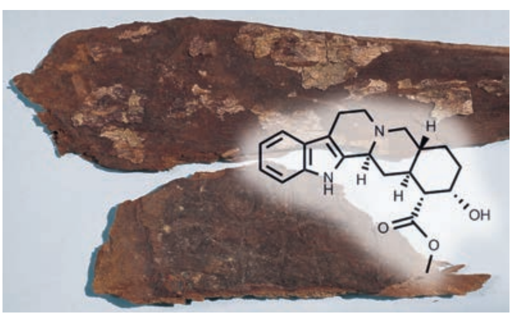
ORIGIN West and Central Africa.

BOTANY Evergreen tree (to 30 m); leaves oblong; flowers small, white; fruit a capsule; seed winged.

CHEMISTRY Bark: monoterpene indole alkaloids (3–6%): **(+)-yohimbine** is the main compound.

PHARMACOLOGY Yohimbine causes vasodilation and decreased blood pressure. It is a central stimulant that increases general anxiety and excitability of the lower abdomen. There is clinical evidence for efficacy in treating erectile dysfunction.

TOXICOLOGY Doses of more than 100 mg yohimbine are dangerous. LD_{50} = 20 mg/kg (mouse, i.p.).



Pausinystalia johimbe (K. Schum.) Beille [= *Corynanthe yohimbe* K. Schum.] (Rubiaceae); *yohimbe* (French); *Yohimbebaum* (German); *yohimbe* (Italian)

Peganum harmala

African rue • harmala

CLASSIFICATION Neurotoxin, mind-altering. TM: Africa, Asia (India). PhEur8, WHO 5.

USES & PROPERTIES The seeds (*Harmalae semen*) or less often the roots have been used to treat stomach pain, eye diseases, rheumatism, nervous conditions and impotence. Smoke from burning seeds is inhaled as an intoxicant, stimulant and hallucinogen (and claimed to be the inspiration behind the concept of flying oriental carpets and their intricate patterns).

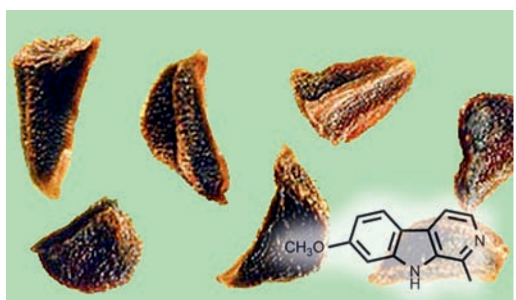
ORIGIN Mediterranean Europe, North Africa, Arabia and western Asia. Commonly cultivated.

BOTANY Small shrub; leaves compound; flowers whitish; fruit a capsule; seeds small.

CHEMISTRY Indole alkaloids (also known as β-carboline or harman alkaloids): **harmine** is the main compound in seeds and roots.

PHARMACOLOGY Harmine (> 4 mg): hallucinogenic, antidepressant, euphoric and aphrodisiac. It was once used to treat Parkinson's disease.

TOXICOLOGY Harmine is highly hazardous: LD_{50} = 38 mg/kg (mouse, i.v.) (see *Banisteriopsis*).



Peganum harmala L. [Nitrariaceae (formerly Zygophyllaceae)]; *harmel* (French); *Steppenraute* (German); *peganum* (Italian)

Pelargonium sidoides

umckaloabo

CLASSIFICATION TM: Africa, Europe. HMPC, clinical studies+.

USES & PROPERTIES The fleshy roots, fresh or dried, are traditionally used in southern Africa to treat dysentery and infections, including tuberculosis. In Europe, standardised special extracts have been used for many years in phytotherapy, mainly to treat bronchitis in children and adults.

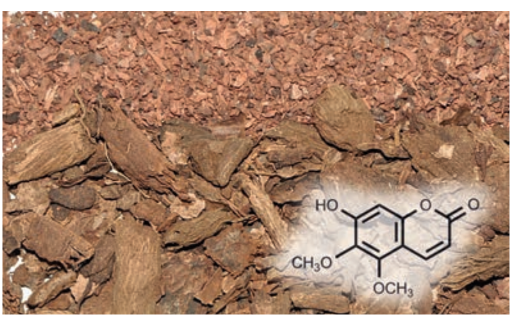
ORIGIN Africa (South Africa and Lesotho). The product is wild-harvested and cultivated.

BOTANY Perennial herb; roots tuberous, red; leaves rounded, silvery, hairy; flowers dark purple or black; fruit a slender, few-seeded schizocarp.

CHEMISTRY Roots with several coumarins: **umckalin** is the main compound. Also many tannins, gallic acid derivatives, oligomeric proanthocyanidins, flavan-3-ols and flavonoids.

PHARMACOLOGY Umckalin is a natural antibiotic. The product has proven immune-stimulant activity. The tannins are likely to be effective against diarrhoea (antibacterial and antiviral activity).

TOXICOLOGY Safe to use at the prescribed dose.



Pelargonium sidoides DC. (Geraniaceae); *Pelargonium sidoides* (French); *Umckaloabo* (German); *Pelargonium sidoides* (Italian)

Petasites hybridus

butterbur

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (rhizomes only), clinical studies+.

USES & PROPERTIES Dried rhizomes (*Petasitidis rhizoma*) are used to treat spastic pains of the head (chronic headache and migraine), lungs (bronchial spasms), gastrointestinal tract (stomach cramps) and urinary tract (kidney and bladder stones). Dried leaves (*Petasitidis folium*): as a tranquilliser against nervous cramps, headache, dysmenorrhoea, allergic rhinitis, wounds and skin ailments.

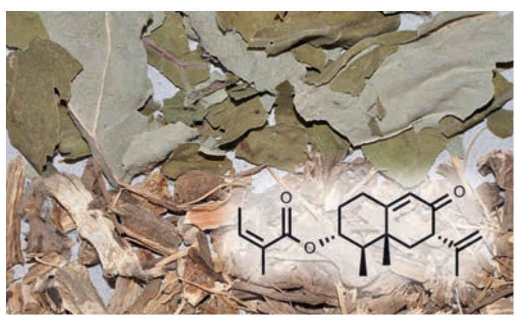
ORIGIN Europe and northwestern Asia. Naturalised in North America.

BOTANY Robust perennial herb; leaves large, hairy; flower heads discoid, purple/rarely yellow.

CHEMISTRY Sesquiterpenoids: **petasin** and isopetasin). Pyrrolizidine alkaloids (PAs, e.g. senkirkine) that are removed in modern preparations.

PHARMACOLOGY The sesquiterpenes are spasmolytic, analgesic and sedative. The alkaloids are mutagenic and carcinogenic liver poisons.

TOXICOLOGY Use only PA-free preparations. The sesquiterpenoids are hepatotoxic in high doses.



Petasites hybridus (L.) Gaertn., Meyer & Scherb. (Asteraceae); *pétasite vulgaire* (French); *Gemeine Pestwurz* (German); *farfaraccio* (Italian)

Petroselinum crispum

parsley

CLASSIFICATION Cell toxin (III); TM: Europe. Pharm., Comm.E+ (root, herb).

USES & PROPERTIES Aerial parts (*Petroselini herba*) and roots (*Petroselini radix*) are traditionally used to treat disorders of the gastrointestinal and urinary tracts (including kidney gravel). Leaves are applied as demulcent to itchy skin. The fruits (*Petroselini fructus*) were once used for relief of period pains and to induce abortion. Parsley is nowadays included (as diuretic) in weight loss products.

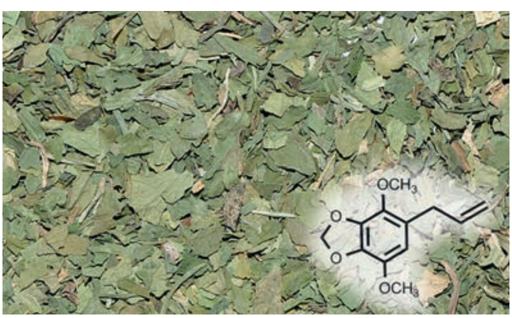
ORIGIN Europe and western Asia. Grown commercially worldwide as a popular culinary herb.

BOTANY Biennial herb; leaves dissected; flowers small, yellow; fruit small, dry schizocarps.

CHEMISTRY Essential oil (0.5% in the herb, 2–6% in fruits) rich in phenylpropanoids: **apiol** and myristicin are the main constituents. Also present are flavonoids (e.g. apiin) and traces of coumarins.

PHARMACOLOGY Diuretic and antipruritic activities are ascribed to the essential oil.

TOXICOLOGY Pure apiol is abortifacient. Very high doses are toxic and may cause liver damage.



Petroselinum crispum (Mill.) A.W. Hill (Apiaceae); *persil* (French); *Petersilie* (German); *prezzemolo* (Italian); *perejil* (Spanish)

Peumus boldus

boldo

CLASSIFICATION Neurotoxin (II). TM: South America (Chile). Pharm., PhEur8, Comm.E+, ESCOP 1, HMPC.

USES & PROPERTIES Dried leaves (*Boldo folium*) are traditionally used as a general tonic and to treat dyspeptic and mild spastic complaints. Dose: infusion of 1–2 g, taken two or three times per day. Boldo leaf extracts are included in cholagogues and biliary preparations, often (and preferably) standardised for their alkaloid content.

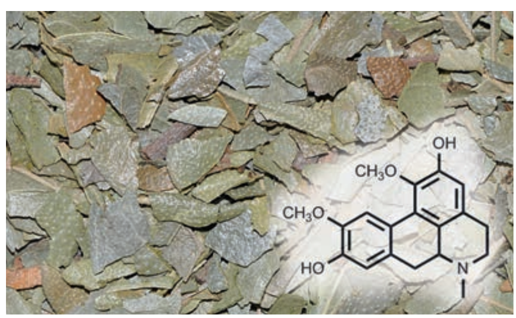
ORIGIN South America (Chile).

BOTANY Shrub or small tree (to 7 m); leaves leathery, minutely warty; fruit a small edible berry.

CHEMISTRY Isoquinoline (aporphine) alkaloids: **boldine** (the main compound) with isocorydine and reticuline. Also essential oil and flavonoids.

PHARMACOLOGY Boldine is an alpha-adrenergic agonist; it stimulates both the production and secretion of bile from the gall bladder. It also has stomachic and mild sedative effects.

TOXICOLOGY At high doses, the alkaloids may cause paralysis, hallucinations and CNS disturbances.



Peumus boldus Mol. (Monimiaceae); *boldo* (French); *Boldo* (German); *boldo* (Italian); *boldo* (Spanish)

Phaseolus vulgaris

common bean • French bean

CLASSIFICATION Cell toxin (II–III). TM: Europe, South America. Pharm., Comm.E+, HMPC.

USES & PROPERTIES Dried bean pods, without seeds (*Phaseoli pericarpium*) are traditionally used as a weak diuretic (to treat urinary tract ailments, gout) and weak antidiabetic medicine. Included in herbal teas sold for kidney and bladder health. Uncooked seeds contain a toxic lectin that has to be destroyed by heating to make them edible.

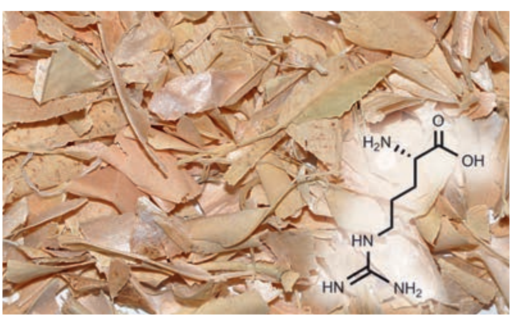
ORIGIN Central and South America. An important vegetable and pulse crop, grown worldwide.

BOTANY Annual herb; stems twining (or short and branched in bushy cultivars); flower white or pink; fruit a narrowly oblong, multi-seeded pod.

CHEMISTRY Amino acids (e.g. asparagine, **arginine**, leucine, tyrosine), silicic acid and an alkaloid (trigonelline). The toxic lectin is phasin.

PHARMACOLOGY The diuretic activity is not yet explained (ascribed to silicic acid and arginine).

TOXICOLOGY Large quantities of the green pods or uncooked seeds may cause vomiting, diarrhoea and stomach pain.



Phaseolus vulgaris L. (Fabaceae); *haricot* (French); *Gartenbohne* (German); *fagiolo* (Italian)

Phellodendron amurense

Amur cork tree

CLASSIFICATION TM: Asia (China). Pharm., WHO 4, clinical studies+ (berberine).

USES & PROPERTIES The inner bark (*huáng bò*) is one of the 50 major herbs in Chinese traditional medicine, used to treat meningitis, dysentery, pneumonia, liver cirrhosis and tuberculosis (also abdominal pain, diarrhoea, gastroenteritis, urinary tract inflammation and conjunctivitis).

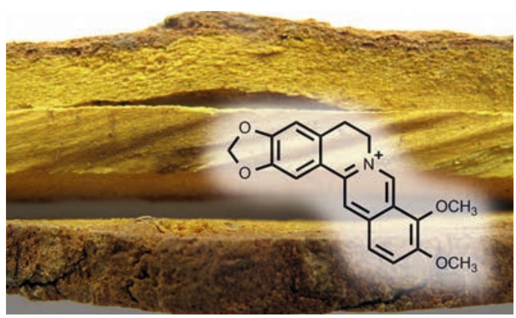
ORIGIN East Asia. Invasive in parts of North America. The tree is planted in gardens and parks.

BOTANY Deciduous tree (to 12 m); bark corky; flowers small, yellow; fruit a fleshy black drupe.

CHEMISTRY Isoquinoline alkaloids (**berberine** is the main compound). Also sesquiterpene lactones and flavonols (e.g. amurensin).

PHARMACOLOGY Antimicrobial activity is usually ascribed to the DNA-intercalating berberine while anti-inflammatory effects may be due to phenolic compounds. Bark extracts are thought to be useful to prevent arthritis and some types of tumours.

TOXICOLOGY Use only under medical supervision. Do not exceed 3–10 g per day.



Phellodendron amurense Rupr. (Rutaceae) *huang bai* (Chinese); *Amur-Korkbaum* (German)

Phyllanthus emblica

Indian gooseberry • emblic

CLASSIFICATION TM: Asia (India, China).

USES & PROPERTIES The fresh or dried, sour-tasting fruit (without seed) is known as emblic or amlak and is used in India as a tonic to treat a wide range of ailments, especially fatigue, dyspepsia and diabetes. *Triphala* or "three fruits", the popular cure-all of Ayurvedic medicine, comprises the fruit pulp of amlak with that of *Terminalia bellirica* and *T. chebula*. In China it is called *yu gan zi* and used to treat throat infections.

ORIGIN Tropical Asia (often cultivated in parks).

BOTANY Deciduous tree (to 15 m); leaves very small, arranged in two rows; fruit a fleshy drupe.

CHEMISTRY Indolizidine alkaloids: **phyllantine** (= 4-methoxysecurinine). Lignans: phyllanthin and hypophyllanthin. Ellagitannins and gallotannins, polyphenols, flavonoids and triterpenoids.

PHARMACOLOGY Activities are mainly linked to the alkaloids (GABA receptor antagonists) and lignans. Amlak is described as rejuvenating, cooling and balancing.

TOXICOLOGY Fruits can be eaten raw or cooked.

Phyllanthus emblica L. (Phyllanthaceae); *yu gan zi* (Chinese); *groseille à maquereau indienne* (French); *Myrobalanenbaum* (German); *amla* (Hindi); *amalika* (Sanskrit); *mirobalano* (Spanish)

Physostigma venenosum

calabar bean • ordeal bean

CLASSIFICATION Neurotoxin, extremely hazardous (Ia). MM: alkaloids (physostigmine).

USES & PROPERTIES Physostigmine is used in modern therapy to treat glaucoma (it reduces intraocular pressure), Alzheimer's disease, delayed gastric emptying, short-term memory loss and orthostatic hypotension (a sudden drop in blood pressure when standing up or stretching). It is an antidote in atropine poisoning.

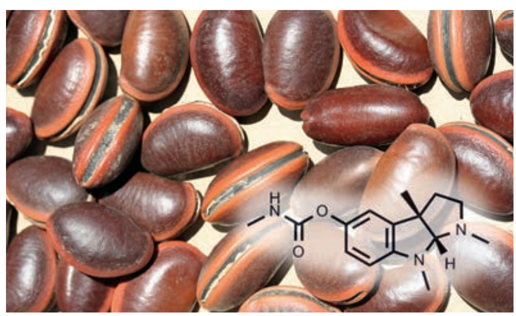
ORIGIN Tropical Africa (named after Calabar in Nigeria). A traditional ordeal poison (survival being proof of innocence, death proof of guilt).

BOTANY Woody climber (to 15 m); leaves trifoliate; flowers pink; fruit a large, 2–3-seeded pod.

CHEMISTRY Simple indole alkaloids: **physostigmine** and related compounds.

PHARMACOLOGY Physostigmine is a reversible cholinesterase inhibitor and acts as an indirect parasympathomimetic. It causes seizures, paralysis of the heart and death by asphyxiation.

TOXICOLOGY Extremely toxic. Physostigmine: LD_{50} (mouse) = 3 mg/kg (p.o.), 0.64 mg/kg (i.p.).



Physostigma venenosum Balf. (Fabaceae); *fève de Calabar* (French); *Calabarbohne* (German); *fava del Calabar* (Italian); *haba de Calabar*, *nuez esere* (Spanish)

Pilocarpus jaborandi

jaborandi

CLASSIFICATION Cell toxin (Ia). TM: South America. Pharm. MM: alkaloids; clinical studies+.

USES & PROPERTIES Dried leaves (*Jaborandi folium*) are traditionally used to treat bronchitis, dry mouth, fever, influenza and tonsillitis. Extracts are used topically to treat hair loss and psoriasis. Pure alkaloid (pilocarpine) is used in modern medicine against glaucoma, to alleviate intraocular pressure.

ORIGIN Central and South America (*P. jaborandi* mainly in Brazil).

BOTANY Evergreen shrub or small tree (to 3 m); leaves compound; flower small, in elongated clusters. The related *P. microphyllus*, *P. pennatifolius* and *P. racemosus* are acceptable alternatives.

CHEMISTRY Imidazole alkaloids: **pilocarpine** is the main compound.

PHARMACOLOGY Pilocarpine is a mAChR agonist (stimulating muscarinic acetylcholine receptors). It increases perspiration, salivation and capillary blood flow.

TOXICOLOGY The lethal dose of pure pilocarpine in adult humans is 60 mg.

Pilocarpus jaborandi Holmes (Rutaceae); *jaborandi* (French); *Gewöhnlicher Jaborandistrauch* (German); *iaborandi* (Italian); *jaborandi* (Spanish)

Pimpinella anisum

anise

CLASSIFICATION TM: Africa, Europe, Asia. Comm.E+, PhEur8, ESCOP 3, WHO 3, HMPC.

USES & PROPERTIES The small dry fruits (*Pimpinellae fructus*) are traditionally used to treat coughs and dyspeptic complaints (indigestion, flatulence). It is often an ingredient of herbal teas, not only for its health benefits but also to improve the taste. Several alcoholic beverages (e.g. raki, sambuca, ouzo) are flavoured with anise.

ORIGIN Europe, Africa and Asia. Africa. Cultivated in temperate regions; partly replaced by star anise (see *Illicium verum*) as source of anethole.

BOTANY Erect annual (to 0.5 m); basal leaves simple, upper ones progressively much divided; flowers white; fruit a small dry schizocarp.

CHEMISTRY Essential oil: ***trans*-anethole** is the main compound.

PHARMACOLOGY Anethole is carminative, spasmolytic and antimicrobial. It is an expectorant and acts by stimulating the ciliary movement of bronchial epithelium cells.

TOXICOLOGY Anethole shows *in vitro* mutagenicity.

Pimpinella anisum L. (Apiaceae); *anis vert* (French); *Anis* (German); *anice verde* (Italian); *anis* (Spanish)

Pimpinella major

greater burnet saxifrage

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (roots only).

USES & PROPERTIES Dried rhizomes and roots of *P. major* or *P. saxifraga* (*Pimpinellae herba*) are used for catarrh and infections of the upper respiratory tract (and included in bronchial remedies). Aboveground parts were once used for numerous ailments (none of which has scientific support).

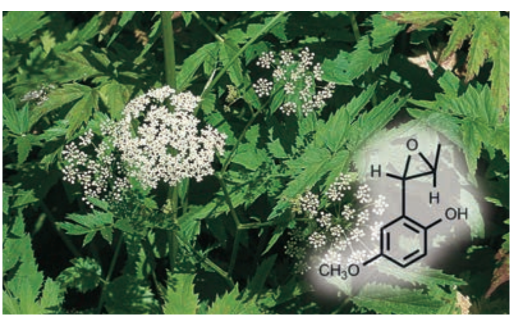
ORIGIN Europe and western Asia (naturalised in North America). The product is wild-harvested.

BOTANY Perennial erect herb (to 1 m); leaves compound; flowers white; fruit small, hairless.

CHEMISTRY Essential oil (to 0.7%): the tiglic acid ester or 2-methylbutyric acid ester of **epoxypseudoisoeugenol** as main constituents. Also present are tri-*nor*-sesquiterpenes, sesquiterpenes, furanocoumarins, phenolic acids and sitosterol.

PHARMACOLOGY Secrolytic and secromotoric activities are ascribed to the essential oil but the antitussive and mild expectorant effects of the herb are not yet fully explained.

TOXICOLOGY Possible mutagenic effects.



Pimpinella major (L.) Hudson (Apiaceae); *grand boucage* (French); *Große Bibernelle* (German); *pimpinella* (Italian)

Pinus sylvestris

Scots pine

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8.

USES & PROPERTIES The essential oil obtained from leaves of this and other species (pine needle oil, *Pini aetheroleum*) or essential oil distilled from turpentine are traditionally used (as inhalants or ingredient of cough medicines) to treat chronic bronchial infections and catarrh of the upper respiratory tract. The oil is also applied to the skin in the form of ointments, emulsions and tinctures for relief of muscular pain, neuralgia and rheumatism. Fresh or dried young branches (pine sprouts, *Pini turiones*) are added to teas, tinctures and syrups.

ORIGIN Europe and Asia.

BOTANY Tree (to 30 m); leaves needle-shaped; cones small, globose. Several other species are sources of turpentine (oleoresin) and essential oil.

CHEMISTRY Essential oil: mainly **α-pinene** and β-pinene; (–)-bornyl-acetate in pine needle oil.

PHARMACOLOGY Antiseptic, secretolytic, expectorant, counter-irritant (stimulates circulation).

TOXICOLOGY Non-toxic in small amounts.

Pinus sylvestris L. (Pinaceae); *pin sauvage* (French); *Waldkiefer* (German); *pino silvestre* (Italian); *pino silvestre* (Spanish)

Piper methysticum

kava kava • kava

CLASSIFICATION Mind-altering (III). TM: Australia, Polynesia, Europe. Pharm., Comm.E+, ESCOP, WHO 2, clinical studies+.

USES & PROPERTIES Rhizomes with roots (*Piperis methystici rhizoma*) have been used as sedatives to treat anxiety, sleep disturbances and stress. The daily dose is 60–210 mg of kava pyrones (or equivalent), continued for three months maximum.

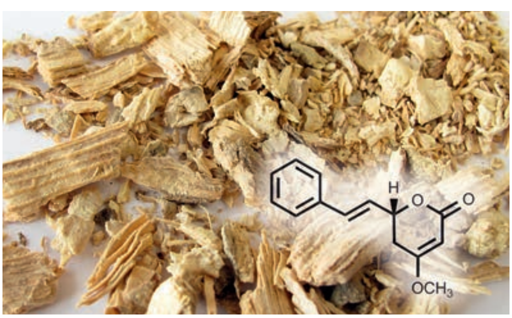
ORIGIN Polynesia (western Pacific). Apparently an ancient cultigen, derived from *P. wichmannii*.

BOTANY Evergreen scrambling shrub (to 3 m); leaves large, silvery below; flowers inconspicuous.

CHEMISTRY Several styrylpyrones (kava pyrones): **kawain** and methysticin are main compounds.

PHARMACOLOGY Anxiolytic (viewed as an alternative to benzodiazepines): the lactones bind to GABA and dopamine neuroreceptors. Efficacy is supported by several clinical trials.

TOXICOLOGY Kava products have been prohibited in some countries because of safety concerns. Contraindication: liver disorders, alcoholism. Chronic abuse may cause liver damage.



Piper methysticum Forster f. (Piperaceae); *kava, kava kava* (French); *Kawapfeffer*, *Rauschpfeffer* (German); *kava-kava* (Italian)

Plantago afra

psyllium • fleawort

CLASSIFICATION TM: Europe. Pharm., Comm. E+, WHO 1, HMPC.

USES & PROPERTIES Ripe seeds of *P. afra* and *P. arenaria* (flea seeds, *Psyllii semen*) are used as bulk laxatives to treat chronic constipation, as well as diarrhoea, irritable colon and inflammation. Other species are used in the same way: *P. ovata* seeds (blond psyllium, *isphagula*, *Plantaginis ovatae semen*) or the seed husks (*Plantaginis ovatae testa*) in India; *P. asiatica* seeds (Asiatic flea seeds, *shazenshi* or *che-qian-zi*) in China and Japan.

ORIGIN Europe (*P. afra*, *P. arenaria*); East Asia (*P. asiatica*); India and Iran (*P. indica*).

BOTANY Annual herb; leaves hairy, whorled; flowers inconspicuous; fruit a small 2-seeded capsule; seeds small, dark brown, resembling fleas.

CHEMISTRY Swelling mucilages in the epidermis of the seed husks absorb large quantities of water. Also present is **aucubin** (an iridoid glucoside).

PHARMACOLOGY Bulk laxatives increase the faecal mass and promote peristalsis.

TOXICOLOGY Non-toxic, even at high doses.

Plantago afra L. [= *P. psyllium* L.] (Plantaginaceae); *herbe aux puces* (French); *Flohkraut* (German); *psillio* (Italian); *psilio* (Spanish)

Plantago lanceolata

ribwort plantain

CLASSIFICATION TM: Europe, Asia (China). Comm.E+, PhEur8, HMPC.

USES & PROPERTIES The whole herb (*Plantaginis lanceolatae herba*) or leaves (*P. lanceolatae folium*) are used in traditional medicine to treat infections of the upper respiratory tract, throat and mouth. It is also applied to wounds and inflammation of the skin.

ORIGIN Europe and Asia (naturalised in many parts of the world – Africa, Australia and America).

BOTANY Perennial herb; leaves in a basal rosette; flowers white or pale pink, in a dense cluster.

CHEMISTRY Iridoid glucosides (2.5%): aucubin (the main compound), **catalpol** and asperuloside. Mucilage (2%), tannins (6.5%), phenolic acids, saponins and flavonoids are also present.

PHARMACOLOGY The antimicrobial and anti-inflammatory activities are ascribed to the iridoid glucosides and their metabolites. The expectorant and bronchodilatory activities are not yet explained.

TOXICOLOGY No serious side effects are known.

Plantago lanceolata L. (Plantaginaceae); *plantain lancéole* (French); *Spitzwegerich* (German); *plantaggine* (Italian); *llantén menor* (Spanish)

Platycodon grandiflorus

Chinese bellflower • balloon flower

CLASSIFICATION TM: Asia (China). WHO 1.

USES & PROPERTIES Dry roots (*Platycodi radix*) have numerous medicinal uses in Chinese traditional medicine: asthma, peptic ulcers, inflammation, high blood pressure and viral infections. The modern use in China is focused on colds and influenza. Roots are eaten as a functional food in China and Korea or included in herbal teas.

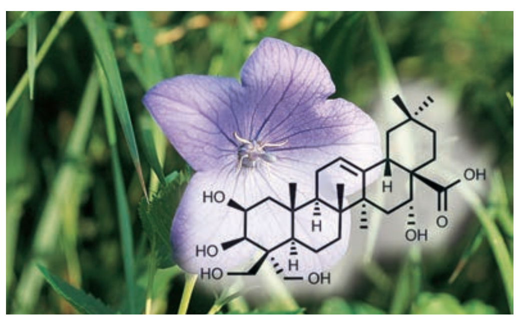
ORIGIN Northeastern Asia (China, eastern Siberia, Japan and Korea). Selected cultivars have become popular garden plants.

BOTANY Perennial herb (ca. 0.5 m); leaves sessile; flowers bell-shaped, violet-blue or white.

CHEMISTRY Triterpene saponins (2%): mainly glycosides of **platycodigenin**.

PHARMACOLOGY Many of the activities of the herb are supported by animal studies, including antibacterial, anticholesterol, anti-inflammatory, antitussive, expectorant and anti-ulcer effects. The production of saliva and bronchial secretions are stimulated but gastric secretions are inhibited.

TOXICOLOGY Non-toxic (edible).



Platycodon grandiflorus (Jacq.) A.DC. (Campanulaceae); *chieh keng* (Chinese); *platycodon à grandes fleurs* (French); *Ballonblume* (German); *platycodon* (Italian)

Podophyllum peltatum

may apple • American mandrake

CLASSIFICATION Cell toxin (Ib); TM: North America. Pharm., Comm.E+. MM: lignans.

USES & PROPERTIES Dried rhizomes (*Podophylli peltati rhizoma*) have been used as purgative medicine (now obsolete) and also for removal of warts and condylomas. The herb and resin obtained from it (called podophyllin; *Podophylli resina*) are used in homoeopathy for liver and gall ailments. It is also a source of pure podophyllotoxin, used in modern medicine (only under strict supervision) to treat cancer and remove warts.

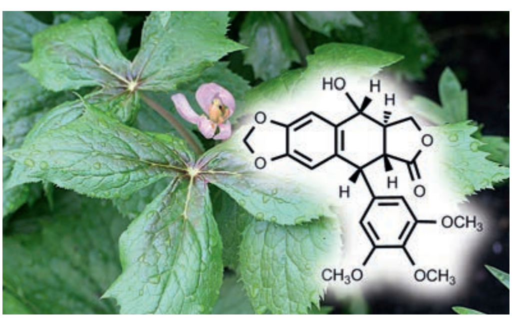
ORIGIN North America (*P. peltatum*) or Himalayan region (*P. hexandrum*, photo below).

BOTANY Perennial rhizomatous herb (to 0.5 m); leaves peltate, in one pair; flowers single, white.

CHEMISTRY Resin: up to 50% **podophyllotoxin**, a lignane used in cancer therapy. It is converted to more stable derivatives (e.g. etoposide).

PHARMACOLOGY The lignans inhibit tumours by inhibiting cell division.

TOXICOLOGY Podophyllotoxin is extremely poisonous: LD_{50} = 8.7 mg/kg (rat, i.v.).



Podophyllum peltatum L. (Berberidaceae); *podophylle pelté, pomme de mai* (French); *Gewöhnlicher Maiapfel* (German); *podofillo* (Italian)

Pogostemon cablin

patchouli • patchouly

CLASSIFICATION TM: Asia (China, India and Malaysia).

USES & PROPERTIES Fresh or dried leaves (*Patchouli folium*) or the essential oil distilled from them (*Patchouli aetheroleum*) are used to treat colds and influenza, fever and headaches. It has the traditional reputation of being an aphrodisiac. The herb or the oil may be applied topically to soothe skin irritations and to repel insects and leeches. The oil is popular in aromatherapy (calming effect) and as an ingredient of cosmetics.

ORIGIN East Asia (India to Malaysia). The plant is commonly grown in gardens in all warm regions.

BOTANY Perennial aromatic herb (to 1 m); leaves soft, hairy; flowers pink (but plants rarely flower).

CHEMISTRY Essential oil with a unique sesquiterpene known as **patchoulol** (=patchouli alcohol). Also present in the oil are several monoterpenes, sesquiterpenes and phenylpropanoids.

PHARMACOLOGY Moisturising, antibiotic and protective effects on skin and mucosa.

TOXICOLOGY No side effects have been reported.

Pogostemon cablin (Blanco) Benth. [= *P. patchouli* Pellet.] (Lamiaceae); *patchouli* (French); *Patschulipflanze* (German); *patchouly* (Italian)

Polygala senega

senega • snakeroot senega

CLASSIFICATION TM: North America. Comm. E+, ESCOP 3, WHO 2, PhEur8. Homoeopathy.

USES & PROPERTIES The dried roots (senega root, *Polygalae radix*) are used in traditional medicine to treat coughs, chronic bronchitis, chronic asthma and emphysema. Infusions of 0.5–1 g of the dry root is taken three times a day. Decoctions are gargled for relief of throat infections.

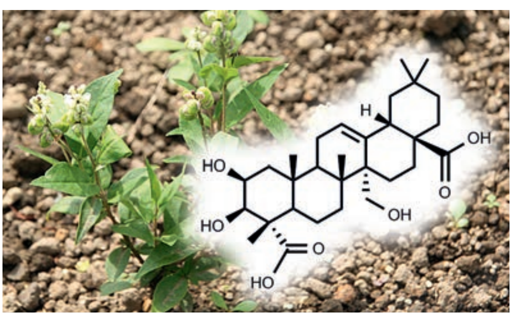
ORIGIN North America (eastern and midwestern parts of the USA and most of Canada). Canadian Senega Indians used it to treat rattlesnake bites.

BOTANY Perennial herb (to 0.5 m); leaves subsessile; flowers with petaloid sepals, one of which has a small tuft (corona) at the tip.

CHEMISTRY Bidesmosidic saponins (up to 12%): senegasaponins A–D (the aglycone is **presenegin**). Also organic acids and methyl salicylate.

PHARMACOLOGY Expectorant, secretolytic, antitussive and anti-inflammatory activities are ascribed to the saponins and methyl salicylate.

TOXICOLOGY There are no serious side effects when used at recommended doses.



Polygala senega L. (Polygalaceae); *polygala sénéga* (French); *Senega Klapperschlangenwurzel* (German); *poligala, serpentella* (Italian)

Polygonum aviculare

knotweed • knotgrass

CLASSIFICATION TM: Europe, Asia (India, China). Pharm., Comm.E+, WHO 5, PhEur8.

USES & PROPERTIES Dried whole herb, including roots (*Polygoni avicularis herba*) is traditionally used for the treatment of upper respiratory tract infections (coughs, bronchial catarrh, sore throat). The recommended dose is 1.5 g of the herb, taken as infusion, three to five times a day. It has also been used as diuretic, topical haemostyptic and remedy for skin ailments.

ORIGIN Europe and Asia. It has become a cosmopolitan weed of cultivation.

BOTANY Wiry annual weed; stems slender; leaves small, with conspicuous sheathing stipules; flowers minute, white to pink.

CHEMISTRY The herb is rich in gallotannins and **condensed tannins** (= catechins) (3.6%). Also flavonols, coumarins, mucilage and salicic acid.

PHARMACOLOGY Expectorant, antibiotic and haemostyptic properties are ascribed to the tannins. Diuretic activity is linked to salicic acid.

TOXICOLOGY The herb is safe to use in low doses.

Polygonum aviculare L. (Polygonaceae); *renouée des oiseaux* (French); *Vogelknöterich* (German); *centinodia* (Italian)

Populus tremuloides

American aspen • Canadian aspen

CLASSIFICATION TM: North America (*P. tremuloides*); Europe. Comm.E+ (buds only, *P. tremula*).

USES & PROPERTIES Bark (*Populi cortex*), leaves (*Populi folium*) and buds (*Populi gemmae*) are used to treat the common cold, rheumatic conditions, cystitis and diarrhoea. *P. tremula* (photo below) is used in the same way.

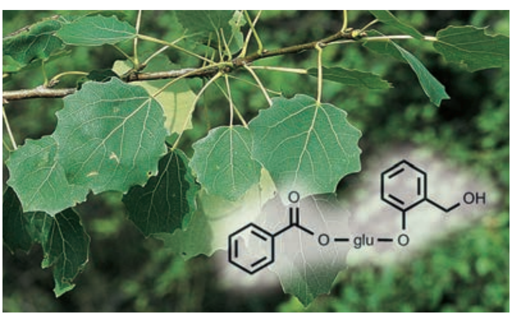
ORIGIN North America. *P. tremula* and *P. nigra* (Europe and Asia) have similar uses. Poplar buds are obtained from balsam poplar (*P. balsamifera*) and balm of Gilead (*P. candicans*).

BOTANY Deciduous tree (to 20 m); leaves on long stalks, quivering; flowers inconspicuous.

CHEMISTRY Benzoyl esters of salicin: mainly **populin** (salicin-5-benzoate). Also salicin and salicortin (similar to willow bark), tannins and triterpenes. The buds are aromatic (essential oil).

PHARMACOLOGY When ingested, the salicin derivates are converted to salicylic acid (which has anti-inflammatory and analgesic activity).

TOXICOLOGY Non-toxic at low doses but general precautions apply.



Populus tremuloides Michaux (Salicaceae); *peuplier faux-tremble* (French); *Amerikanische Espe* (German); *pioppo* (Italian)

Potentilla anserina

silverweed

CLASSIFICATION TM: Europe. Comm.E+.

USES & PROPERTIES Fresh or dried leaves and flowers (*Anserinae herba*) are used to treat non-specific diarrhoea and inflammation of the mouth and throat. Traditionally it has been used against colic, cramps, spasms and menstrual disorders. Topical uses include eczema, sores and bleeding haemorrhoids. A tea made from 2 g of the dry herb is taken three times a day. It can also be gargled for sore throat and mouth infections.

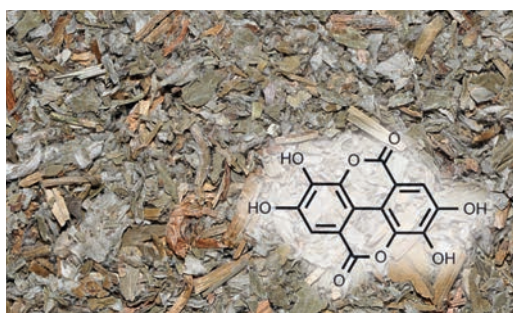
ORIGIN Europe, Asia and North America.

BOTANY Perennial ground-hugging herb; leaves pinnate, silver-hairy; flowers yellow.

CHEMISTRY Tannins (5–10%), based on **ellagic acid**. Flavonoids (flavonols, e.g. kaempferol, quercetin), proanthocyanidins, phenolic acids (caffeic acid, ferulic acid).

PHARMACOLOGY Astringent, anti-inflammatory and haemostyptic properties. These activities are due to tannins and other phenolics which also contribute to the spasmolytic properties.

TOXICOLOGY Safe to use at recommended doses.



Potentilla anserina L. (Rosaceae); *herbe d'ansérine*, *argentine* (French); *Gänsefingerkraut* (German); *argentina anserina*, *potentilla* (Italian)

Potentilla erecta

tormentil

CLASSIFICATION TM: Europe. Pharm., Comm. E+, PhEur8, HMPC.

USES & PROPERTIES The dried rhizomes without roots (*Tormentillae rhizoma*) are a traditional remedy in Europe for diarrhoea, dysentery, gastroenteritis and enterocolitis. An infusion of 2–3 g is taken two or three times per day between meals. Infusions or tinctures may be gargled for sore throat and inflammations of the mouth. Externally it is applied to wounds, sores and inflamed skin.

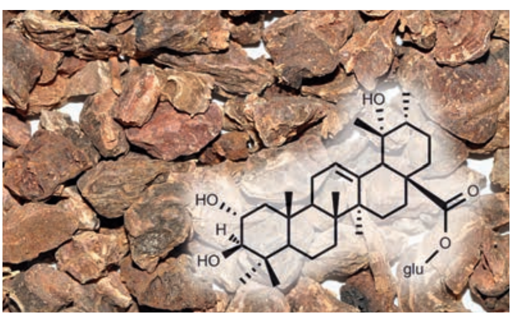
ORIGIN Europe (central and eastern regions).

BOTANY Small perennial herb; leaves sessile, digitate, bright green, toothed, sparsely hairy.

CHEMISTRY Tormentil rhizomes contain up to 20% catechin-type tannins. These include agrimoniin and other ellagitannins and catechin gallates. High levels of oligomeric proanthocyanidins (to 20%) and triterpene saponins (**tormentoside**).

PHARMACOLOGY Tannins: antimicrobial, astringent and antidiarrhoeal activities. The triterpenes may be anti-inflammatory and antihypertensive.

TOXICOLOGY Safe to use at prescribed doses.



Potentilla erecta (L.) Räusch [= *P. tormentilla* Stokes] (Rosaceae); *tormentille* (French); *Blutwurz* (German); *tormentilla* (Italian)

Primula veris

cowslip

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP, PhEur8, HMPC.

USES & PROPERTIES The rhizome and root (*Primulae radix*) are used as expectorants to treat coughs, bronchitis and catarrh of the nose and throat. Tea made from 0.2–0.5 g of the root is taken with honey, every two to three hours. The flowers with the calyx (*Primulae flos cum calycibus*) (2–4 g) are traditionally taken for relief of nervous conditions and headaches, and also as cardiac tonic.

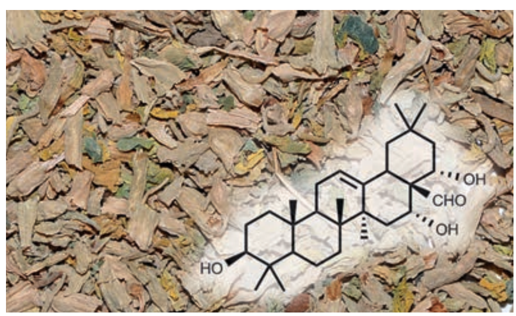
ORIGIN Europe and Asia.

BOTANY Deciduous perennial herb; rhizome fleshy; leaves basal, wrinkled; flowers yellow.

CHEMISTRY The flowers contain triterpene saponins and flavonoids. The roots have, in addition to triterpene saponins (aglycone: **primverogenin A** and B), also phenolic glycosides.

PHARMACOLOGY Expectorant and secretolytic activities can be explained by the presence of saponins. The putative value in treating nervous conditions is not yet explained.

TOXICOLOGY Do not exceed specified doses.



Primula veris L. [= *P. officinalis* (L.) Hill.] (Primulaceae); *primevère officinale*, *coucou* (French); *Wiesen-Schlüsselblume* (German); *primavera* (Italian)

Prunus africana

red stinkwood • pygeum

CLASSIFICATION TM: Africa, Europe. WHO 2, PhEur8, WHO 2, AHP, clinical studies+.

USES & PROPERTIES The bark (*Pygei africani cortex*) is used against benign prostate hyperplasia. Extracts of phytosterols are taken in doses of 100 mg per day for six to eight weeks. Commercial formulations often include saw palmetto fruits (*Serenoa repens*) and nettle roots (*Urtica dioica*).

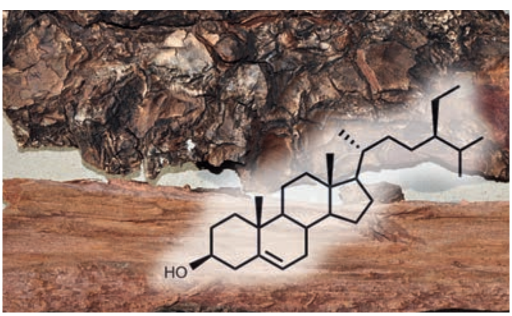
ORIGIN Africa (tropical and subtropical parts). There are concerns about sustainable use.

BOTANY Evergreen tree (30 m), often with buttress roots; leaves glossy, dark green; flowers white, in spike-like racemes; fruit a small drupe.

CHEMISTRY Sitosterol and sitosterol glycosides (free and glycosylated **β-sitosterol** and campesterol). Also present are triterpenes and tannins.

PHARMACOLOGY Phytosterols appear to inhibit the binding of dihydrotestosterone in the prostate and may inhibit 5α-reductase and aromatase. Clinical evidence exists for efficacy in treating the symptoms of prostatitis.

TOXICOLOGY Phytosterols have a low toxicity.



Prunus africana (Hook. f.) Kalkman [= *Pygeum africanum* Hook. f.] (Rosaceae); *pygeum* (French); *Pygeum africanum* (German); *pygeum* (Italian)

Prunus dulcis

almond

CLASSIFICATION Cell (respiratory) toxin, highly hazardous (Ib–II). TM: Europe. Pharm., PhEur8.

USES & PROPERTIES The ripe seeds (*Semen Amygdalae*) are the source of almond oil, which is used as dispersion agent for injections and as carrier oil in aromatherapy and cosmetics (also the source of "laetrile", a controversial cancer treatment).

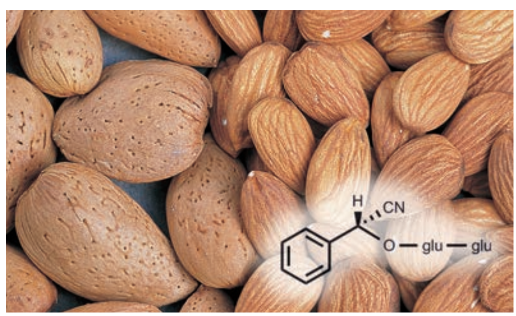
ORIGIN Europe and Asia. Almonds are produced mainly in the USA (California), Spain and Italy.

BOTANY Deciduous tree (to 10 m); flowers white or pink; fruit velvety, single-seeded.

CHEMISTRY In common with other edible Rosaceae fruits, bitter almond seeds contain high levels of cyanogenic diglucosides (mainly **amygdalin**). Sweet almonds have only trace amounts.

PHARMACOLOGY Hydrogen cyanide (HCN) is released when amygdalin is cleaved by the enzyme emulsin. Small amounts are easily inactivated but large doses can be fatal due to respiratory arrest.

TOXICOLOGY The lethal dose of HCN in humans is 1 mg/kg (5–12 bitter almonds may be fatal for a child; 20–60 for an adult).



Prunus dulcis (Mill) D.A. Webb (Rosaceae); *amandier* (French); *Mandelbaum* (German); *mandorla* (Italian); *almendro* (Spanish)

Prunus laurocerasus

cherry laurel

CLASSIFICATION Cell toxin (Ib–II). TM: Europe.

USES & PROPERTIES The leaves were formerly used for treating mucosal infections of the mouth and throat. Cherry-laurel water is still occasionally used in Europe as a respiratory stimulant. It contains 0.1% hydrogen cyanide and was sometimes used for suicide and murder. The fruits resemble small cherries and are attractive to children.

ORIGIN Southeastern Europe and Asia Minor. It is grown in many parts of the world as a screen plant.

BOTANY Evergreen shrub (to 0.5 m); leaves large, glossy green; flowers white, in elongated clusters; fruit a small fleshy drupe, black when ripe.

CHEMISTRY The toxic compounds are cyanogenic glucosides: prunasin (up to 1.5% of fresh weight) in leaves; **amygdalin** (ca. 0.2%) in seeds.

PHARMACOLOGY The intact plant/leaf is harmless but damage (e.g. chewing) breaks the cells and expose the cyanogenic glucosides to enzymes, resulting in a release of hydrogen cyanide (HCN).

TOXICOLOGY HCN is extremely poisonous but fatal cases of poisoning by cherry laurel are rare.

Prunus laurocerasus L. (Rosaceae); *laurier-cerise* (French); *Kirschlorbeer*, *Lorbeerkirsche* (German); *lauroceraso* (Italian); *lauroceraso*, *laurel-cerezo* (Spanish)

Prunus spinosa

blackthorn • sloe

CLASSIFICATION Cell toxin (Ib–II). TM: Europe. Pharm., Comm.E+ (fruit only).

USES & PROPERTIES Ripe fruits, fresh or dried (*Pruni spinosae fructus*), are used for the treatment of mucosal infections of the mouth, gums and throat. The juice of fresh fruits or a tea made from 2–4 g of dried fruit are used as a gargle. Dried flowers (*Pruni spinosae flos*) have numerous traditional uses (as diaphoretic, diuretic, expectorant and mild laxative). They are used as an infusion of 1–2 g in a cup of boiling water, taken once or twice during the day or night.

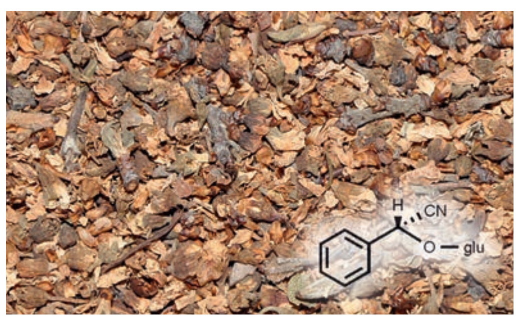
ORIGIN Europe, western Asia and North America.

BOTANY Deciduous shrub (to 4 m); stems thorny; leaves dull green; flowers white; fruit fleshy, bluish black, resembling small plums.

CHEMISTRY Tannins, flavonoids and cyanogenic glucosides (**prunasin**) are the main compounds.

PHARMACOLOGY Tannins are astringent and often used for their antiseptic, antidiarrhoeal and anti-inflammatory activities.

TOXICOLOGY High doses can be dangerous.



Prunus spinosa L. (Rosaceae); *prunellier* (French); *Schlehdorn*, *Schlehe* (German); *prugnolo* (Italian)

Psidium guajava

guava tree

CLASSIFICATION TM: South America, India, Africa.

USES & PROPERTIES Fresh or dried leaves (*Djamboe folium*, *Psidii pyriferi folium*) are mainly used to treat diabetes and diarrhoea. Other ailments recorded to be treated with guava leaf include cough, fever, malaria and ulcers (and externally for boils and wounds). The fruits are rich in vitamin C.

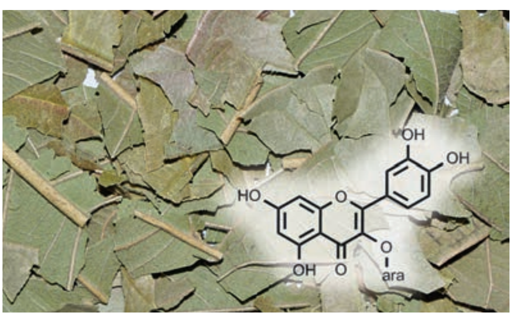
ORIGIN Central America (naturalised in many parts of the world and cultivated as a fruit crop).

BOTANY Shrub or small tree (4 m); leaves with prominent veins; fruit a large, many-seeded berry.

CHEMISTRY The leaves are rich in tannins (9–12%), flavonoids, essential oil and triterpenoids. Amritoside (a glycoside of ellagic acid) and **guajaverin** (a glycoside of quercetin) are major compounds. The oil contains eugenol.

PHARMACOLOGY Tannins are non-specific protein poisons that are active against microbial infections. They are also vasoconstricting and form a protective layer on the skin and mucosa.

TOXICOLOGY Non-toxic at low doses.



Psidium guajava L. (Myrtaceae); *goyave, goyavier* (French); *Guayavebaum* (German); *guava* (Italian); *guayaba* (Spanish)

Psychotria ipecacuanha

ipecac • ipecacuanha

CLASSIFICATION Cell toxin, mind-altering, highly hazardous (Ib). TM: South America, Europe. Pharm., PhEur8. MM: emetin.

USES & PROPERTIES Rhizomes (*Ipecacuanhae radix*) or standardised root powder (*Ipecacuanhae pulvis normatus*) are expectorant at low doses and emetic at higher doses. Extracts are used in emetic syrups, to induce vomiting in cases of poisoning.

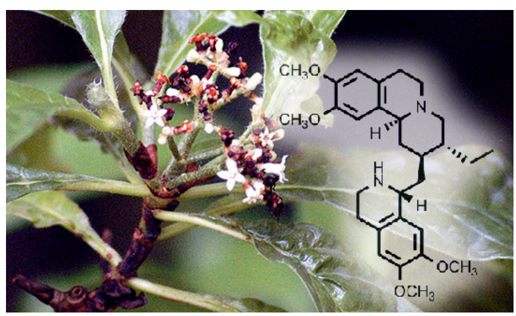
ORIGIN South America (Brazil). Other species (inferior substitutes and adulterants) are sometimes sold as ipecac or ipecacuanha.

BOTANY Small shrublet (to 0.4 m); leaves opposite; flowers white; fruit a small, red drupe.

CHEMISTRY Isoquinoline alkaloids (4%): **emetine** and cephaeline are the major compounds.

PHARMACOLOGY Emetine and cephaeline have strong emetic activity. They also stimulate the excretion of water in bronchial tissue and are therefore expectorant and secretolytic. The alkaloids are pronounced inhibitors of protein synthesis.

TOXICOLOGY The lethal oral dose in humans is 57 mg/kg (emetine) or 32 mg/kg (cephaeline).



Psychotria ipecacuanha (Brot.) Stokes [= *Cephaelis ipecacuanha* (Brot.) A. Rich.] (Rubiaceae); *ipécacuanha* (French); *Brechwurzel* (German); *ipecacuana* (Italian, Spanish)

Pteridium aquilinum

bracken fern

CLASSIFICATION Cell toxin and neurotoxin, highly hazardous (Ib).

USES & PROPERTIES The cooked and leached young shoots are used as a vegetable in Japan and other parts of the world. Poisonous substances are not completely removed. They can also be passed onto humans through milk or dairy products from cows that are regularly exposed to bracken fern.

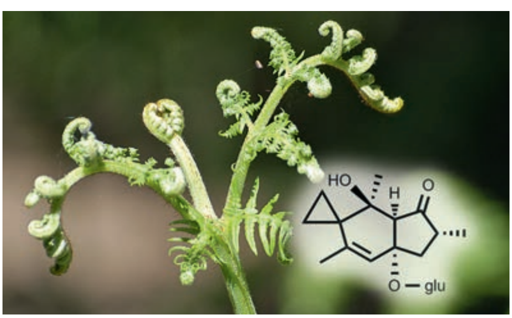
ORIGIN Cosmopolitan. One of the most widely distributed plants, often forming dense stands.

BOTANY Robust fern (to 1.5 m); leaves large, leathery, the young fronds curled like a fiddle head.

CHEMISTRY **Ptaquiloside** (a sesquiterpene) is the main toxic compound; also prunasin (a cyanogenic glucoside) and the enzyme thiaminase.

PHARMACOLOGY Ptaquiloside is strongly mutagenic and carcinogenic. Thiaminase destroys vitamin B_1, resulting in deficiency symptoms and CNS disturbances in animals.

TOXICOLOGY Ptaquiloside has been implicated in the high incidence of cancer amongst people who regularly eat bracken fronds.



Pteridium aquilinum (L.) Kuhn (Dennstaedtiaceae); *fougère aigle* (French); *Adlerfarn* (German); *felce aquilina* (Italian)

Pueraria lobata

kudzu vine • Japanese arrowroot

CLASSIFICATION TM: Asia (China). Pharm., PhEur8.

USES & PROPERTIES Dried roots (*Puerariae radix*) are used in China to treat colds, influenza, fevers, muscle aches, gastritis, dysentery, hypertension, migraines and angina pectoris. It is also believed to be an old Chinese antidote for alcoholism. The flowers (*Puerariae flos*) are rarely used. In modern times it is used as a hangover treatment, to improve cerebral circulation and for relief of neck pain. The daily dose (dried root) is 9–15 g.

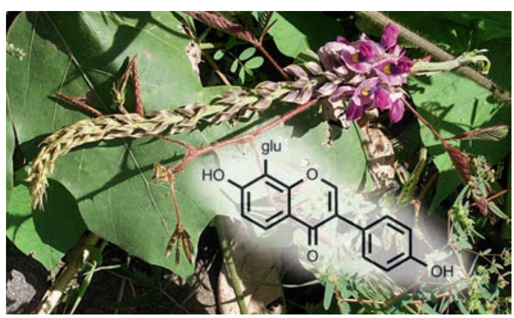
ORIGIN Asia (China, Japan and India). It is naturalised in North America (an aggressive invader).

BOTANY Woody climber (30 m or more); leaves pinnately trifoliate; flowers purple; fruit a pod.

CHEMISTRY Isoflavones: mainly **puerarin**, daidzein and daidzin (phytoestrogenic antioxidant).

PHARMACOLOGY The flavonoids are spasmolytic and increase blood flow to the brain and heart. The activity against alcohol abuse is ascribed to daidzin and daidzein (the evidence is not yet convincing).

TOXICOLOGY No serious side effects are known.



Pueraria lobata (Willd.) Ohwi [= *P. montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. Almeida] (Fabaceae); *ge gen* (Chinese); *kudzu* (French); *Kudzubohne* (German); *kudzu* (Italian)

Punica granatum

pomegranate

CLASSIFICATION Neurotoxin (II). TM: Europe, Africa, Asia. Pharm., WHO 4. DS: fruit juice.

USES & PROPERTIES The dried fruit rind or fruit pulp (*Granati pericarpium*) are remedies for upset stomachs and diarrhoea, while the root bark is a traditional anthelmintic (now obsolete). The acidic and slightly astringent fruit juice has become popular as a dietary supplement.

ORIGIN Southeastern Europe. Widely cultivated and rapidly gaining popularity as a fruit juice crop.

BOTANY Deciduous shrub (to 5 m); stems spiny; flowers orange, with a prominent calyx; fruit large, many-seeded; seeds fleshy, edible.

CHEMISTRY Fruit rind is rich in tannins (to 28%), with punicalin and punicalagin as main compounds. Piperidine alkaloids in the root and stem bark (but not the fruit): mainly **pelletierine**.

PHARMACOLOGY The cholinergic alkaloids are effective anthelmintics, while the antidiarrhoeal effects are due to the tannins.

TOXICOLOGY The seeds are safe to eat but the alkaloids in the bark and roots are very poisonous.

Punica granatum L. [Lythraceae (formerly Punicaceae)]; *grenadier* (French); *Granatapfelbaum* (German); *melograno* (Italian)

Quassia amara

quassia • Surinam quassia

CLASSIFICATION Cell toxin (II–III). TM: South America, Europe. Pharm.

USES & PROPERTIES The wood (*Quassia lignum*) and wood extracts have a long history of use as bitter tonics to stimulate appetite and improve digestion. Extracts are included in stomachics and cholagogues. An infusion of 0.5 g of powdered wood can be taken half an hour before meals. Quassia extracts are anthelmintic and insecticidal.

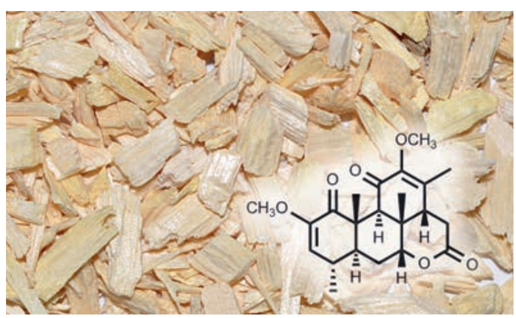
ORIGIN South America (commonly cultivated).

BOTANY Shrub or small tree (to 4 m); leaves compound, the rachis winged; flowers bright red.

CHEMISTRY Extremely bitter-tasting seco-triterpenes (quassinoids) in the wood: main compounds are **quassin** (bitterness value of 17 000 000), neoquassin and 18-hydroxyquassin. Also present are several canthinone and β-carboline alkaloids.

PHARMACOLOGY Bitter tonic (*amarum*) effect (increased secretion of gastric juices and stimulation of appetite). Antimicrobial (and insecticidal) activity is ascribed to alkaloids and quassinoids.

TOXICOLOGY Large doses are dangerous.



Quassia amara L. (Simaroubaceae); *bois amer* (French); *Quassiaholzbaum* (German); *quassia* (Italian); *quassia surinam* (Spanish)

Quercus robur

oak • common oak

CLASSIFICATION Cell toxin (III). TM: Europe. Pharm., Comm.E+, PhEur8, HMPC.

USES & PROPERTIES Bark from young branches and small trees (*Quercus cortex*) are taken (3 g, as decoction) to treat acute diarrhoea and stomach cramps. Also topically (20 g/litre): wounds, eczema and inflammation of skin and mucosa (mouth and throat, genital and anal areas).

ORIGIN Europe. (*Q. petraea* bark is also used.)

BOTANY Deciduous tree (to 50 m); leaves lobed; flowers small; fruit a characteristic nut (acorn).

CHEMISTRY Oak bark is rich in condensed tannins (to 20%). The main compounds are ellagitannins (e.g. **roburin** and castalagin), catechins and oligomeric proanthocyanidins.

PHARMACOLOGY Tannins are well known for their astringent, haemostyptic, antidiarrhoeal, antimicrobial and anti-inflammatory properties.

TOXICOLOGY Tannins and polyphenols are toxic only at very high doses.

NOTES Persistent diarrhoea (especially in young children) should receive urgent medical attention.

Quercus robur L. (Fagaceae); *chêne blanc* (French); *Stieleiche* (German); *quercia commune* (Italian)

Rauvolfia serpentina

Indian snakeroot

CLASSIFICATION Neurotoxin, mind-altering, highly hazardous (Ib). TM: Asia, Europe. Pharm., Comm.E+, WHO 1. MM: alkaloids.

USES & PROPERTIES Dried roots (Indian snake-root; *Rauwolfiae radix*) have traditional uses (e.g. treatment of snakebite) but are mostly taken (600 mg/day) for mild hypertension, anxiety and mental ailments. Isolated alkaloids (6 mg/day) are used in modern medicine to treat hypertension.

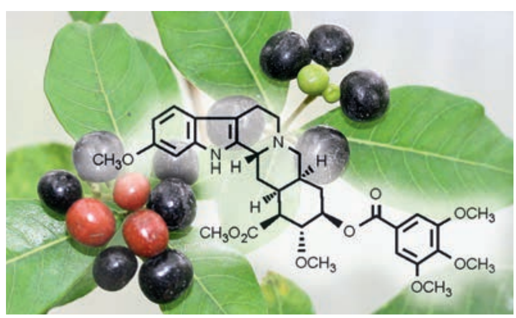
ORIGIN Asia and eastern Asia (Pakistan to Indonesia). African *R. vomitaria* (photo below) has become an alternative source of raw material.

BOTANY Small shrub (0.5 m); leaves in whorls; fruit a fleshy drupe, black when ripe.

CHEMISTRY Numerous monoterpene indole alkaloids (1–3%): **reserpine** is the main compound.

PHARMACOLOGY Reserpine inhibits the reuptake of noradrenaline and other neurotransmitters.

TOXICOLOGY Alkaloids may cause severe and long-lasting depression, and should only be used under proper medical supervision. Overdosing regularly causes fatalities.



Rauvolfia serpentina (L.) Benth. ex Kurz (Apocynaceae); *arbre aux serpents* (French); *Rauwolfia*, *Schlangenholz* (German); *sarpagandha* (Hindi); *rauwolfia*, *serpentina indiana* (Italian)

Rhamnus catharticus

buckthorn

CLASSIFICATION Cell toxin (II). TM: Europe, Africa. Pharm., Comm.E+.

USES & PROPERTIES The dried ripe fruits (*Rhamni cathartici fructus*) are used as stimulant laxative (especially in cases of haemorrhoids and rectal-anal surgery, where a soft stool is required). In traditional medicine it was used as a diuretic and "blood purifier".

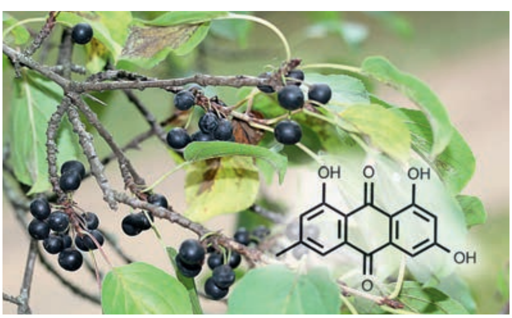
ORIGIN Europe, Asia and North Africa.

BOTANY Deciduous spiny shrub (to 3 m); leaves opposite; flowers small, yellow; fruit a small drupe.

CHEMISTRY Anthranoids of the emodin type (2–5%, up to 1.4 mg/fruit): **emodin** and emodin-anthrone, frangulins and glucofrangulins.

PHARMACOLOGY The 1,8-dihydroxyanthracene glycosides act as prodrugs; they are converted by bacteria in the colon into the active anthrones. The result is a laxative effect (soft stool, faster bowel movements).

TOXICOLOGY Anthraquinones may be mutagenic when used on a long-term basis. Their use as OTC laxatives has been banned in the USA.



Rhamnus cathartica L. (Rhamnaceae); *nerprun purgatif* (French); *Echter Kreuzdorn* (German); *spina cervina* (Italian); *espino cerval* (Spanish)

Rhamnus frangula

alder buckthorn

CLASSIFICATION Cell toxin (II). TM: Africa, Europe. Pharm., Comm.E+, PhEur8, HMPC.

USES & PROPERTIES The bark of the stem and branches (*Frangulae cortex*) is used as stimulant laxative. It has to be stored for one year (or heat-treated). The typical dose is 2 g of bark in 150 ml water (maximum of 20–30 mg of anthrones/day).

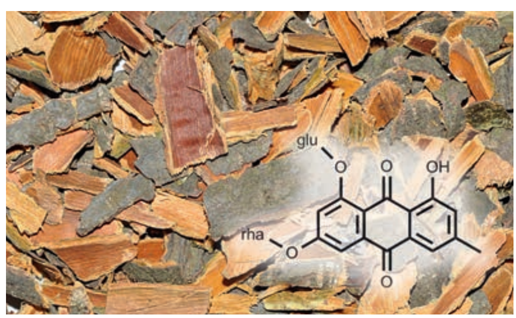
ORIGIN Europe, Asia and North Africa.

BOTANY Shrub (3–5 m); stems brittle, not thorny; leaves with prominent veins; flowers small, yellow; fruit a 2–3-seeded drupe, black when ripe.

CHEMISTRY During storage, anthrone and dianthrone glycosides in fresh bark are oxidised to anthraquinone glycosides: **glucofrangulin A** and B and structurally similar compounds.

PHARMACOLOGY A laxative effect occurs when anthraquinone glycosides are converted to active anthrones (by bacterial enzymes) in the colon.

TOXICOLOGY Do not use for more than a week or two without seeking medical advice. Chronic use is associated with mutagenic effects. Do not use during pregnancy or while breastfeeding.



Rhamnus frangula L. [= *Frangula alnus* Mill.] (Rhamnaceae); *bourdaine* (French); *Faulbaum* (German); *frangola* (Italian); *frangola* (Spanish)

Rhamnus purshianus

cascara sagrada tree

CLASSIFICATION Cell toxin (II). TM: North America, Europe. Comm.E+, ESCOP 5, WHO 2, PhEur8, HMPC.

USES & PROPERTIES The aged bark (*cascara sagrada*; *Rhamni purshiani cortex*) is traditionally used as stimulant laxative. It is still a very popular ingredient of many commercial preparations.

ORIGIN North America (western coastal region, from Canada to California), where the bark is produced on a large scale in plantations.

BOTANY Deciduous shrub or tree (to 12 m); leaves oblong; flowers greenish; fruit a small red drupe.

CHEMISTRY Hydroxyanthraquinone glycosides (6–9%): mainly *O*-glycosides of aloe-emodin, chrysophanol and emodin, as well as **cascaroside A**–D (these are *C*-glycosides).

PHARMACOLOGY The active anthrones are formed in the colon; they reduce the re-uptake of liquids and increase the motility of the colon.

TOXICOLOGY Potentially mutagenic and abortive (see warning under *R. frangula*).

NOTES *Cascara sagrada* means "holy bark".

Rhamnus purshianus DC. (Rhamnaceae); *sacrée* (French); *Amerikanischer Faulbaum* (German); *cascara sagrada* (Italian); *cáscara sagrada* (Spanish)

Rheum palmatum

rhubarb • Chinese rhubarb

CLASSIFICATION Cell toxin (especially leaves) (III). TM: Europe, Asia (China). Comm.E+, ESCOP, WHO 1, PhEur8, HMPC.

USES & PROPERTIES Sliced and dried rhizomes (*Rhei radix*) are used to treat constipation. The laxative dose is 1–2 g. In low doses (0.1–0.2 g), it is used to treat diarrhoea and liver ailments.

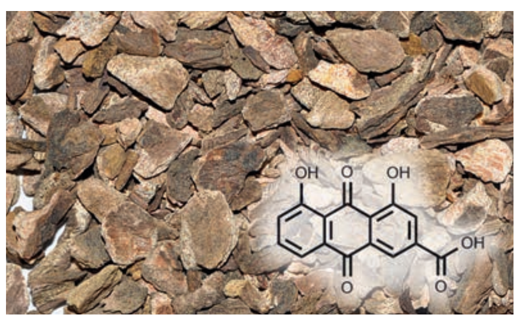
ORIGIN Asia (NW China and Tibet). *R. officinale* is an acceptable alternative but not *R. rhaponticum*.

BOTANY Robust perennial herb; leaves large, palmately lobed (or rounded, in *R. officinale*).

CHEMISTRY Diversity of anthraquinones (3–12%): glycosides of **rhein**, aloe-emodin and other aglycones. Rich in tannins (5–10%). Rhubarb leaves contain high levels of oxalic acid.

PHARMACOLOGY Laxative effect: anthrones released in the colon. Antidiarrhoeal activity: tannins. Excessive ingestion of leaves causes kidney damage (lethal dose of oxalic acid is 5 g).

TOXICOLOGY The dried rhizomes show no serious side effects when used in prescribed doses (but chronic use may be harmful).



Rheum palmatum L. (Polygonaceae); *dai hoàng, da huang* (Chinese); *rhubarbe* (French); *Medizinal-Rhabarber* (German); *rabarbaro* (Italian)

Rhodiola rosea

roseroot • arctic root

CLASSIFICATION TM: Europe. Pharm., HMPC, clinical studies+.

USES & PROPERTIES The rhizomes have a long history of use by the Vikings and Russians: to increase strength, endurance and resistance to cold and disease; to promote fertility and a long life. It is today widely used (as standardised liquid extracts in 40% alcohol) as an adaptogenic tonic: to increase physical and mental endurance, and to moderate the symptoms of asthenia and old age. The fresh rhizome smells like attar-of-roses (hence *rosea*).

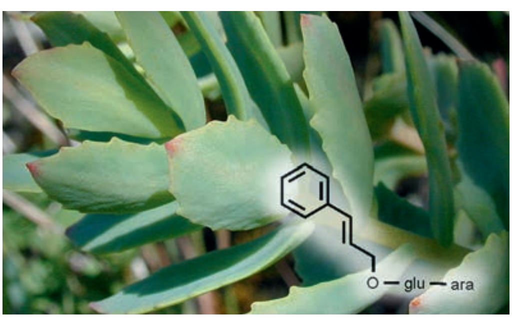
ORIGIN Arctic region (Scandinavia and Siberia).

BOTANY Perennial herb (to 0.6 m); leaves succulent; flowers yellow. (*Rhodiola* is sometimes considered to be a subgenus of *Sedum*.)

CHEMISTRY Phenylpropanoids (rosavins, 3% in liquid extracts): mainly **rosavin**, rosin and rosarin. Phenylethanols (0.8–1%): mainly salidroside (= rhodiolin). Also flavonoids, monoterpenes, acids.

PHARMACOLOGY The adaptogenic tonic uses listed above are supported by several clinical studies.

TOXICOLOGY No harmful side effects are known.



Rhodiola rosea L. [= *Sedum rosea* (L.) Scop.; *S. rhodiola* DC.] (Crassulaceae); *rhodiole rose* (French); *Rosenwurz* (German); *rodiola rosea* (Italian); *rosenrot* (Swedish)

Rhus toxicodendron

poison ivy • poison oak

CLASSIFICATION Cell toxin, strongly irritant, extremely hazardous (Ia).

USES & PROPERTIES Poison ivy is a common cause of allergic skin dermatitis (called poison ivy rash or *Rhus* dermatitis). Skin contact with the oleoresin that exudes from broken stems or leaves causes inflammation and blistering. About 350 000 people are affected in the USA each year (only a small percentage of the population is not allergic).

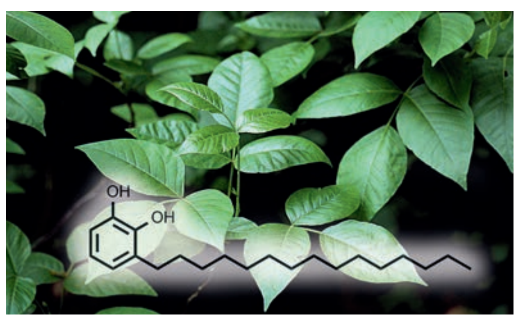
ORIGIN America (southern Canada to Guatemala) and eastern Asia (China and Japan).

BOTANY Variable: deciduous climber (vine), shrub or tree; leaves alternate, trifoliate, long-petiolate.

CHEMISTRY The resin is a mixture of several pentadecylcatechols (with C15 or C17 alkyl chains), collectively called urushiol (= toxicodendrin). An example is **urushiol I**.

PHARMACOLOGY Urushiol is absorbed within 10 minutes (wash immediately with soap and water).

TOXICOLOGY Urushiol is strongly irritant and extremely allergenic. It causes severe blistering and ulceration of the skin and mucosa.



Rhus toxicodendron L. [= *Toxicodendron pubescens* Mill.] (Anacardiaceae); *sumac grimpant* (French); *Giftsumach* (German); *edera velenosa* (Italian); *hiedra venenosa* (Spanish)

Ribes nigrum

blackcurrant

CLASSIFICATION TM: Europe. ESCOP 4, HMPC. DS: fresh fruits, juices, syrups and seed oil.

USES & PROPERTIES Dried leaves (*Ribis nigri folium*) are still popular as a diuretic tea (2–4 g of leaves, taken several times a day). Ripe fruits and juices are dietary supplements and functional food items during the cold and flu season. The seed oil is an alternative to evening primrose oil.

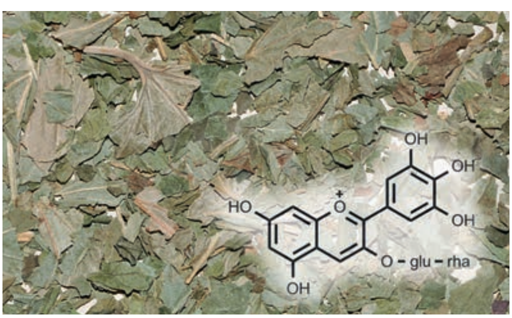
ORIGIN Central and eastern Europe. It is grown as a domestic and commercial crop in cold regions.

BOTANY Deciduous, aromatic shrub (ca. 1.5 m); leaves 5-lobed; flowers greenish red; fruit a multi-seeded berry, dark glossy purple, almost black.

CHEMISTRY Polyphenols and anthocyanins: the rutinosides and glucosides of delphinidin and cyanidin (**tulipanin** is a main compound). Flavonoids (0.5%), diterpenes and essential oil are also present. Leaves and especially fruits are rich in vitamin C. Seed oil contains 15% γ-linolenic acid.

PHARMACOLOGY Leaves have diuretic and hypotensive effects. The flavonoids are venotonics.

TOXICOLOGY Fruits and leaves are non-toxic.



Ribes nigrum L. (Grossulariaceae); *cassis* (French); *Schwarze Johannisbeere* (German); *ribes nero* (Italian)

Ricinus communis

castor oil plant

CLASSIFICATION Cell toxin, extremely hazardous (Ia). TM: Europe, Africa. Pharm., PhEur8.

USES & PROPERTIES The seed oil (*Ricini oleum*), extracted by cold pressing (to avoid the water-soluble lectins) is a traditional purgative medicine. The seeds are used to oil the *mitad* (the pan used to prepare the traditional Ethiopian teff bread).

ORIGIN Africa (probably Ethiopia, the area of greatest genetic diversity). Widely naturalised.

BOTANY Robust shrub (to 4 m); leaves large; flowers terminal; fruit a 3-seeded capsule; seeds large.

CHEMISTRY The seeds contain ricin (a toxic lectin) and ricinine (a pyridine alkaloid). Ricin is one of the deadliest of all known natural substances. The laxative effect is due to **ricinoleic acid**.

PHARMACOLOGY Ricin inhibits ribosomal protein synthesis (injection causes fatal disruption of all vital organs). The alkaloid is also very toxic.

TOXICOLOGY The fatal dose of ricin in humans is 1 mg/kg (p.o.) or a mere 1 μg/kg (i.p.). Ingestion of five to six seeds can be lethal in children, 10 to 20 in adults (or 180 mg of milled seeds).

Ricinus communis L. (Euphorbiaceae); *ricin* (French); *Rizinus*, *Christuspalme* (German); *ricino* (Italian); *ricino* (Spanish)

Rosa canina

rose • dog rose

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (petals only), ESCOP Suppl., PhEur8.

USES & PROPERTIES Dried ripe fruits, without the seeds (fruit pericarp; *Rosae pseudofructus*) are a traditional remedy for digestive ailments and are included in herbal teas for flavour. The seeds are traditionally used as diuretic and for treating urinary disorders. Dried rose petals from *R. centifolia* and *R. damascena* (*Rosae flos*) are used in mouth rinses.

ORIGIN Europe and Asia (naturalised in parts of North America and Africa). Fruits of *Rosa roxburghii* are used in China.

BOTANY Deciduous shrub (to 3 m); flowers single, pink; fruit fleshy, red (known as rose hips).

CHEMISTRY Rose hips are rich in **vitamin C** (to 2.4%). Also present are carotenoids (rubixanthin, lycopene and β-carotene), tannins, flavonoids, organic acids (and fatty acids such as GLA in seeds).

PHARMACOLOGY The fruits have demonstrated diuretic, anti-inflammatory and hypoglycaemic activity. Petals are antioxidant and astringent.

TOXICOLOGY No side effects at low doses.

Rosa canina L. (Rosaceae); *églantier* (French); *Hundsrose*, *Gemeine Heckenrose* (German); *rosa canina* (Italian)

Rosmarinus officinalis

rosemary

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP, WHO 4, PhEur8, HMPC.

USES & PROPERTIES The dried leaves (*Rosmarini folium*) are used as a general tonic for digestive disturbances, headache and nervous complaints (2 g, 3 times/day). Essential oil (*Rosmarini aetherolium*) is used in ointments and bath oils for skin hygiene, improved blood circulation and minor pains. Internal use: 2 drops, up to 10 times/day).

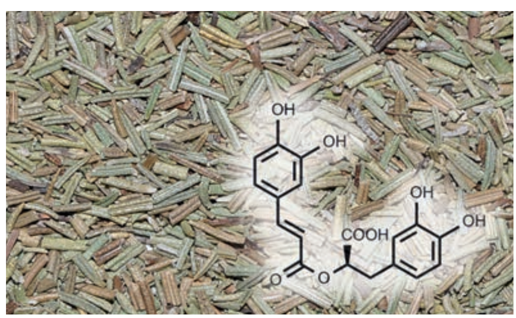
ORIGIN Europe (Mediterranean region). Widely cultivated as a culinary herb and garden plant.

BOTANY Evergreen aromatic shrub (to 1 m); leaves narrow, silvery below; flowers usually blue.

CHEMISTRY Essential oil (2.5%): mainly 1,8-cineole, α-pinene and camphor. Of medicinal relevance is the presence of **rosmarinic acid**, bitter diterpenes, triterpene alcohols and flavonoids.

PHARMACOLOGY Rosemary herb is mildly spasmolytic, analgesic and choleretic. Rosmarinic acid has antioxidant, anti-inflammatory and antimicrobial activities. The flavonoids are venotonics.

TOXICOLOGY Non-toxic in small doses.



Rosmarinus officinalis L. (Lamiaceae); *romarin* (French); *Rosmarin* (German); *rosmarino* (Italian); *roméro* (Spanish)

Rubus fruticosus

bramble • blackberry

CLASSIFICATION TM: Europe. Pharm., Comm. E+. (*R. idaeus*: HMPC).

USES & PROPERTIES Enzymatically fermented and dried leaves (*Rubi fruticosi folium*) are used as astringent in European medicine to treat non-specific acute diarrhoea. It is also used against inflammation of the mouth and throat. Raspberry leaf (from *R. idaeus*) has similar uses (and to ease labour). Both are added to commercial herbal teas.

ORIGIN Europe. A species complex and invasive weed in many parts of the world. Raspberry occurs naturally in Europe, Asia and North America.

BOTANY Woody shrub (to 3 m); stems and leaves prickly; flowers white or pale pink; fruit black. Raspberry leaves are silver-hairy below and the red fruit separates from the stalk when ripe.

CHEMISTRY Hydrolysable tannins (10%): **gallotannins, dimeric ellagitannins**. Also flavonoids.

PHARMACOLOGY Astringent and antidiarrhoeal activities are typical of tannins. Raspberry leaf has uterotonic effects (contraction of uterine muscles).

TOXICOLOGY No noteworthy side effects.

Rubus fruticosus L. (Rosaceae); *ronce noire* (French); *Brombeere* (German); *rovo* (Italian)

Ruscus aculeatus

butcher's broom

CLASSIFICATION Cell toxin (III). TM: Europe. Pharm., Comm.E+, ESCOP, PhEur8, HMPC.

USES & PROPERTIES Rhizomes and roots (*Rusci aculeati rhizoma*) are traditionally used to treat haemorrhoids and varicose veins. Extracts and pure compounds are included in ointments and suppositories (used for symptomatic relief). They are also ingredients of commercial mixtures for oral use, to treat venous and lymphatic vessel insufficiency.

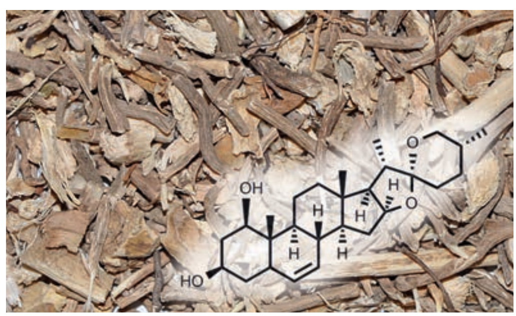
ORIGIN Europe and Asia.

BOTANY Evergreen perennial shrublet (to 1 m); stems leaf-like (phylloclades); fruit a red berry.

CHEMISTRY Steroidal saponins (to 6%): ruscin (monodesmosidic spirostane type) with its aglycone, **ruscogenin**; as well as ruscoside (bidesmodic furostane type) with its aglycone, neoruscogenin.

PHARMACOLOGY The steroidal saponins have venotonic and anti-inflammatory activities.

TOXICOLOGY *Ruscus* saponins are only slightly hazardous (no serious poisoning in humans) but may cause gastrointestinal disturbances.



Ruscus aculeatus L. (Asparagaceae); *petit houx* (French); *Stechender Mäusedorn* (German); *pungitopo* (Italian)

Ruta graveolens

rue • herb of grace

CLASSIFICATION Cell toxin (Ib–II). TM: Europe. Pharm. (now obsolete).

USES & PROPERTIES The dried leaves (*Rutae folium*) or dried tops (*Rutae herba*) are traditional tonics, used for many ailments, including loss of appetite, dyspepsia, sore throat, fever, circulatory problems, venous insufficiency, high blood pressure, hysteria, menstrual disorders, abortion, arthritis, sprains, wounds and skin ailments.

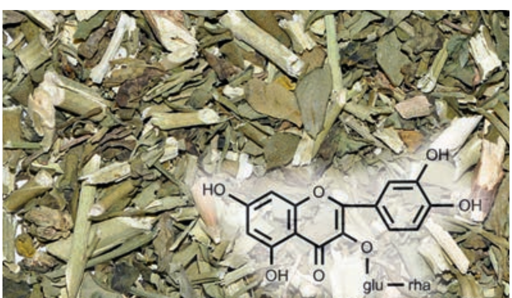
ORIGIN Southern Europe. Widely cultivated as an ornamental plant. The Mediterranean Aleppo rue (*R. chalepensis*) is used in the same way.

BOTANY Aromatic shrub (to 1 m); leaves compound; flowers yellow; fruit a capsule; seeds black.

CHEMISTRY Coumarins, furanocoumarins, furanoquinoline alkaloids, flavonoids (**rutin**, 5%), essential oil (2-undecanone as major compound).

PHARMACOLOGY Antimicrobial, antispasmodic, anti-exudative, analgesic, ion-channel inhibiting. Rutin is a venotonic and capillary protectant.

TOXICOLOGY The furanocoumarins and alkaloids are mutagenic: avoid during pregnancy.



Ruta graveolens L. (Rutaceae); *rue* (French); *Weinraute* (German); *ruta* (Italian); *ruda común* (Spanish)

Salix alba

white willow

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 4, HMPC (*S. purpurea*) clinical studies+.

USES & PROPERTIES The dried bark from 2–3 year old branches (*Salix cortex*) is traditionally used for fever, influenza, headaches, rheumatism and minor pains (2–3 g, taken as tea, 3–4 × per day).

ORIGIN Europe and Asia. Basket willow (*S. purpurea*) and crack willow (*S. fragilis*) are also used.

BOTANY Deciduous tree (to 20 m); leaves silvery; flowers small, naked, in small spikes (catkins).

CHEMISTRY Phenolic glycosides (salicylates, salicortin, silicin); phenolic acids (chlorogenic acid) and oligomeric proanthocyanidins (1%).

PHARMACOLOGY Anti-inflammatory, analgesic, antipyretic and antirheumatic activies (supported by clinical studies). Salicortin is hydrolysed to salicin, which is converted by intestinal hydrolysis to saligenin. The latter is absorbed into the bloodstream and converted in the liver to **salicylic acid** (the active compound). Aspirin, the well-known analgesic, is the acetylated form of salicylic acid.

TOXICOLOGY Low toxicity; salicin is non-irritant.

Salix alba L. (Salicaceae); *saule blanc* (French); *Silberweide* (German); *salice bianco* (Italian)

Salvadora persica

mustard tree • toothbrush tree

CLASSIFICATION TM: Africa (dental care).

USES & PROPERTIES Pieces of root (ca. 10 mm in diameter and 100–200 mm long) are traditional toothbrush sticks. They are known as *miswak* (or *siwak*) and are commonly sold by vendors on local markets. The end of the stick is chewed until the fibres separate; the brush is rubbed across the teeth in vertical strokes. Root extracts ("peelu extracts") are ingredients of commercial toothpastes.

ORIGIN Africa (Namibia to North Africa) and Asia (Arabia to Pakistan and India).

BOTANY Shrub or small tree (to 5 m); leaves opposite, fleshy; flowers small; fruit a small red drupe.

CHEMISTRY Lignan glycosides, phenolic glycosides (syringin) and benzyl glucosinolates, the latter are enzymatically converted to volatile **benzyl isothiocyanate** (a mustard oil).

PHARMACOLOGY Strong antibacterial and antiplaque activities (supported by human studies). Benzyl isothiocyanate is active against gram-negative bacteria (those associated with periodontitis).

TOXICOLOGY Non-toxic in low doses.

Salvadora persica L. (Salvadoraceae); *arak*, (Arabic); *salvadora persica* (French); *Senfbaum*, *Zahnbürstenbaum* (German); *salvadora persica* (Italian); *peelu* (Urdu)

Salvia divinorum

magic mint • diviner's sage

CLASSIFICATION Cell toxin, mind-altering (II). TM: Central America (Mexico).

USES & PROPERTIES The leaves have traditional medicinal uses in treating headache and digestive, rheumatic and urinary tract disorders. The plant is psychoactive and has been used by shamans for divining and healing rituals (it is perhaps the legendary *pipiltzintzintl* of the Aztecs). An illegal narcotic in some countries: leaves are chewed or smoked for an unusual psychoactive experience that lasts several minutes to one hour.

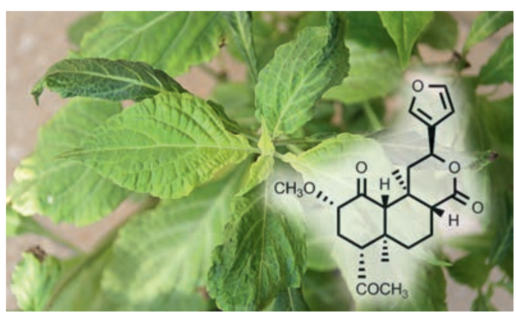
ORIGIN Central America (Oaxaca in Mexico). A sterile cultigen, sometimes grown in gardens.

BOTANY Perennial herb (to 2 m); leaves opposite; flowers 2-lipped, pale blue.

CHEMISTRY Diterpenoids (neoclerodane type): **salvinorin A** (the main active compound), with salvinorin B and other salvinorins (all inactive).

PHARMACOLOGY Salvinorin A is an agonist of the kappa opioid neuroreceptor (the only non-alkaloid to show this activity, at doses as low as 200 µg).

TOXICOLOGY Low toxicity; side effects unknown.



Salvia divinorum Epling & Játiva (Lamiaceae); *sauge des devins* (French); *Wahrsagesalbei*, *Zaubersalbei* (German); *salvia dei veggenti* (Italian)

Salvia officinalis

sage • garden sage

CLASSIFICATION TM: Europe. Comm.E+, ESCOP 2, WHO 5, PhEur8, HMPC.

USES & PROPERTIES The dried leaves (*Salviae folium*, *Salviae trilobae folium*) are traditionally used for a wide range of ailments, including digestive disorders, flatulence, diarrhoea, diabetes, excessive perspiration, night sweats, gingivitis and inflammation of the mucosa of the mouth and throat. The daily dose is 4–6 g of the herb or 0.3 g of the essential oil. Sage is a popular culinary herb.

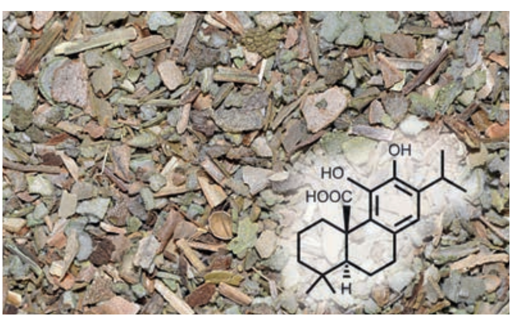
ORIGIN Mediterranean Europe. Cultivated.

BOTANY Shrublet (to 0.6 m); leaves simple (basally lobed in trilobed sage, *S. fruticosa*); flowers blue.

CHEMISTRY Essential oil (3%): mainly thujone; diterpenoids: **carnosic acid** (= salvin), a preservative in food and oral hygiene products, and the structurally related carnosol (bitter value 14 000); triterpenes (oleanic acid) and rosmarinic acid.

PHARMACOLOGY Proven antispasmodic; antiseptic, carminative and antisudorific activities.

TOXICOLOGY Thujone is neurotoxic: avoid large amounts/chronic use (see *Artemisia absinthium*).



Salvia officinalis L. (Lamiaceae); *sauge officinale, sauge commune* (French); *Echter Salbei*, *Gartensalbei* (German); *salvia* (Italian); *salvia officinal* (Spanish)

Sambucus nigra

elder • elderberry tree

CLASSIFICATION Cell toxin (III). TM: Europe, North America. Pharm., Comm.E+ (flowers), WHO 2 (flowers), PhEur8, HMPC.

USES & PROPERTIES The dried, sieved flowers, without stalks (*Sambuci flos*) or the fresh or dried fruits (*Sambuci fructus*) are traditionally used to treat colds, cough, catarrh and fever. An infusion of 3 g (flowers) or 10 g (fruits) is taken several times a day (or extracts and tinctures, such as elderberry wine). The flowers are an ingredient of herbal tea mixtures and herbal preparations while the fruits provide a natural colouring for food products.

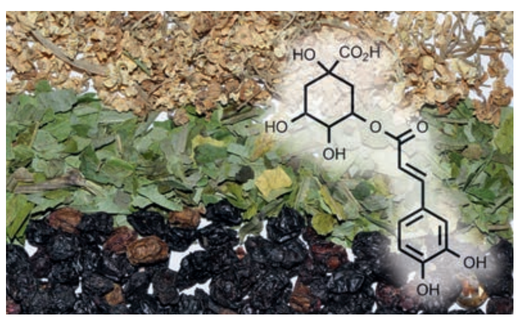
ORIGIN Europe, Asia and North Africa.

BOTANY Shrub or small tree (to 6 m); leaves compound; flowers white; fruit a 3-seeded black drupe.

CHEMISTRY Flowers and fruits are rich in flavonoids: rutin (2%), quercitrin and hyperoside. Flowers: **chlorogenic acid** (3%) and triterpenoids; fruits: tannins (3%) and cyanidin glycosides.

PHARMACOLOGY Diaphoretic, anti-inflammatory (flowers, fruits); diuretic, mild laxative (fruits).

TOXICOLOGY Non-toxic when heated.



Sambucus nigra L. [Adoxaceae (formerly Caprifoliaceae)]; *grand sureau* (French); *Schwarzer Holunder* (German); *sambuco* (Italian); *sauco* (Spanish)

Sanguinaria canadensis

bloodroot

CLASSIFICATION Cell toxin (Ib–II). TM: North America. Pharm., clinical studies+.

USES & PROPERTIES The dried rhizome with the roots removed (*Sanguinariae canadensis rhizoma*) is traditionally used as expectorant, spasmolytic and emetic to treat asthma, bronchitis, cough, croup, laryngitis and pharyngitis. It is an ingredient of expectorants, cough syrups and stomachics and historically also oral hygiene products such as mouth rinses and toothpastes.

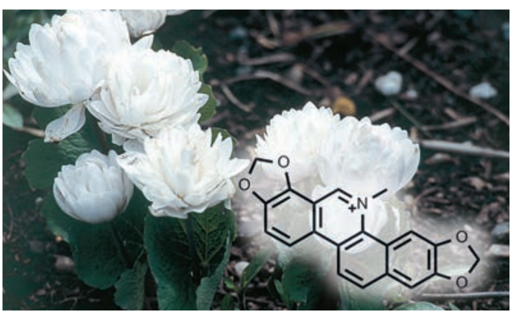
ORIGIN North America. It is an ornamental plant.

BOTANY Perennial herb (to 0.4 m); rhizomes and stems with red sap; leaves rounded, lobed; flowers large, white; fruit a bilocular capsule.

CHEMISTRY Isoquinoline alkaloids (9%): mainly **sanguinarine** (50%) and several others.

PHARMACOLOGY Sanguinarine is strongly antibiotic and anti-inflammatory. It counteracts dental plaque and gingivitis (showed in clinical studies).

TOXICOLOGY Sanguinarine: LD_{50} (mouse) = 19.4 mg/kg (i.v.), 102 mg/kg (s.c.). It is no longer used to any extent in oral rinses because of side effects.



Sanguinaria canadensis L. (Papaveraceae); *sanguinaire du Canada* (French); *Kanadische Blutwurzel* (German); *sanguinaria* (Italian)

Sanguisorba officinalis

burnet • greater burnet • garden burnet

CLASSIFICATION TM: Europe, Asia. PhEur8.

USES & PROPERTIES The dried rhizome and root (*Sanguisorbae rhizoma et radix*) and sometimes the dried aboveground parts (*Sanguisorbae herba*) are traditionally used to stop bleeding (hence the generic name). It is an effective remedy for acute diarrhoea and has been used to treat inflammation of the mouth and throat, ulcerative colitis, uterine bleeding, burns, wounds, ulcers and eczema.

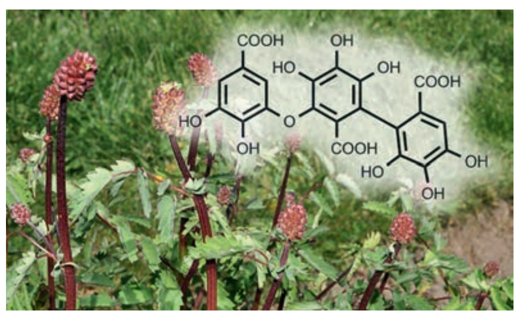
ORIGIN Europe and Asia. Salad burnet (*S. minor*) is a culinary herb with similar medicinal uses. Both species are commonly grown in herb gardens.

BOTANY Erect perennial herb (to 1 m); leaves pinnate; flowers small, in dense, oblong heads.

CHEMISTRY Ellagitannins: sanguiin H-6 is a major compound (an isomer of agrimoniin with **sanguisorbic acid** ester groups as linking units); also saponins (sanguisorbin) and proanthocyanidins.

PHARMACOLOGY The astringent, haemostyptic, antihaemorrhoidal, antimicrobial and anti-inflammatory activities are ascribed to the tannins.

TOXICOLOGY No serious side effects are known.



Sanguisorba officinalis L. (Rosaceae); *sanguisorbe*; *grande pimprenelle* (French); *Großer Wiesenknopf* (German); *sorbastrella* (Italian)

Sanicula europaea

sanicle • wood sanicle

CLASSIFICATION TM: Europe. Comm.E+ (*Saniculae herba* only).

USES & PROPERTIES The dried herb (*Saniculae herba*) is traditionally used as an expectorant to treat infections of the upper respiratory tract. An infusion of 1–2 g is taken 3 × per day. It is also taken orally for an upset stomach, diarrhoea, flatulence and excessive bleeding or gargled for infections of the mouth and throat. Leaves were once popular as poultice to treat wounds and skin ailments.

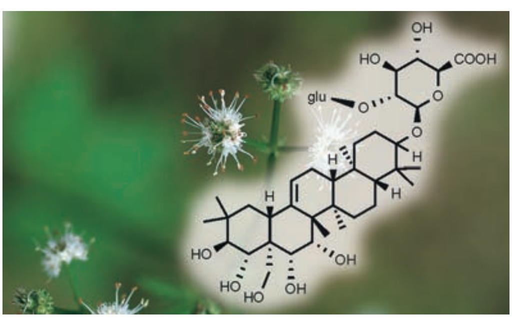
ORIGIN Europe, Asia and North Africa.

BOTANY Deciduous perennial herb (to 0.4 m); leaves deeply lobed; flowers small, white; fruit a small bristly schizocarp.

CHEMISTRY Monodesmosidic triterpenoid saponins: **saniculoside A** and many others; flavonoids (e.g. rutin), organic acids (e.g. rosmarinic and chlorogenic acids), mucilage and tannins.

PHARMACOLOGY The saponins are responsible for the expectorant effects; tannins are astringent and have styptic activity.

TOXICOLOGY No side effects reported.



Sanicula europaea L. (Apiaceae); *sanicle* (French); *Sanikel* (German); *sanicola*, *erba fragolina* (Italian); *saniculu* (Spanish)

Santalum album

sandalwood • white sandalwood

CLASSIFICATION Cell toxin (II). TM: Europe, Asia (India). Comm.E+.

USES & PROPERTIES Wood (from the trunk or branches) is known as white sandalwood (*Santali lignum albi*) and has been traditionally used to treat cystitis, gonorrhoea and other infections of the urinary tract. The total daily dose of wood chips is 10–20 g. Extracts can be used topically for skin ailments and internally for indigestion and chest complaints. Essential oil distilled from the wood is used in perfumery but also in aromatherapy against nervous disorders.

ORIGIN Asia (India). Cultivated to some extent.

BOTANY Evergreen semi-parasitic tree (to 10 m); leaves opposite; flowers small; fruit a purple drupe.

CHEMISTRY Essential oil (ca. 5% in the wood) with sesquiterpene alcohols (55% of the oil): **α-santalol** and β-santalol are the main compounds.

PHARMACOLOGY Antibacterial and spasmolytic activities are ascribed to the sesquiterpenes.

TOXICOLOGY Ingestion of large amounts can cause stomach disorders and nephritis.

Santalum album L. (Santalaceae); *santal blanc* (French); *Weißer Sandelbaum* (German); *sandalo* (Italian); *leño de santalo citrino* (Spanish)

Saponaria officinalis

soapwort • red soapwort

CLASSIFICATION Cell toxin (III). TM: Europe. Comm.E+ (root only).

USES & PROPERTIES Dried rhizomes and roots (*Saponariae rubrae radix*), less often the herb, are mainly used to treat cough and bronchitis; also as diuretic, antirheumatic and topically for eczema and skin ailments. Extracts were formerly included in cough medicines. Soapwort was once used as a soap substitute (*sapo* is the Latin for soap).

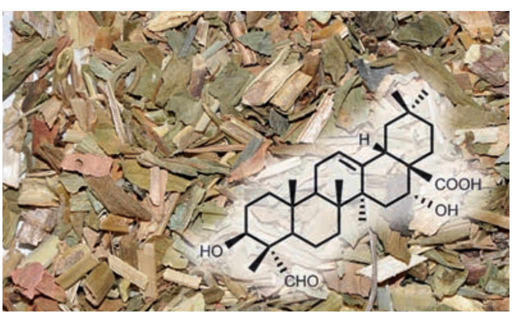
ORIGIN Europe and Asia (naturalised in North America). A popular garden plant.

BOTANY Mat-forming perennial herb (to 0.5 m); leaves opposite; flowers attractive, pink.

CHEMISTRY Triterpene saponins (to 8%): **quillaic acid** is a main aglycone, together with saponarosides, saponasides A–D and gypsogenin.

PHARMACOLOGY Expectorant effects are ascribed to stimulation of the *nervus vagus* which results in bronchial excretions. Anti-inflammatory activity may be linked to corticomimetic effects.

TOXICOLOGY Soapwort is slightly poisonous when large amounts are ingested.



Saponaria officinalis L. (Caryophyllaceae); *saponaire* (French); *Gewöhnliches Seifenkraut* (German); *saponaria* (Italian); *hierba japonera* (Spanish)

Sceletium tortuosum

sceletium • kanna

CLASSIFICATION Mind-altering, sedative, euphoric (III). TM: Africa (South Africa). AHP.

USES & PROPERTIES The dried whole plant is traditionally used as a hypnotic and sedative to counteract anxiety, stress and nervous tension; also to suppress hunger and thirst, to treat colic in infants and as replacement therapy for alcohol addiction. It is traditionally used as a masticatory, without any physical or psychological dependency.

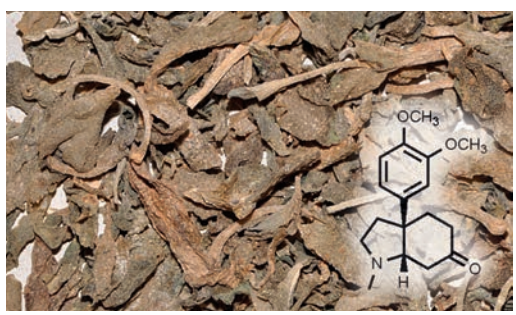
ORIGIN Africa (dry western parts of the Cape region of South Africa); now a medicinal crop plant.

BOTANY Short-lived perennial succulent; leaves succulent, skeletonised in summer; flowers yellow; fruit a hygroscopic, many-seeded capsule.

CHEMISTRY Mesembrine-type alkaloids (to 2.3%): mainly **mesembrine** or mesembrenol, depending on the chemotype (some clones are alkaloid-free).

PHARMACOLOGY The alkaloids are hypnotic and sedative (euphoric at high doses, but not hallucinogenic). Clinical studies are underway.

TOXICOLOGY Low toxicity. Pure alkaloids and high doses may cause side effects.



Sceletium tortuosum (L.) N.E. Br. or ***Mesembryanthemum tortuosum*** (L.) (Aizoaceae); *kougoed* (Afrikaans); *sceletium* (French); *Sceletium* (German); *kanna* (Khoi)

Schinus molle

pink pepper

CLASSIFICATION Cell toxin (II). TM: Central and South America.

USES & PROPERTIES Leaf extracts and leaf sap have been used to treat ophthalmia, toothache, gingivitis, rheumatism, menstrual disorders, bronchitis, gonorrhoea, gout, tuberculosis, tumours, ulcers, urethritis, warts, wounds and urinary ailments. Bark extracts are used against diarrhoea. The ripe fruits are an aromatic spice (pink pepper).

ORIGIN South America (Argentina, Chile and Peru); naturalised in many parts of the world.

BOTANY Evergreen tree (to 15 m); leaves pinnate; flowers small, white; fruit a small red drupe.

CHEMISTRY Leaf oil: mainly α-pinene and β-pinene. Fruit oil: **α-phellandrene**, β-phellandrene and α-terpineol. The skin and mucosal irritant (in the Brazilian *S. terebinthifolia)* is cardanol.

PHARMACOLOGY Diuretic, analgesic, expectorant, stomachic, anti-inflammatory, tonic and vulnerary activities (not linked to particular compounds).

TOXICOLOGY Use in small quantities only.

Schinus molle L. (Anacardiaceae); *xiao ru xiang* (Chinese); *poivre rose* (French); *Peruanischer Pfefferbaum* (German); *pimenta rosa*, *aroeira* (Portuguese); *arveira*, *terebino* (Spanish)

Schisandra chinensis

Chinese mock-barberry • lemon wood

CLASSIFICATION TM: Asia (China). Pharm., WHO 3, PhEur8, clinical studies+.

USES & PROPERTIES Dried ripe fruits (*Schisandrae fructus*), less often dried leaves (*Schisandrae folia*) are used in decoctions as general tonic, liver protectant and sedative; externally for skin disorders. Used for colds and sea-sickness (Japan), diarrhoea, excessive sweating and as a calming medicine (China) and as adaptogenic tonic, to reduce thirst, hunger and exhaustion (eastern Russia). Ripe fruits are used for juices, jams and sweets; the Chinese name means "five flavours".

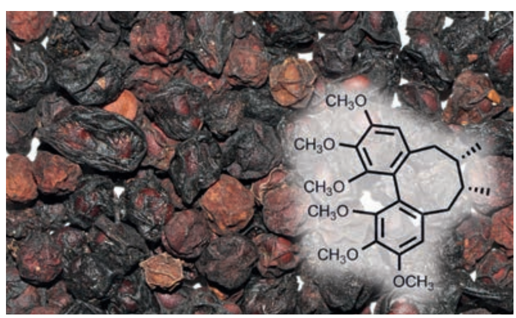
ORIGIN Asia (eastern Russia, China, Japan, Korea). Cultivated in China and Korea.

BOTANY Deciduous climber (vine); leaves prominently veined; flowers yellow; fruit a red drupe.

CHEMISTRY Lignans: **schizandrin A** (= deoxyschizandrine) and gomisin are main compounds.

PHARMACOLOGY Schizandrine has immune-stimulating, adaptogenic, hepatoprotective, antiviral, neuroprotective and antioxidant activity.

TOXICOLOGY Non-toxic; avoid during pregnancy.



Schisandra chinensis (Turcz.) Baill. (Schisandraceae); *wu wei zi* (Chinese); *schisandra de Chine* (French); *Chinesische Beerentraube*, *Chinesisches Spaltkölbchen* (German)

Scopolia carniolica

scopolia

CLASSIFICATION Cell toxin, mind-altering (Ib).TM: Europe. Comm.E+. MM: alkaloids.

USES & PROPERTIES Dried rhizomes (*Scopoliae rhizoma*) are used to treat spasms of the gastrointestinal and urinary tracts. The maximum daily dose is 3 mg of alkaloids (single dose: 0.25–1 mg). It has been used topically for relief of rheumatism. The leaves are used for alkaloid extraction.

ORIGIN Europe. Alps and Carpathian mountains. Grown in gardens and on a commercial scale.

BOTANY Deciduous perennial herb (to 0.5 m); leaves soft; flowers purplish brown.

CHEMISTRY Tropane alkaloids (0.3–0.8% in rhizomes, 0.5% in leaves): mainly ***L*-hyoscyamine**, with small amounts of *L*-scopolamine (and their racemic mixtures, atropine and atroscine).

PHARMACOLOGY The alkaloids are mAChR antagonists and thus antispasmodic (parasympatholytic); they cause relaxation of smooth muscles.

TOXICOLOGY The alkaloids are toxic and can only be used under medical supervision. Side effects: hyperthermia, tachycardia and hallucinations.

Scopolia carniolica Jacq. (Solanaceae); *scopolia* (French); *Glockenbilsenkraut* (German); *scopolia* (Italian)

Scutellaria baicalensis

Baikal skullcap

CLASSIFICATION TM: Asia (China). Pharm.

USES & PROPERTIES The dried roots (*Scutellariae radix*) is one of the 50 fundamental herbs in Chinese traditional medicine. It is used to treat cough, allergies, inflammation, arteriosclerosis, dermatitis and high blood lipids. It is also useful in treating cerebral thrombosis and paralysis caused by stroke. The daily dose is 3–9 g. Aerial parts of American and European skullcaps are traditional nerve tonics and sedatives (1–2 g, 3 × per day).

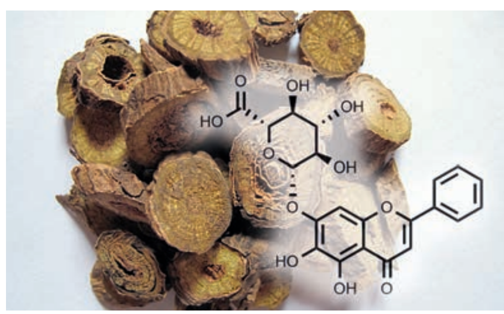
ORIGIN Asia (Russia to China and Japan). (North America: *S. virginiana*; Europe: *S. galericulata*).

BOTANY Perennial herb (to 0.5 m); leaves opposite; flowers erect, helmet-shaped, blue.

CHEMISTRY *Scutellaria* species are rich in flavonoids. *S. baicalensis* has flavone *O*-glycosides (up to 20% in roots), with **baicalin** and wogonoside as main compounds.

PHARMACOLOGY Studies have shown antiseptic, antipyretic, antihypertonic, analgesic, lipid-lowering and smooth muscle-relaxing activities.

TOXICOLOGY No serious side effects are known.



Scutellaria baicalensis Georgi (Lamiaceae); *huáng qín* (Chinese); *scutellaire du lac Baîkal* (French); *Chinesisches Helmkraut*, *Baikal-Helmkraut* (German)

Securidaca longepedunculata

violet tree

CLASSIFICATION Cell toxin (II). TM: Africa, Europe.

USES & PROPERTIES The roots or root bark (sometimes stem bark or leaves) are a traditional panacea, used for a wide range of ailments in Africa. These include cough, rheumatism, toothache, headache and constipation. It also has contraceptive uses and is applied externally for treating wounds and rheumatic pain.

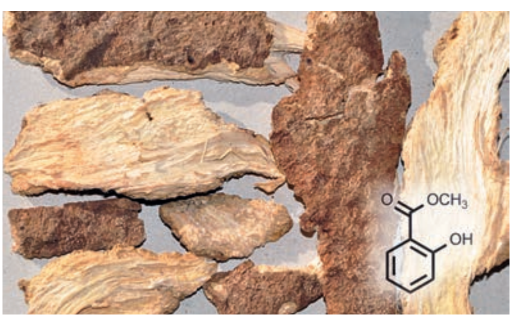
ORIGIN Tropical Africa. It is wild-harvested only.

BOTANY Tree (to 6 m); leaves small, crowded on branch ends; flowers pink; fruit a winged nutlet.

CHEMISTRY The essential oil of the roots contains high levels of **methyl salicylate**. Also present are triterpenoid saponins (presenegenin glycosides) and indole alkaloids (securinine).

PHARMACOLOGY Methyl salicylate can penetrate skin, with anti-inflammatory and counterirritant effects. Expectorant and secretolytic effects may be due to the saponins.

TOXICOLOGY Traditionally used as ingredient of arrow poisons. Self-medication can be dangerous.



Securidaca longepedunculata Fres. (often given as "*S. longipedunculata*" in the literature) (Polygalaceae); *securidaca* (French); *Securidaca* (German)

Senecio jacobaea

common ragwort

CLASSIFICATION Cell toxin, mutagenic, hepatotoxic (II). TM: Europe, North America.

USES & PROPERTIES Fresh or dried above-ground parts [*S. jacobaea* and *S. ovatus* (photo below) in Europe, *S. serratuloides* in Africa] are traditionally used in wound treatment, as internal and external haemostyptics. Formerly used as teas and poultices but are no longer considered safe.

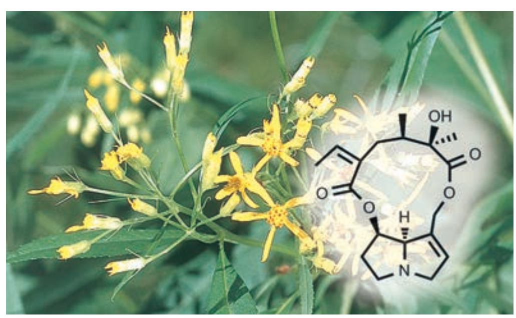
ORIGIN Europe, Asia and North Africa (naturalised in North America). *Senecio* species occur in all parts of the world, often as weeds.

BOTANY Erect perennial herb (to 1 m); leaves pinnately compound; flowers yellow, in small heads.

CHEMISTRY Macrocyclic pyrrolizidine alkaloids (0.3%): **senecionine** (the main compound) with seneciphylline, jacobine and others.

PHARMACOLOGY Pyrrolizidine alkaloids (PAs) are haemostyptics. Those with an unsaturated necine base (such as senecionine) are cumulative liver poisons (also mutagenic and carcinogenic).

TOXICOLOGY Safety limit for intake of PAs: 1 µg/day. Senecionine: LD_{50} = 64 mg/kg (mouse, i.v.).



Senecio jacobaea L. or ***Jacobaea vulgaris*** Gaertn. (Asteraceae); *herbe St. Jacques* (French); *Jakobskreuzkraut* (German); *senecione di San Giacomo* (Italian)

Senna alexandrina

senna

CLASSIFICATION TM: Africa, Europe, Asia. Comm.E+, ESCOP 5, WHO 1, 5, PhEur8.

USES & PROPERTIES Dried leaves (*Sennae folium*) or dried pods (*Sennae fructus*) are traditionally used as a purgative medicine to treat acute constipation. Tea is made from 1 or 2 g (see below). It is the most popular of natural laxatives and an ingredient of many commercial preparations.

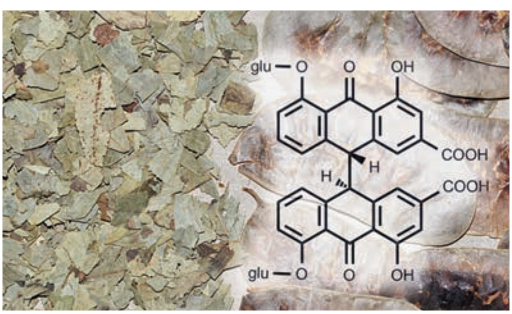
ORIGIN Northeastern Africa and the Middle East. Commercial sources are Egypt and Sudan (Alexandrian or Khartoum senna; use 1 g) or India and Malaysia (Tinnevelly senna; use 2 g).

BOTANY Shrub (to 2 m); leaves pinnate, with narrow leaflets; flowers yellow, stamens straight; fruit a flat, broad, many-seeded pod.

CHEMISTRY Dianthrone glucosides (3%): mainly **sennoside A** and sennoside B; also flavonoids.

PHARMACOLOGY Sennosides are converted in the colon to rhein, a stimulant and irritant laxative. The flavonoids are thought to prevent griping.

TOXICOLOGY Low toxicity, but chronic use can be dangerous due to severe electrolyte imbalances.



Senna alexandrina Mill. [= *Cassia senna* L., *C. angustifolia* Vahl., *C. acutifolia* Del.] (Fabaceae); *senna* (French); *Senna* (German); *senna* (Italian); *sen* (Spanish)

Serenoa repens

saw palmetto • sabal

CLASSIFICATION TM: Europe, North America. Comm.E+, WHO 2, PhEur8, clinical studies+.

USES & PROPERTIES The dried fruits (*Sabal fructus*) are traditionally used to treat the symptoms of benign prostate hyperplasia. These include a weak urinary stream, delayed onset of urination, pollakiuria (increased frequency of urination) and nycturia (urination at night).

ORIGIN North America (southeastern USA).

BOTANY Palm tree (to 3 m); leaves fan-shaped; flowers in clusters; fruit a drupe, black when ripe.

CHEMISTRY Short-chain fatty acids (e.g. **lauric acid**); various phytosterols: mainly β-sitosterol (also in pumpkin seeds, see *Cucurbita pepo*).

PHARMACOLOGY Efficacy of this drug or combinations with *Urtica dioica* are clinically proven. The phytosterols prevent the binding of dihydrotestosterone at the androgen receptors, and inhibit 5α-reductase and aromatase (so that the conversion to oestrogen is blocked). Lauric acid is thought to have cholesterol-lowering activity.

TOXICOLOGY Non-toxic.

Serenoa repens (Bartram) Small (Arecaceae); *palmier de l'Amérique du Nord* (French); *Sägepalme*, *Zwergpalme* (German); *palmetta di Florida* (Italian)

Sesamum indicum

sesame

CLASSIFICATION TM: Asia (India). DS: functional food.

USES & PROPERTIES Sesame seeds and sesame oil have many traditional uses as food (e.g. food oil with a long shelf life, tahini, halva), cosmetics (e.g. hair and skin care) and medicine (skin ailments, rashes, acne and nose drops for chronic sinusitis). It is a potentially valuable dietary supplement (nutraceutical, functional food ingredient) to reduce cholesterol and blood sugar levels.

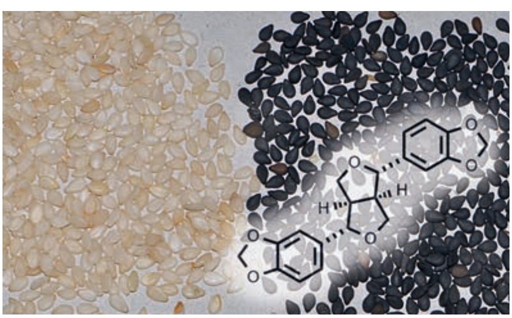
ORIGIN Africa and Asia. A major cultivated crop.

BOTANY Erect annual herb (to 2 m); leaves oblong; flowers axillary, pink; fruit a many-seeded capsule; seeds small, white, brown or black.

CHEMISTRY Unsaturated fatty acids; high levels (to 2.5%) of furofuran lignans: mainly **sesamin**, sesamolin, sesaminol glucosides and sesamol.

PHARMACOLOGY The lignans are thought to reduce cholesterol and act as antioxidants. Antimicrobial, hypoglycaemic and hypotensive activities.

TOXICOLOGY Sesame is not toxic but causes severe allergies in some people.



Sesamum indicum L. (Pedaliaceae); *hu ma* (Chinese); *sésame* (French); *gingli* (Hindi); *Sesam* (German); *sesamo* (Italian); *sésamo* (Portuguese, Spanish)

Silybum marianum

milk-thistle • St Mary's thistle

CLASSIFICATION TM: Europe. Comm.E+, WHO 2, PhEur8, clinical studies+. MM: silymarin.

USES & PROPERTIES Ripe fruits (*Cardui mariae fructus*) are used as digestive tonic to treat dyspepsia and bile disorders. Daily dose: 12–15 g (or 200–400 mg of silymarin). Silymarin is used as liver tonics and hepatoprotectives, to treat cirrhosis, chronic liver inflammation and liver damage resulting from mushroom (*Amanita*) poisoning. Aerial parts are used as cholagogue (bile and liver).

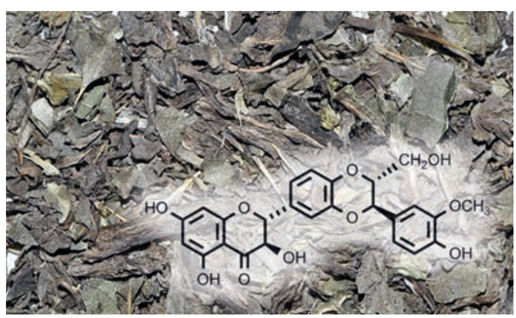
ORIGIN Southern Europe, North Africa and western Asia. Plants are commonly cultivated.

BOTANY Biennial herb (to 2 m); leaves spiny, white-mottled along veins; flowers purple, in spiny heads; fruit a small, one-seeded nutlet (achene).

CHEMISTRY Of medicinal relevance is silymarin, a mixture of antioxidant flavanolignans (2–3%). **Silybin** (a benzodioxane) is the main compound.

PHARMACOLOGY Silymarin prevents toxins from entering liver cells and stimulates liver cell regeneration. Efficacy is supported by clinical studies.

TOXICOLOGY Non-toxic.



Silybum marianum (L.) Gaertn. (Asteraceae); *chardon Marie* (French); *Mariendistel* (German); *carduo mariano* (Italian); *cardo mariano* (Spanish)

Solanum dulcamara

bittersweet • woody nightshade

CLASSIFICATION Cell toxin (Ib–II). TM: Europe. Comm.E+, HMPC, clinical trials+.

USES & PROPERTIES Leafless, two- or three-year old stems (*Dulcamarae stipites* or *stipes*) are taken orally and applied topically for symptomatic relief of chronic eczema and pruritus. It is also used for catarrh, cough, bronchitis, asthma and rheumatism. Tea from 1 g of dry stems is taken 3 ×/day (maximum daily dose of 3 g). Decoctions or infusions (1–2 g in 150 ml water) are used externally.

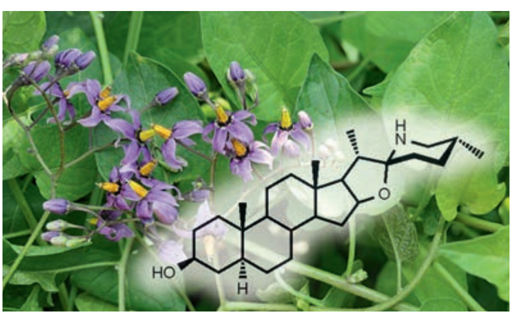
ORIGIN Europe and Asia (weed in North America).

BOTANY Woody climber (to 5 m); leaves simple; flowers purple; fruit a small red berry.

CHEMISTRY Steroidal alkaloids (glycosides of **soladulcidine** and others); steroidal saponins (bidesmosides of protoyamogenin or monodesmosides of spirostan-26-one); tannins.

PHARMACOLOGY Anticholinergic, antiphlogistic, antiseptic, astringent and secretolytic effects. Efficacy against eczema supported by clinical data.

TOXICOLOGY Safe to use at low doses. Unripe fruits are very poisonous.



Solanum dulcamara L. (Solanaceae); *douce-amère* (French); *Bittersüßer Nachtschatten* (German); *dulcamara* (Italian)

Solanum nigrum

black nightshade

CLASSIFICATION Cell and neurotoxin (Ib–II).

USES & PROPERTIES *Solanum nigrum* and other species have edible fruits (when ripe) but may cause severe poisoning when green fruits are eaten. The common potato (*S. tuberosum*) has historically caused fatalities when green tubers (that were exposed to the sun) are used as food.

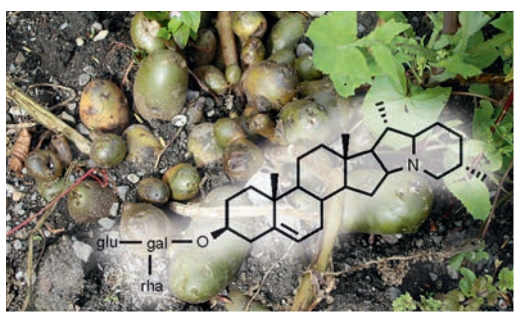
ORIGIN Europe. Naturalised in many parts of the world. Similar-looking species include garden huckleberry (*S. melanocerasum*) and msoba (*S. retroflexum*). Potato (*S. tuberosum*, photo below) originated in Central and South America.

BOTANY Perennial herb; leaves lobed; flowers white; fruit a small, dark purple to black berry.

CHEMISTRY Green fruits and leaves contain steroidal alkaloids: the main ones are α-solacidine in *S. nigrum* and **α-solanine** in *S. tuberosum*.

PHARMACOLOGY Steroidal glycoalkaloids behave like saponins, causing leaks in biomembranes; the tertiary nitrogen interacts with cholinesterase.

TOXICOLOGY Solanine: minimum toxic dose is 2–5 mg/kg i.p.; lethal oral dose is 300–500 mg.



Solanum nigrum L. (Solanaceae); *long kui* (Chinese); *morelle noire* (French); *Schwarzer Nachtschatten* (German); *solano nero* (Italian); *yerba mora* (Spanish)

Solidago virgaurea

goldenrod • European goldenrod

CLASSIFICATION TM: Europe, North America. Pharm., Comm.E+, ESCOP 2, PhEur8, HMPC.

USES & PROPERTIES Dried aboveground parts, (*Solidaginis virgaureae herba*) are traditionally used as diuretic and urinary disinfectant to treat infections of the bladder and kidneys. Tea made from 2–3 g of dry herb is taken 3–5 × per day (the daily dose is 6–12 g). Extracts are taken orally for cough and rheumatism, gargled for mouth and throat infections and applied to sores and wounds.

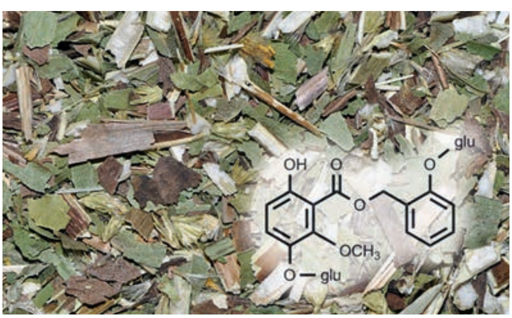
ORIGIN Europe, Asia, Africa and North America.

BOTANY Erect herb (to 1 m); flower heads relatively large. Early goldenrod (*S. gigantea*) and Canadian goldenrod (*S. canadensis*) are also used.

CHEMISTRY Flavonoids (glycosides of quercetin); triterpene saponins (virgaureasaponins); phenolic glycosides (**leiocarposide**); organic acids, polysaccharides and essential oil.

PHARMACOLOGY Leiocarposide is diuretic; the saponins and flavonoids have anti-inflammatory, antiseptic and antitumour activities.

TOXICOLOGY No side effects have been recorded.



Solidago virgaurea L. (Asteraceae); *solidago*, *verge d'or* (French); *Echte Goldrute* (German); *verga d'oro* (Italian)

Spilanthes acmella

spilanthes • toothache plant • pará cress

CLASSIFICATION TM: Central and South America.

USES & PROPERTIES Dried, aboveground parts, harvested during the flowering period (*Spilanthis oleraceae herba)* are traditionally used as tonic and antibiotic to treat inflammation of mucosa of the mouth and throat, toothache, indigestion, intestinal parasites, colds, influenza, respiratory infections, headache, cold sores and herpes. A typical oral dose is 0.5–2 g, but stronger tinctures can be applied as local anaesthetic in case of toothache.

ORIGIN South America. Perhaps an ancient cultigen of Peruvian origin; naturalised and cultivated as salad herb in many warm parts of the world.

BOTANY Weedy annual (to 0.4 m); leaves soft; flower heads single, axillary, with disc florets only.

CHEMISTRY The strong tingling sensation in the mouth is caused by **spilanthol** (an isobutylamide).

PHARMACOLOGY Local anaesthetic, antibiotic, antiphlogistic and saliva-stimulating (sialagogue) properties are ascribed to spilanthol.

TOXICOLOGY Non-toxic; however, massive doses can cause distress.

Spilanthes acmella (L.) Murr. [= *Acmella oleracea* (L.) R.K. Jansen]; (Asteraceae); *cresson de Para*, *spilanthe des potagers* (French); *Parakresse* (German)

Stevia rebaudiana

stevia • sugar-leaf

CLASSIFICATION TM: South America. DS: natural sweetener.

USES & PROPERTIES Fresh or dried leaves are traditionally used as a sweetener in teas and beverages. It has been developed as a non-sugar sweetener because of safety concerns about artificial sweeteners. Stevia is added to soft drinks and other food items to reduce calorie intake.

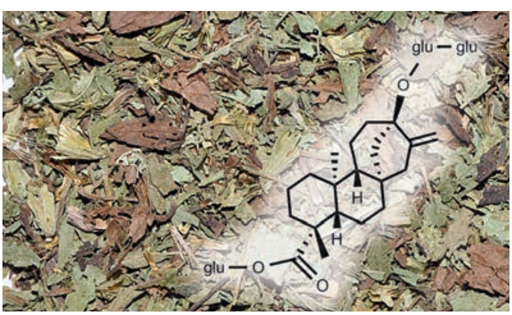
ORIGIN South America (Paraguay). Grown in herb gardens and cultivated on a large commercial scale.

BOTANY Perennial herb (to 0.6 m); leaves oblong, toothed; flowers small, white.

CHEMISTRY The sweet taste is due to diterpenoid glycosides, mainly **stevioside** but also rebaudioside A. The latter is slightly sweeter and less bitter and therefore preferred in commercial sweeteners.

PHARMACOLOGY Stevia is 300 times as sweet as sucrose. It adds no calories: the sugar is released from the glycoside only in the colon, where it is not absorbed but metabolised by bacteria.

TOXICOLOGY After many years of use in Japan, no side effects have been recorded.



Stevia rebaudiana (Bertoni) Bertoni (Asteraceae); *stevia* (French); *Stevia* (German); *stevia* (Italian); *stevia* (Spanish)

Strophanthus gratus

strophanthus

CLASSIFICATION Cell toxin, extremely hazardous (Ia). TM: Africa. MM: source of ouabain.

USES & PROPERTIES The ripe seeds (*Strophanthi grati semen*) are extracted for pure cardiac glycosides, used as heart tonics. The crude drug is not used, only standardised extracts that are injected (often as emergency treatment) to slow down the heart rate but increase the force and efficiency of the contraction. *Strophanthus* was used as source of arrow and spear poisons in Africa.

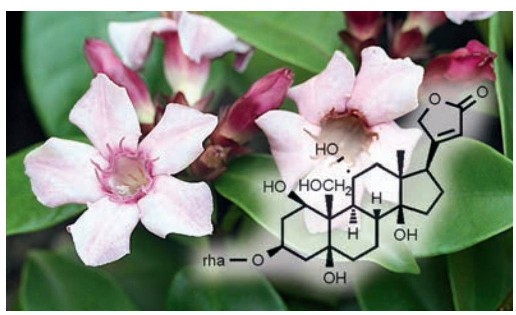
ORIGIN Tropical West Africa. *S. kombe* in southern and eastern Africa.

BOTANY Woody climber (to 10 m); leaves opposite, with milky latex; flowers attractive, pink.

CHEMISTRY Complex mixtures of heart glycosides of the cardenolide type (3–8%): *S. gratus* has **ouabain** (*g*-strophanthin) as main constituent (90% of glycosides); *S. kombe* has *k*-strophanthin.

PHARMACOLOGY Cardiac glycosides inhibit Na^+, K^+-ATPase. They exert inotropic activity.

TOXICOLOGY Ouabain is very toxic when injected; large oral doses are dangerous.



Strophanthus gratus (Wallich & Hook.) Baillon (Apocynaceae); *strophanthus* (French); *Strophanthus* (German); *strofanto* (Italian)

Strychnos nux-vomica

nux vomica

CLASSIFICATION Cell toxin, mind-altering, extremely hazardous (Ia). TM: Europe. Pharm.

USES & PROPERTIES Ripe seeds (*Strychni semen*) were traditionally taken orally as stimulants and bitter tonics, and used topically as analgesics. The maximum daily dose is 10 mg. Nowadays they are no longer used to any extent except in homoeopathy. The seeds were once the method of choice to destroy rodents and other vermin.

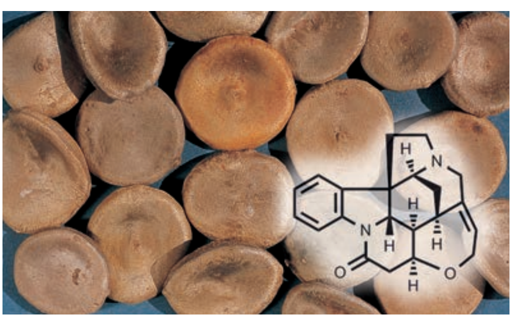
ORIGIN Southern Asia. Cultivated in tropical areas.

BOTANY Evergreen tree (to 25 m); stems spiny; leaves three-veined from the base; flowers small, white; fruit yellow, 6–8-seeded; seeds discoid.

CHEMISTRY Monoterpene alkaloids (1–3%): the main compounds are **strychnine** and brucine.

PHARMACOLOGY Strychnine inhibits the glycine receptor and increases the excitability of the entire nervous system, causing spasms, irreversible contraction of bronchial muscles or cardiac arrest.

TOXICOLOGY The seeds are very poisonous and not suitable for self-medication. Strychnine: lethal dose in children is 5 mg, in adults 100–300 mg.



Strychnos nux-vomica L. (Loganiaceae); *noix vomique* (French); *Brechnussbaum* (German); *noce vomica* (Italian)

Styphnolobium japonicum

Japanese pagoda tree

CLASSIFICATION Cell toxin (III). Parm., PhEur8. MM: flavonoids (rutin).

USES & PROPERTIES The dried, unopened flower buds (*Sophoreae flos*, *Sophorae gemmae*) are used for extraction of flavonoids. The main flavonoid (rutin) is used to treat the symptoms of capillary and venous insufficiency (swollen legs, varicose veins, cramps, haemorrhage and haemorrhoids). Extracts are used in creams and ointments. Very high doses are used (1 g/day for 8 weeks, even 2 g).

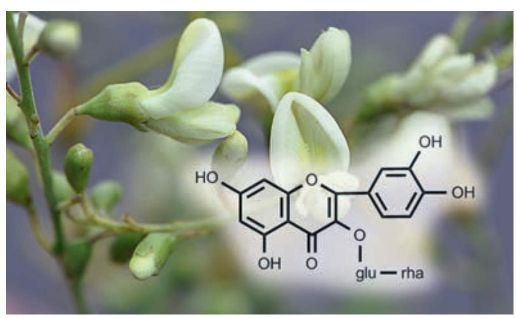
ORIGIN Asia (China and Korea). A popular street tree in many parts of the world.

BOTANY Deciduous tree (to 20 m); leaves pinnate; flowers white; fruit a fleshy, many-seeded pod.

CHEMISTRY The main active compound is **rutin** (quercetin 3-rutinoside) at levels of up to 20% of dry weight in the flower buds.

PHARMACOLOGY Flavonoids are widely accepted to be antioxidant and anti-inflammatory. Studies showed that phenolic compounds strengthen capillaries and reduce capillary permeability.

TOXICOLOGY Toxic in animals; safe at low doses.



Styphnolobium japonicum (L.) Schott [= *Sophora japonica* L.] (Fabaceae); *sophora japonica* (French); *Japanischer Schnurbaum* (German); *sofora* (Italian)

Symphytum officinale

comfrey

CLASSIFICATION Cell toxin (III). TM: Europe. Comm.E+ (external only), ESCOP Suppl., HMPC.

USES & PROPERTIES Dried rhizome and roots (*Symphyti radix*) or sometimes aboveground parts (*Symphyti herba*) are used externally against wounds, sores, glandular swellings, sprains and dislocations. Poultices and pastes made from fresh root can also be used. Root and leaf infusions were once taken orally to treat lung and stomach disorders (internal use is now considered unsafe).

ORIGIN Europe and western Asia. Naturalised in North America. A common garden plant.

BOTANY Perennial herb (to 1 m); leaves bristly hairy; flowers blue (white), in one-sided clusters.

CHEMISTRY **Allantoin** (0.8%); mucilage (fructans); toxic pyrrolizidine alkaloids (PAs) (0.4%), such as symphytine and intermedine; tannins (4–6%).

PHARMACOLOGY Wound-healing effects are due to allantoin (promotes granulation and tissue regeneration) and the mucilage (demulcent effects).

TOXICOLOGY PAs are mutagens and liver poisons. Symphytin: LD_{50} = 300 mg/kg (mouse, i.p.).

Symphytum officinale L. (Boraginaceae); *grande consoude* (French); *Gemeiner Beinwell* (German); *consolida maggiore* (Italian)

Synsepalum dulcificum

miracle fruit • miraculous berry

CLASSIFICATION TM: Africa. DS: sweetener.

USES & PROPERTIES Ripe fruits are traditionally eaten half an hour before a meal to sweeten the taste of sour food items such as palm wine and fermented cereals. The change in taste perception lasts between half an hour and one hour. Freeze-dried granules and tablets have become popular in Japan, where they are used as food additive by patients suffering from diabetes and obesity.

ORIGIN West and Central tropical Africa. Experimental plantations have been established.

BOTANY Evergreen shrub (to 6 m); fruit an oblong red drupe, ca. 20 mm long.

CHEMISTRY The active compound is a glycoprotein called **miraculin**. It is destroyed by heat.

PHARMACOLOGY Miraculin modifies taste buds so that sour taste (but not other tastes) is perceived as sweet (equivalent to ca. 0.3 molar sucrose; it satisfies the craving for sweet foods without adding calories to the diet). The protein itself is not sweet but more or less tasteless.

TOXICOLOGY No adverse side effects are known.

Synsepalum dulcificum (Schum. & Thonn.) Daniell (Sapotaceae); *shen mi guo* (Chinese); *fruit miraculeux* (French); *Wunderbeere* (German)

Syzygium aromaticum

clove tree

CLASSIFICATION TM: Europe, Asia (India). Comm.E+., WHO 2, PhEur8, HMPC.

USES & PROPERTIES Dried flower buds, known as cloves (*Caryophylli flos*) or the essential oil distilled from them (clove oil; *Caryophylli aetheroleum*) are traditionally used against toothache (a few drops of pure oil) and to treat inflammation of the mouth and throat, nausea and gastrointestinal disorders (diluted to 5%). Externally applied against rheumatism and myalgia. A culinary spice.

ORIGIN Southeast Asia (Moluccas Islands).

BOTANY Evergreen tree (to 12 m); leaves glossy; flowers white, with prominent stamens.

CHEMISTRY Essential oil in high yields (15–20%), with **eugenol** (85%), eugenyl acetate (to 15%) and β-caryophyllene (to 7%). Also flavonoids, tannins, phenolic acids and triterpenes.

PHARMACOLOGY The oil has local anaesthetic, antiseptic, antispasmodic and carminative activities. Eugenol is analgesic and anti-inflammatory.

TOXICOLOGY Cloves are not toxic in small amounts but the oil can cause allergic reactions.

Syzygium aromaticum (L.) Merr.& Perry (Myrtaceae); *giroflier* (French); *Gewürznelkenbaum* (German); *chiodi di garofano* (Italian); *clavero* (Spanish)

Tagetes minuta

Mexican marigold • wild marigold

CLASSIFICATION TM: South America.

USES & PROPERTIES Dried aboveground parts are traditionally used as medicinal tea for the common cold, infections of the upper and lower respiratory tract, digestive ailments, stomach upsets, diarrhoea and liver ailments. Used since ancient times as culinary herb and flavourant in beverages and condiments (known as black mint). The oil is used in perfumery and as flavour compound in many major food products, including cola drinks.

ORIGIN South America (southern parts). It has become a weed in most parts of the world.

BOTANY Erect annual herb (1–2 m); leaves pinnate, glandular; flower heads small, yellow.

CHEMISTRY Essential oil with **dihydrotagetone,** β-ocimene and tagetone as main compounds. Also present are several thiophenes.

PHARMACOLOGY Anti-inflammatory, bronchodilatory, hypotensive, spasmolytic and tranquillising effects (shown in animal studies). The thiophenes are also antiviral and antibacterial.

TOXICOLOGY No ill effects; use in moderation.

Tagetes minuta L. (Asteraceae), *tagète*, *tagette* (French); *Mexikanische Studentenblume* (German); *cravo de defuncto* (Portuguese); *anisillo*, *huacatay* (Spanish)

Tamarindus indica

tamarind • Indian date

CLASSIFICATION TM: Africa, Asia (India). Pharm. DS: functional food.

USES & PROPERTIES The fleshy, reddish brown fruit mesocarp (*Tamarindorum pulpa*) is traditionally eaten as a mild laxative. It may be used as a general tonic to improve appetite and digestion. Extracts and infusions are also used in India as general tonics to treat fever, liver conditions and bile ailments. It is widely used in the food industry (e.g. in drinks, chutneys and condiments).

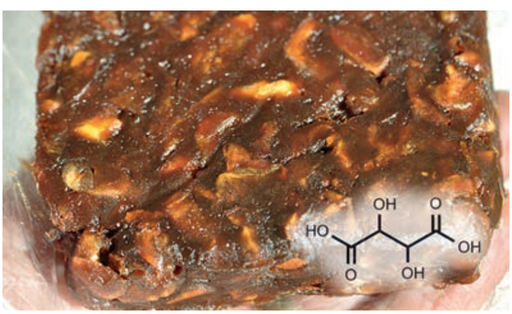
ORIGIN Northeast Africa (Ethiopia and Sudan). It spread from here to India and the rest of Asia. Tamarind means "Indian date" (*tamar* = date).

BOTANY Evergreen tree (to 25 m); leaves pinnately compound; flowers yellow; fruit a fleshy pod.

CHEMISTRY The edible but sour fruit pulp contains pectins, sugars and organic acids (12–15%): **tartaric acid**, malic acid and citric acid. Also minor aromatic substances (cinnamates).

PHARMACOLOGY The pulp has a mild laxative effect and is also astringent and mildly antiseptic.

TOXICOLOGY The fruit pulp is non-toxic (edible).



Tamarindus indica L. (Fabaceae); *tamarinier* (French); *Tamarinde* (German); *tamarindo* (Italian)

Tanacetum parthenium

feverfew

CLASSIFICATION TM: Europe. Pharm., ESCOP 2, WHO 2, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Aboveground parts (*Tanaceti parthenii herba*) are mainly used as a migraine prophylaxis but traditionally also to treat fever, rheumatism, skin ailments and gynaecological disorders. In a clinical study, a daily dose of 100 mg dry herb per day (equivalent to 0.5 mg parthenolide) reduced the number of migraine attacks.

ORIGIN Southern Europe and western Asia. It is commonly grown as a garden plant.

BOTANY Perennial herb (to 0.5 m); leaves lobed, aromatic; flower heads yellow and white.

CHEMISTRY Sesquiterpene lactones: **parthenolide** is the main compound. Also an essential oil (with camphor, chrysanthenyl acetate, camphene).

PHARMACOLOGY The lactones inhibit the formation of prostaglandins and leucotrienes; anti-inflammatory, spasmolytic and antimicrobial.

TOXICOLOGY Feverfew is not toxic but may cause side effects in sensitive persons: skin rashes, mouth ulcers, indigestion and stomach pain.

Tanacetum parthenium (L.) Sch. Bip. (Asteraceae); *grande camomille* (French); *Mutterkraut* (German); *partenio* (Italian); *matricaria* (Spanish)

Taraxacum officinale

dandelion

CLASSIFICATION TM: Europe. Pharm., Comm. E+, ESCOP 2, HMPC.

USES & PROPERTIES The whole herb (roots and leaves) collected just before flowering (*Taraxaci radix cum herba*) used as a diuretic, mild choleretic, bitter tonic and as supportive treatment in case of liver and gall bladder ailments. In traditional medicine it is a mild laxative and remedy for arthritis and rheumatism; externally for skin ailments. Infusions of 4–10 g are taken 3×/day.

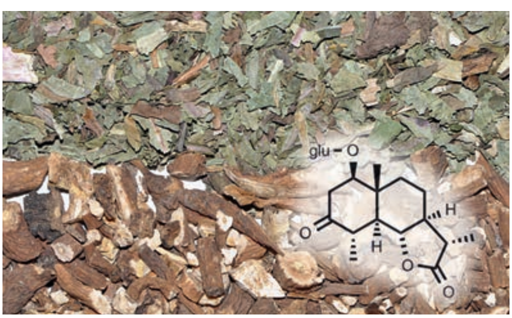
ORIGIN Europe, Asia and North America. A diverse species complex and cosmopolitan weed.

BOTANY Perennial herb with a fleshy taproot; all parts with milky latex; leaves toothed; flower heads solitary; fruit a small, wind-dispersed achene.

CHEMISTRY Bitter sesquiterpene lactones: tetrahydroridentin B and **taraxacolide β-*D*-glucoside**; triterpenes (taraxasterol); sterols; flavonoids.

PHARMACOLOGY Bitter lactones are probably responsible for diuretic and cholagogic activities.

TOXICOLOGY No toxic or adverse effects. The latex may cause dermatitis after repeated exposures.



Taraxacum officinale Weber ex Wigg. (Asteraceae); *pissenlit*, *dent de lion* (French); *Gemeiner Löwenzahn* (German); *taraxaco* (Italian); *diente de leon* (Spanish)

Taxus baccata

yew • English yew

CLASSIFICATION Cell toxin, extremely hazardous (Ia). MM: paclitaxel, clinical studies+.

USES & PROPERTIES The bark (originally) and nowadays the leaves of *Taxus* species are extracted for starting materials to produce paclitaxel analogues. Paclitaxel was originally isolated from the Pacific yew (*T. brevifolia*). Ca. 110–250 mg/m^2 per body per day are used to treat ovarian and breast cancer (at 3–4 week intervals).

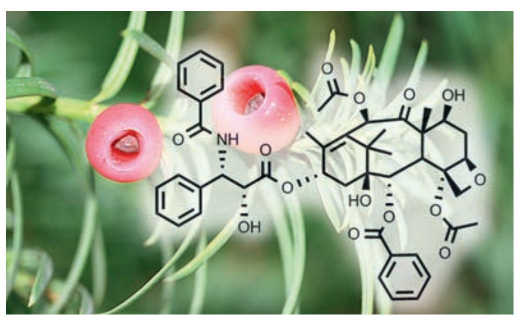
ORIGIN Europe (Mediterranean). (*T. brevifolia* occurs on the west coast of North America.)

BOTANY Evergreen tree (to 20 m); leaves linear; cone small, surrounded by a red, non-toxic aril.

CHEMISTRY Diterpene pseudoalkaloids such as **paclitaxel** (Taxol®) and structural analogues (e.g. docetaxel or Taxotere®) are produced by semisynthesis from the diterpenes extracted from leaves.

PHARMACOLOGY Taxol® and related compounds are spindle poisons that stop cell division by preventing the depolymerisation of microtubules.

TOXICOLOGY Extremely poisonous: 50 g of leaves can be fatal. Not suitable for self-medication.



Taxus baccata L. (Taxaceae); *if* (French); *Eibe* (German); *tasso* (Italian); *tejo* (Spanish)

Terminalia chebula

black myrobalan • chebulic myrobalan

CLASSIFICATION TM: Asia (India). WHO 4.

USES & PROPERTIES The dried, ripe fruit rind, known as black chebulic or black myrobalan (*Myrobalani fructus*; *abhaya* in Sanskrit) is used as a panacea to treat ongoing colds, cough, flatulence, constipation, diarrhoea, piles, lack of libido and memory loss. It is used externally for wound healing and as gargle for inflammation in the mouth and throat. In Ayurvedic medicine it is one of the three components of *triphala* (a general tonic).

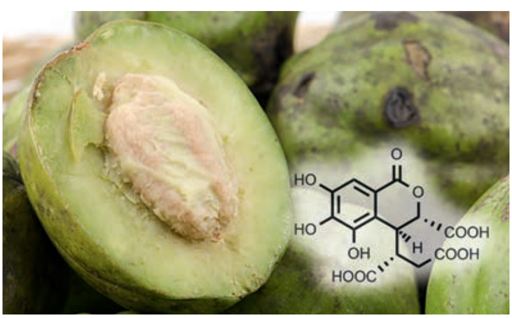
ORIGIN Asia (India to China).

BOTANY Deciduous tree (to 25 m); leaves simple; flowers yellow; fruit a large orange-brown drupe.

CHEMISTRY The main compounds are tannins, coumarins (e.g. chebulin) and triterpenes. **Chebulic acid** was isolated from the ripe fruits. Together with ellagitannins it occurs as chebulagic acid and chebulinic acid.

PHARMACOLOGY Digestive, anti-inflammatory, anthelmintic, cardiotonic, aphrodisiac and restorative properties have been ascribed to the fruits.

TOXICOLOGY No serious side effects are known.



Terminalia chebula Retz. (Combretaceae); *myrobalan noire* (French); *Chebula-Myrobalane* (German); *haritaki* (Sanskrit)

Theobroma cacao

cacao

CLASSIFICATION TM: Europe, C and S America.

USES & PROPERTIES Ripe, fermented seeds (*Cacao semen*) were used to prepare ritual drinks with a reputation of curing stomach ailments, bronchitis and catarrh, but also acting as stimulants and aphrodisiacs. Cacao butter (*Cacao oleum*) was once a carrier for suppositories and is used in ointments and cosmetics. Cacao solids are used for chocolate, chocolate drinks and dietary supplements.

ORIGIN Tropical Central and South America. Cultivated also in Africa and Asia.

BOTANY Evergreen tree (4–8 m); leaves alternate; fruit large, multi-seeded; seeds 25 mm long.

CHEMISTRY The seeds contain triglycerides (50%), flavonoids, tannins, and alkaloids [mainly **theobromine** (3%) and caffeine (0.3%)].

PHARMACOLOGY Theobromine is stimulant, diuretic, antitussive and reduces high blood pressure. Flavanols have antioxidant and vasotonic effects.

TOXICOLOGY Habitual use of large doses lead to appetite loss, nausea, anxiety and withdrawal headaches. Chocolate is toxic to dogs and cats.

Theobroma cacao L. [Malvaceae formerly Sterculiaceae)]; *cacaotier*, *cacaoyer* (French); *Kakaobaum* (German); *cacao* (Italian); *cacao real* (Spanish)

Thevetia peruviana

yellow oleander

CLASSIFICATION Cell toxin (Ib). TM: Europe, North America (now obsolete).

USES & PROPERTIES The seeds (*Thevetiae semen*) are very poisonous and have resulted in accidental deaths (also suicide and murder). Extracts and pure compounds have been used to treat the symptoms of heart insufficiency. A mixture of heart glycosides called *Thevetin* was once sold as a heart tonic. Powdered seeds were used as rat poison.

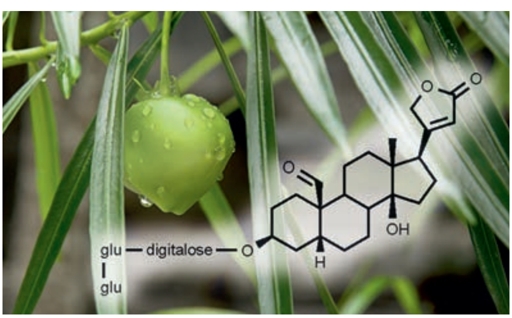
ORIGIN Central and South America. Yellow oleander is a popular garden shrub in all warm regions.

BOTANY Shrub (to 10 m); leaves glossy, with white latex; flowers yellow; fruit a 2–4-seeded capsule.

CHEMISTRY A large number of heart glycosides (cardenolides; 5% in seeds): **thevetin A** and B, and peruvoside are the main compounds.

PHARMACOLOGY The cardenolides inhibit Na^+, K^+-ATPase, resulting in a disruption of signal transduction to the heart muscle cells.

TOXICOLOGY All parts of the plant are toxic but the seeds are extremely poisonous: four can be fatal in children, eight to 10 in adults.



Thevetia peruviana (Pers.) K. Schum. (Apocynaceae); *arbre à lait, laurier jaune* (French); *Gelber Oleander, Gelber Schellenbaum* (German); *oleandro giallo* (Italian)

Thuja occidentalis

American arbor-vitae • white cedar

CLASSIFICATION Cell toxin, neurotoxin, mind-altering (Ib). TM: North America.

USES & PROPERTIES The flattened branches with scale leaves (*Thujae summitates*) or the essential oil (*Thujae aetheroleum*) are traditionally used to treat fever, colds, bronchitis, cystitis, rheumatism and headaches (formerly to induce abortion). Extracts and ointments are used to treat warts, skin rashes, rheumatic pain and neuralgia.

ORIGIN North America. A popular garden tree.

BOTANY Evergreen tree (to 20 m); branches flattened; leaves minute, scale-like; cones small. *T. orientalis* (photo below) is chemically similar.

CHEMISTRY Essential oil with up to 65% thujone (both **α-thujone** and β-thujone); also polysaccharides, sesquiterpenes and flavonoids.

PHARMACOLOGY A traditional decongestant and diuretic, thought to have immune-stimulant activity. Thujone is a cumulative neurotoxin.

TOXICOLOGY Chronic use of thujone may lead to hallucinations, depression and epileptic seizures. α-Thujone: LD_{50} = 87.5 mg/kg (mouse, s.c.).

Thuja occidentalis L. (Cupressaceae); *thuya d'occident, thuya américain* (French); *Abendländischer Lebensbaum* (German); *thuja* (Italian); *tuya* (Spanish)

Thymus vulgaris

thyme • garden thyme

CLASSIFICATION TM: Europe, Africa. Comm. E+, ESCOP 1, WHO 1, 5, PhEur8, HMPC.

USES & PROPERTIES Dried leaves and flowers (*Thymi herba*) and volatile oil (*Thymi aetheroleum*) are used against respiratory ailments (coughs, colds, bronchitis) and digestive disturbances (upset stomach, stomach cramps, lack of appetite). Tea made from 1–4 g is taken several times a day. Extracts are gargled for sore throat or mucosal infections of the mouth and can be applied to the skin to treat minor wounds and rashes. The oil or extracts are used in commercial products.

ORIGIN Europe. Spanish thyme (*T. zygis*) is an acceptable alternative; also other species (grown in herb gardens) are used in traditional medicine.

BOTANY Perennial shrublet (to 0.3 m); leaves opposite, greyish green; flowers pale to dark violet.

CHEMISTRY Essential oil with **thymol** (to 50%) and carvacrol; rosmarinic acid; flavonoids.

PHARMACOLOGY Oil (and thymol) is antibiotic; also expectorant and spasmolytic.

TOXICOLOGY Safe in small doses (culinary herb).

Thymus vulgaris L. (Lamiaceae); *thym* (French); *Echter Thymian* (German); *timo* (Italian); *tomillo* (Spanish)

Tilia cordata

lime • linden

CLASSIFICATION TM: Europe. Pharm., Comm. E+, WHO 5, PhEur8, HMPC.

USES & PROPERTIES Dried flowers with the bracts (*Tiliae flos*) are traditionally used as herbal tea, mainly to treat coughs, colds and fever but also influenza, sore throat, bronchitis, digestive ailments, nausea, hysteria and palpitations. Externally it is used against itchy skin problems. The daily dose is 2–4 g. The herb or extracts (also from the sapwood) are included in commercial products.

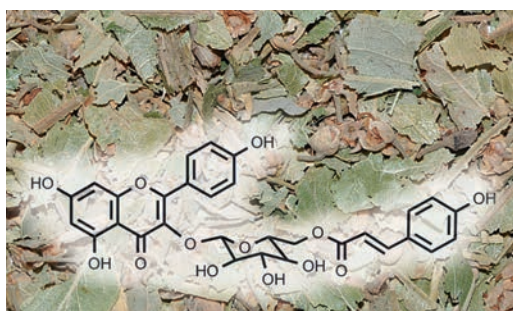
ORIGIN Europe. Large-leaved lime (*T. platyphyllos*) is an alternative source. Both are garden trees.

BOTANY Deciduous tree (to 30 m); leaves heart-shaped; flowers subtended by a large bract.

CHEMISTRY Rich in mucilage (arabino-galactans, 10%), proanthocyanidins, gallocathechins, phenolic acids and flavonoids (e.g. quercetin glycosides and **tiliroside**, a coumaric acid ester).

PHARMACOLOGY Diaphoretic activity; also mild sedative, antispasmodic, emollient, antioxidant, diuretic and astringent.

TOXICOLOGY No side effects are known.



Tilia cordata Mill. [Malvaceae (formerly Tiliaceae)]; *tilleul à petites feuilles* (French); *Winterlinde* (German); *tiglio* (Italian)

Trifolium pratense

red clover

CLASSIFICATION TM: Europe, Asia. DS: phytoestrogens.

USES & PROPERTIES Flowering aboveground parts (*Trifolii pratensis flos*) are used in Ayurvedic medicine as expectorant, antispasmodic and anti-inflammatory medicine. It is used to extract isoflavones, marketed as dietary supplements and as an alternative to hormone replacement therapy. It is used to treat menopausal symptoms and is claimed to prevent cancer and osteoporosis.

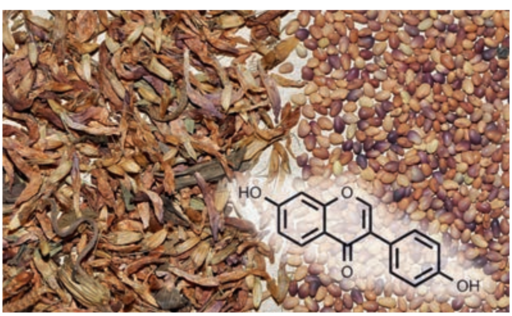
ORIGIN Europe and Asia. A cultivated pasture and common weed in many parts of the world.

BOTANY Short-lived perennial herb (to 0.8 m); leaves trifoliate, with pale marks; flowers pink.

CHEMISTRY Isoflavones: mainly **formononetin** and biochanin A, with some genistein and daidzein. Also cyanogenic glucosides and salicylic acid.

PHARMACOLOGY Isoflavonoids can mimic the effects of endogenous oestrogens. Medical claims are not unambiguously supported by clinical data.

TOXICOLOGY Non-toxic when used in small doses but side effects are possible in cancer patients.



Trifolium pratense L. (Fabaceae); *trèfle commun* (French); *Rotklee*, *Wiesenklee* (German); *trifoglio* (Italian)

Trigonella foenum-graecum

fenugreek

CLASSIFICATION TM: Africa, Europe, Asia. Pharm., Comm.E+, WHO 3, PhEur8, HMPC, clinical studies+. DS: functional food.

USES & PROPERTIES Ripe, dried seeds (*Foenugraeci semen*) are used as a digestive tonic for loss of appetite, anorexia and weight loss. Daily dose: 3–18 g. Functional food, used in supportive treatment of high cholesterol and diabetes. Seeds are applied as poultice, oils or ointments for relief of boils, ulcers, eczema and inflamed skin. The seeds and leaves have many uses as food and spice.

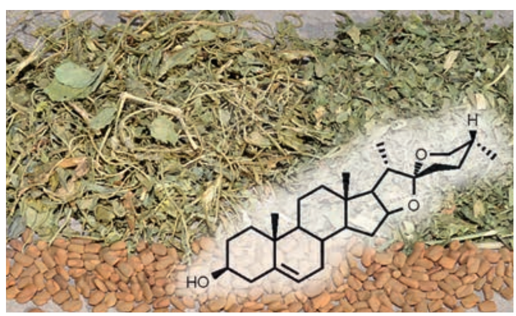
ORIGIN Mediterranean region, North Africa and western Asia. Cultivated as a crop since antiquity.

BOTANY Annual herb (to 0.5 m); leaves trifoliate; flowers white; fruit a many-seeded, pointed pod.

CHEMISTRY Mucilage (to 45%, galactomannans); proteins (to 30%); steroidal saponins (glycosides of **diosgenin** and yamogenin); alkaloids; peptides.

PHARMACOLOGY Hypoglycaemic and cholesterol-lowering effects supported by clinical studies (also expectorant, anti-inflammatory, uterotonic).

TOXICOLOGY Non-toxic (edible).



Trigonella foenum-graecum L. (Fabaceae); *fénugrec* (French); *Griechischer Bockshornklee* (German); *fieno-greco* (Italian): *fenugreco* (Spanish)

Tropaeolum majus

nasturtium

CLASSIFICATION TM: Central and South America, Europe. Comm.E+. DS: functional food.

USES & PROPERTIES Fresh or dried leaves (*Tropaeoli herba*) are traditionally used as a natural antibiotic to help clear up infections of the respiratory and urinary tracts. Leaves can also be applied in the form of a poultice as a counter-irritant in case of rheumatic or muscular pain and to treat candida and other fungal infections.

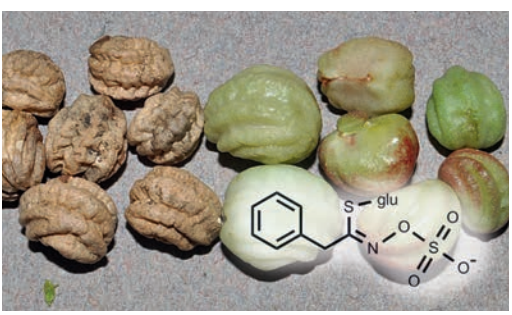
ORIGIN South America (Peru). Nasturtium is a popular garden plant, grown for its edible flowers.

BOTANY Spreading perennial (to 1.5 m); stems fleshy; leaves peltate; flowers large, with a distinctive nectar spur; seeds round, fleshy.

CHEMISTRY The main active compound is benzyl isothiocyanate (= benzyl mustard oil). It is formed through enzymatic hydrolysis from **glucotropaeolin** (= benzyl glucosinolate) in the intact plant.

PHARMACOLOGY Mustard oils bind to proteins, hence their antiviral, antifungal and antibacterial activities. Benzyl mustard oil is a severe irritant.

TOXICOLOGY All parts are edible (used in salads).



Tropaeolum majus L. (Tropaeolaceae); *capucine grande*, *cresson d'Inde* (French); *Große Kapuzinerkresse* (German); *nasturzio* (Italian)

Turnera diffusa

damiana

CLASSIFICATION Cell toxin, stimulant (III). TM: Central America. Pharm.

USES & PROPERTIES Dried leaves (*Damianae folium*) are used since the time of the Mayas as stimulant, general tonic and aphrodisiac. An infusion of 2–4 g of dry leaves is taken 3 × per day to counteract stress, depression and fatigue, with putative benefits in impotence, loss of libido, prostate problems and menstrual disturbances. Leaves can be smoked with effects similar to marijuana. Extracts are used in urinary products and tonics.

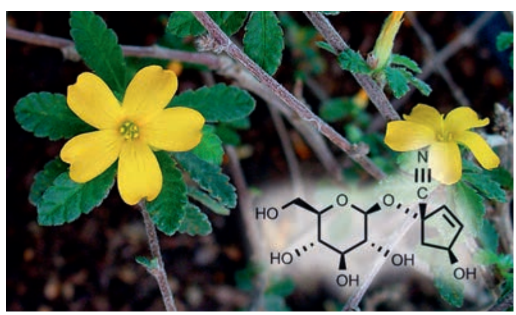
ORIGIN Tropical America (Mexico, southern California and the Caribbean Islands).

BOTANY Aromatic shrub (to 2 m); leaves small, prominently veined; flowers yellow.

CHEMISTRY Cyanogenic glucoside (**tetraphyllin B**); arbutin (0.7%); essential oil with α-pinene, β-pinene, calamene, α-copaene and others.

PHARMACOLOGY The aphrodisiac use is claimed to be supported by animal studies but the tonic and euphoric activities are not yet explained.

TOXICOLOGY Poorly known (but used as tea).



Turnera diffusa Willd. [= *Damiana diffusa* var. *aphrodisiaca* (L.F. Ward.) Urb.] [Passifloraceae (formerly Turneraceae)]; *damiana* (French); *Damiana* (German)

Tussilago farfara

coltsfoot

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (leaf only).

USES & PROPERTIES Dried leaves (*Farfarae folium*) are traditionally used to treat cough, inflammation of the mouth and throat, asthma and bronchitis. A tea is made from 0.6–2.5 g of the herb, taken 3 × per day. Tinctures and syrups can also be used and commercial cough syrups and teas are available.

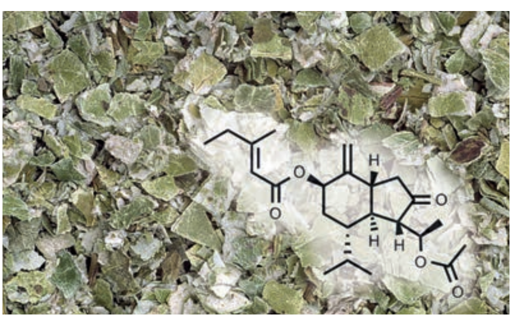
ORIGIN Asia, Europe and North Africa.

BOTANY Deciduous herb; leaves white-hairy below; flower heads yellow, emerging before leaves.

CHEMISTRY Mucilage (10%); **tussilagone** (a sesquiterpene ester); trace amounts of pyrrolizidine alkaloids (PAs) such as senkirkine and tussilagine.

PHARMACOLOGY Experiments showed that tussilagone is a respiratory stimulant. The mucilage forms a protective layer over inflamed mucosa, so that the urge to cough is suppressed.

TOXICOLOGY PAs are cumulative liver poisons but the levels are extremely low (0.01%). Safe limit: 1 µg of total PAs per day (length of treatment not to exceed six weeks per year).



Tussilago farfara L. (Asteraceae); *pas d'âne*, *tussilage* (French); *Huflattich* (German); *farfaro* (Italian); *farfara* (Spanish)

Uncaria tomentosa

cat's claw

CLASSIFICATION TM: Central and South America. Pharm., WHO 3 (*U. tomentosa*), WHO 4 (*U. rhynchophylla*).

USES & PROPERTIES The root (*Uncariae tomentosae radix*) or stem bark (*Uncariae tomentosae cortex*) is used as general tonic and panacea for a very wide range of ailments (including chronic fatigue syndrome, asthma, diabetes, arthritis, cancer, AIDS and many more). It is claimed to be an adaptogenic tonic and immune stimulant.

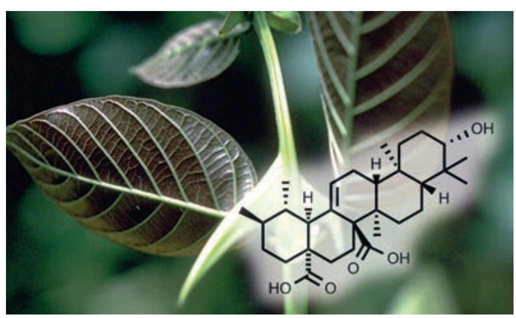
ORIGIN Tropical South and Central America. (*U. rhynchophylla* in Asia.)

BOTANY Woody climber (to 60 m); stems spiny; leaves opposite; flowers in rounded heads.

CHEMISTRY Monoterpene indole alkaloids (some with pentacyclic oxindoles, some with tetracyclic); triterpene saponins (glycosides of **quinovic acid**).

PHARMACOLOGY Immune-modulating, anti-inflammatory, antimutagenic, antioxidant and antiviral activities demonstrated *in vitro*. Clinical evidence for relief from rheumatoid arthritis.

TOXICOLOGY No serious side effects are known.



Uncaria tomentosa DC. (Rubiaceae); *Katzenkralle* (German); *uña de gato* (Spanish)

Urtica dioica

stinging nettle

CLASSIFICATION Cell toxin (III). TM: Europe. Comm.E+, ESCOP 2 (root), 4 (herb), WHO 2 (root), PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Aboveground parts (*Urticae herba*) are used to treat rheumatism (also urinary tract infections and kidney gravel). Roots (*Urticae radix*) are used to reduce the symptoms of benign prostate hyperplasia and urological ailments. The daily dose is 8–12 g (leaf) or 4–6 g (root).

ORIGIN Europe and Asia (weed in many countries).

BOTANY Perennial herb (to 1.5 m); leaves opposite, drooping; flowers small, in slender clusters. The annual *U. urens* (top right) is also used.

CHEMISTRY Leaves: silicic acid (5%), flavonol glycosides, phenolic acids. Roots: polysaccharides, a lectin (UDA), sitosterols and their glycosides.

PHARMACOLOGY Antioxidant phenolics in leaves: mild diuretic, analgesic and anti-inflammatory effects. Sitosterols explain the use of roots.

TOXICOLOGY Non-toxic. Stinging hairs on the leaves inject **histamine** and acetylcholine into the skin, causing extreme irritation and pain.

Urtica dioica L. (Urticaceae); *ortie brûlante* (French); *Große Brennnessel* (German); *ortica maschio* (Italian); *ortiga mayor* (Spanish)

Vaccinium macrocarpon

large cranberry • American cranberry

CLASSIFICATION TM: North America. WHO 4, ESCOP Suppl., clinical studies+. DS: fruits/juice.

USES & PROPERTIES Fruit juice or extracts are taken to treat urinary tract infections. Effective daily dose: 360–960 ml of juice, or 1–6 tablets of concentrated extract. As preventative supplement: 30–300 ml with at least 30% cranberry. Traditional uses include loss of appetite, scurvy, gastrointestinal ailments, asthma and fever.

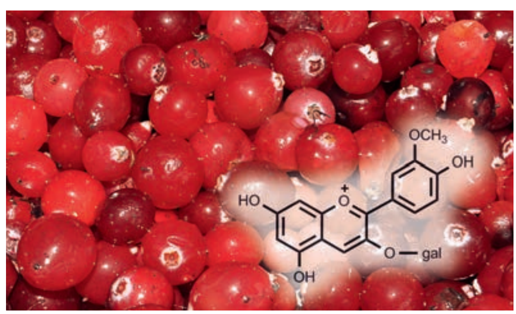
ORIGIN Eastern parts of North America. Small cranberry (*V. oxycoccus*): entire arctic region.

BOTANY Evergreen aquatic shrublet (to 0.15 m); leaves small; flowers pale pink; fruit an edible berry, 9–20 mm in diameter (*V. oxycoccus*: 6–8 mm).

CHEMISTRY Rich in organic acids (30%), polyphenols, condensed tannins, procyanidins, anthocyanins (mainly the **3-*O*-galactoside of peonidin** and delphinidin; 3-*O*-glucosides in *V. oxycoccus*).

PHARMACOLOGY Bacteriostatic, diuretic; prevents bacteria from adhering to the wall of the urinary tract. Efficacy has been proven by clinical studies.

TOXICOLOGY Edible (but note drug interactions).



Vaccinium macrocarpon Ait. (Ericaceae); *da guo yue jie* (Chinese); *airelle à gros fruits* (French); *Großfrüchtige Moosbeere* (German); *mirtillo palustre* (Italian)

Vaccinium myrtillus

bilberry

CLASSIFICATION TM: Europe, North America. Comm. E+, WHO 4, PhEur8. DS: dry fruits.

USES & PROPERTIES Dried, ripe berries (*Myrtilli fructus*) are mainly used to treat diarrhoea in children, as well as inflammation of the mouth and throat. Daily dose: 20–60 g of dried berries. The fruits and leaves have many traditional uses.

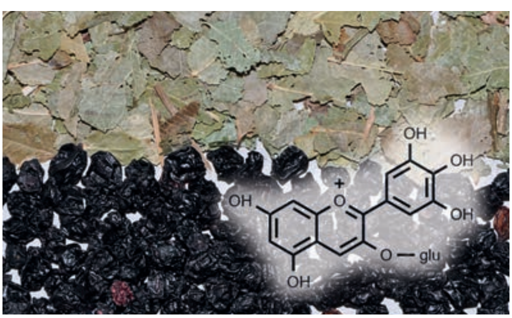
ORIGIN Europe, Asia and North America. The American blueberry (highbush blueberry) is *V. corymbosum* (much lower levels of anthocyanins).

BOTANY Shrublet (to 0.8 m); stems angular; flowers small, white; fruit a bluish black berry, 6 mm in diameter (to 12 mm in *V. corymbosum*).

CHEMISTRY Anthocyanins (7.5%), mainly **myrtillin** (= delphinidin 3-*O*-glucoside). *V. corymbosa*: malvidin/petunidin. Also condensed tannins (12%); proanthocyanidins; flavonoids; iridoid glucosides.

PHARMACOLOGY Antidiarrhoeal activity, ascribed to the tannins. Lipid-lowering and hypoglycaemic effects have been demonstrated (also antimicrobial, venotonic, wound-healing, antioxidant).

TOXICOLOGY Edible (even in large amounts).



Vaccinium myrtillus L. (Ericaceae); *airelle myrtille* (French); *Heidelbeere*, *Blaubeere* (Germany); *mirtillo* (Italian); *arandano commun* (Spanish)

Vaccinium vitis-idaea

cowberry • lingonberry

CLASSIFICATION TM: Europe, Asia, North America. DS: fruits and fruit juice.

USES & PROPERTIES Ripe fruits, fruit extracts or fruit juice are used as dietary supplements to prevent oxidative stress and reduce the risk of cardiovascular diseases. Leaves are traditionally used as diuretic and urinary tract antiseptic.

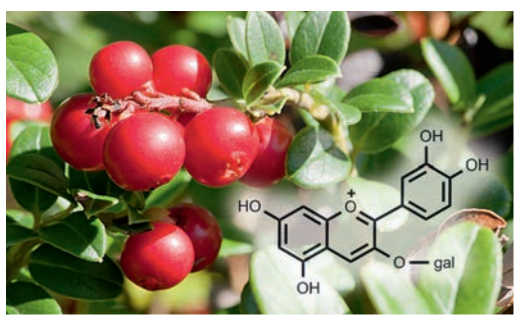
ORIGIN Europe, Asia and North America.

BOTANY Mat-forming evergreen shrublet; leaves glossy; flowers white, waxy; fruit a red berry, 6–8 mm in diameter.

CHEMISTRY Fruits are rich in anthocyanins (mainly **cyanidin 3-*O*-galactoside**). Also vitamin C (22 mg per 100 g), minerals and organic acids. Leaves have high levels of tannins and anthocyanins.

PHARMACOLOGY A human study showed that the cyanidin galactoside (partly metabolised) is excreted in urine 4–8 hours after ingestion. Anthocyanins have antioxidant and radical-scavenging activities. Indications of anti-inflammatory, anti-obesity and antidiabetic effects.

TOXICOLOGY The fruits are non-toxic (edible).



***Vaccinium vitis-idaea* L.** (Ericaceae); *airelle rouge, myrtille rouge* (French); *Kronsbeeren, Preiselbeere* (German); *mirtillo rosso* (Italian)

Valeriana officinalis

valerian • common valerian

CLASSIFICATION Cell toxin, mind-altering (III). TM: Europe. Comm.E+, ESCOP 4, WHO 1; PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Rhizomes and roots (*Valerianae radix*) are important commercial sedatives and tranquillisers, used in many products to treat restlessness, anxiety, sleeplessness and the symptoms of menopause and premenstrual syndrome. Daily dose: 10 g (2–3 g, up to 5 × per day, as tea).

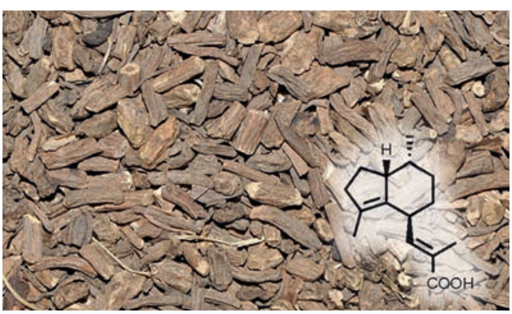
ORIGIN Europe, Asia (naturalised in N. America).

BOTANY Perennial herb (to 1.2 m); rhizomes and roots aromatic; leaves pinnate; flowers white.

CHEMISTRY Valepotriates (unusual iridoid derivatives, 0.5–2%): valtrate and didrovaltrate; cyclopentane sesquiterpenoids: **valerenic acid**; essential oil (mainly bornyl acetate).

PHARMACOLOGY Valerenic acid and the essential oil are sedative, valtrate is thymoleptic and didrovaltrate is tranquillising. Clinical studies indicate efficacy against minor nervous conditions.

TOXICOLOGY Valepotriates are potentially mutagenic, so that infusions are safer than tinctures.



Valeriana officinalis L. (Valerianaceae); *valériane officinale* (French); *Gemeiner Baldrian*, *Arzneibaldrian* (German); *valeriana* (Italian)

Vanilla planifolia

vanilla

CLASSIFICATION TM: Central and South America, Europe.

USES & PROPERTIES Cured vanilla pods ("beans") were originally used as flavour ingredient of chocolate, with the reputation of having aphrodisiac properties and inducing a feeling of well-being. Vanilla is widely used in the food and beverage industries and also to mask unpleasant odours and tastes in medicines and cough syrups.

ORIGIN Central America (mainly Mexico).

BOTANY Climber (vine) (to 3 m); leaves simple, fleshy; flower greenish yellow; fruit a capsule with thousands of minute black seeds.

CHEMISTRY **Vanillin** (2%) is the main flavour compound, enzymatically released from a glucoside (vanilloside) when the fruits are cured.

PHARMACOLOGY Vanillin has demonstrated antimutagenic, chemopreventative, antimicrobial, antioxidant and anti-inflammatory activities. It shows potential for use against sickle-cell anaemia and inflammatory bowel disease.

TOXICOLOGY Allergic reactions (but very rare).

Vanilla planifolia Andr. (Orchidaceae); *vanille* (French); *Echte Vanille* (German); *vaniglia* (Italian); *vainilla* (Spanish)

Veratrum album

white hellebore • false hellebore

CLASSIFICATION Cell toxin, neurotoxin, extremely hazardous (Ia). TM: Europe, Asia.

USES & PROPERTIES All plant parts of this and related species are extremely poisonous and have been used since ancient times for murder and suicide, but also to treat gout, rheumatism and neuralgic pains. It was once an ingredient of sneezing powders and was used to kill lice, insects and rats.

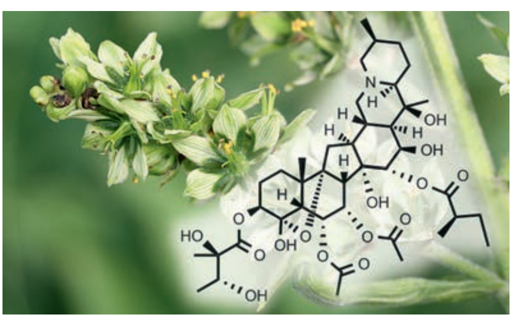
ORIGIN Europe and Asia. Grown in gardens.

BOTANY Perennial herb; leaves broad, whorled, pleated; flowers green and white.

CHEMISTRY Steroidal (triterpenoid) alkaloids: **protoveratrine B** is a main compound, together with protoveratrine A, germerine and cyclopamine. The original source of resveratrol (hence the name).

PHARMACOLOGY The alkaloids are very toxic (they affect Na^+-channels), with mutagenic, emetic, analgesic and antirheumatic activities. They are lipophilic (easily absorbed, even through the skin).

TOXICOLOGY The lethal dose in humans is 20 mg of protoveratrine B (or 1–2 g of the dry rhizome). Cyclopamine causes malformations in animals.



Veratrum album L. (Melanthiaceae); *vérâtre blanc* (French); *Weißer Germer* (German); *veratro bianco* (Italian); *vedegambre*, *eléboro blanco* (Spanish)

Verbascum phlomoides

mullein • orange mullein

CLASSIFICATION TM: Europe. Pharm., Comm. E+ (flowers only), PhEur8, HMPC.

USES & PROPERTIES Dried flowers (petals with stamens; *Verbasci flos*) are used against catarrh of the respiratory tract (cough, bronchitis and influenza). It is a traditional diuretic and diaphoretic, taken as tea (1 g in 150 ml water), 3–4 × per day. Extracts are used in cough syrups and ointments to treat sores, boils, earache and haemorrhoids.

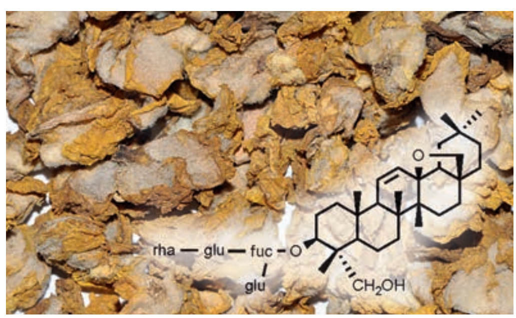
ORIGIN Europe, western Asia and North Africa. *V. densiflorum* and *V. thapsus* are also used.

BOTANY Biennial herb; leaves in a robust rosette; flowers yellow, in a large panicle (to 2 m).

CHEMISTRY Triterpene saponins (including **verbascosaponin**); mucilage (3%); iridoid glucosides (aucubin, catalpol); flavonoids (kaempferol, rutin).

PHARMACOLOGY Secretolytic and expectorant activity (saponins); demulcent and soothing effects on skin and mucosa (mucilage); weak diuretic activity (flavonoids); anti-inflammatory properties (iridoid glucosides).

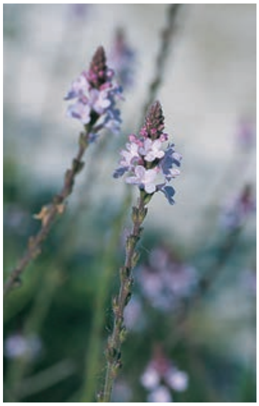
TOXICOLOGY No side effects are known.



Verbascum phlomoides L. (Scrophulariaceae); *molène faux-phlomis* (French); *Filz-Königskerze* (German); *barbarasco* (Italian)

Verbena officinalis

vervain



CLASSIFICATION TM: Europe, Asia. Pharm., Comm.E–.

USES & PROPERTIES Aboveground parts, collected while flowering (*Verbenae herba*) are traditionally used as diuretic and bitter tonics to treat fever, chronic bronchitis and rheumatism. Vervain herb is externally applied to slow-healing wounds. The recommended dose is 1.5 g of the dry herb, prepared as tea (3–4 g per day).

ORIGIN North temperate region (Europe, Asia, North Africa and North America).

BOTANY Perennial herb (to 1 m); leaves widely spaced, opposite; flowers small, lilac, in spikes.

CHEMISTRY Iridoid glucosides (0.2–0.5%): mainly **verbenalin** (= cornin) and hastatoside. Caffeic acid derivatives: verbascoside.

PHARMACOLOGY The herb is a traditional diuretic, expectorant, galactogogue and antirheumatic but there is limited data. Verbenalin is thought to have antitussive and sleep-promoting activity. The iridoids are anti-inflammatory and analgesic.

TOXICOLOGY There are no known side effects.

Verbena officinalis L. (Verbenaceae); *ma bian cao* (Chinese); *verveine officinelle* (French); *Eisenkraut* (German); *verbena commune* (Italian)

Vinca minor

periwinkle • lesser periwinkle

CLASSIFICATION Cell toxin (II). TM: Europe (now obsolete). MM: source of alkaloids.

USES & PROPERTIES Leaves (*Vincae minoris folium*) were once used in traditional medicine but are now a source of raw material for alkaloid extraction. The alkaloids are given orally (as prescription medicine, 40–60 mg per day) to stimulate cerebral circulation and to treat senility, memory loss and other cerebrovascular disorders.

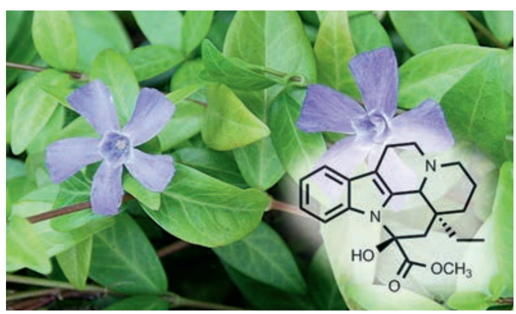
ORIGIN Europe. A popular garden plant.

BOTANY Small, herbaceous perennial with milky latex; stems trailing; leaves opposite; flowers blue.

CHEMISTRY Numerous monoterpene indole alkaloids (1–4%), mainly **vincamine** (10%) which is nowadays synthesised from tabersonine (a seed alkaloid from African *Voacanga africana*).

PHARMACOLOGY Human studies showed that vincamine reduces blood pressure and stimulates blood flow to the brain.

TOXICOLOGY The herb is potentially toxic and is not suitable for self-medication. Side effects include leukocytopaenia and lymphocytopaenia.



Vinca minor L. (Apocynaceae); *petite pervenche* (French); *Kleines Immergrün* (German); *pervinca minore* (Italian); *hierba doncella* (Spanish)

Viola tricolor

wild pansy • heartsease

CLASSIFICATION TM: Europe. Comm. E+, ESCOP Suppl., PhEur8, HMPC.

USES & PROPERTIES Dried aboveground parts (*Violae tricoloris herba*) are used in supportive treatment of mild seborrhoeic skin conditions (scaly, flaky, itchy and red skin), eczema, pruritus, acne and impetigo. Tea made from 1.5–3 g is taken 3 × per day (4 g in 150 ml for external use). Included in commercial antitussives, cholagogues, roborants, tonics and dermatological remedies.

ORIGIN Europe and Asia. Also cultivated.

BOTANY Annual or short-lived perennial herb; leaves stipulate; flowers typically three-coloured.

CHEMISTRY Salicylic acid derivatives (**methyl salicylate** and violutoside); organic acids, flavonoids, anthocyanins, saponins, tannins and mucilage.

PHARMACOLOGY Methyl salicylate, saponins, flavonoids and mucilage may contribute to the antimicrobial and anti-inflammatory effects. Traditional uses also indicate expectorant, diaphoretic, antirheumatic and diuretic activities.

TOXICOLOGY There are no safety concerns.

Viola tricolor L. (Violaceae); *pensée sauvage* (French); *Feldstiefmütterchen* (German); *viola del pensiero* (Italian)

Viscum album

mistletoe • European mistletoe

CLASSIFICATION Cell toxin (II). TM: Europe. Pharm., Comm.E+. MM: source of extracts for injection; clinical studies+.

USES & PROPERTIES The fresh or dried herb (*Visci herba*) or leaves only (*Visci folium*) are a traditional adjuvant in treating hypertension, vertigo and cephalic congestion. An infusion of 2.5 g is taken 1–2 × per day. This use should be distinguished from parenteral use: special extracts are injected to treat degenerative inflammation of joints and as palliative therapy for malignant tumours.

ORIGIN Europe and Asia.

BOTANY Semi-parasitic woody shrub; leaves leathery, yellowish; flowers small; fruit a white drupe.

CHEMISTRY Numerous lectins (0.1%); polypeptides (called viscotoxins); polysaccharides.

PHARMACOLOGY When injected: cytostatic and cytotoxic at high doses, with non-specific immune stimulation at low doses (ascribed to the lectins and partly also to the polysaccharides).

TOXICOLOGY Not suitable for self-medication. Necrosis and other serious side effects may occur.

Viscum album L. [Santalaceae (formerly Viscaceae)]; *gui blanc* (French); *Mistel* (German); *vischio* (Italian); *muérdago* (Spanish)

Visnaga daucoides

visnaga • khella

CLASSIFICATION TM: Europe, Africa. Pharm., Comm.E– (withdrawn in 1994), WHO 3.

USES & PROPERTIES The ripe fruits (*Ammi visnagae fructus*) or more often standardised extracts are used as preventive treatment of asthma, spastic bronchitis and *angina pectoris*. Infusions of the fruits (0.5 g) are rarely used in traditional medicine for colic and as diuretic to treat kidney ailments.

ORIGIN Mediterranean region.

BOTANY Erect annual herb (to 1.5 m); leaves feathery; flowers small; fruit a small dry schizocarp, borne on persistent rays. The species is usually included in the genus *Ammi* (as *A. visnaga*).

CHEMISTRY Furanocoumarins (khellin, visnagin) and pyranocoumarins (**visnadin**, samidin).

PHARMACOLOGY Visnadin is a strong vasodilator; khellin and visnagin are antispasmodic. Extracts act as muscle relaxants with antispasmodic, vasodilatory and anti-asthmatic activity.

TOXICOLOGY Visnaga is no longer considered to be safe. Side effects include pseudo-allergic reactions, reversible liver ailments and insomnia.

Visnaga daucoides Gaertn. or ***Ammi visnaga*** (L.) Lam. (Apiaceae); *khella* (Arabian); *herbe aux cure-dents* (French); *Khellakraut*, *Bischofskraut* (German); *visnaga* (Italian)

Vitex agnus-castus

chaste tree

CLASSIFICATION TM: Europe. Comm.E+, WHO 4, PhEur8, HMPC, clinical studies+.

USES & PROPERTIES Ripe, dried fruits (chaste tree fruit; *Agni casti fructus*) are traditionally used as an anaphrodisiac (hence the name “monk’s pepper”). Nowadays they are used for gynaecological, menstrual and menopausal disorders. In homoeopathy, for depression, impotence and hypogalactia (inadequate lactation). The daily dose is up to 3 g.

ORIGIN Europe and Asia (Mediterranean).

BOTANY Shrub (to 5 m); leaves digitate; flowers lilac, blue (white); fruit a small, 4-seeded berry.

CHEMISTRY Diterpenes (**vitexilactone**, rotundifurane); iridoid glucosides (casticin, penduletin); flavonoids; essential oil (1,8-cineole, limonene).

PHARMACOLOGY The diterpenes indirectly inhibit prolactin secretion. Clinical studies support the use of standardised extracts for symptomatic relief of premenstrual stress syndrome, dysmenorrhoea, *corpus luteum* deficiency and mastalgia.

TOXICOLOGY Non-toxic but some side effects have been reported, such as skin rashes.

Vitex agnus-castus L. [Lamiaceae (formerly Verbenaceae)]; *gattilier agneau-chaste* (French); *Mönchspfeffer* (German); *agnocasto* (Italian)

Vitis vinifera

grape vine

CLASSIFICATION Cell toxin, mind-altering (III). TM: Europe. ESCOP Suppl., HMPC. DS: grape seed oil, resveratrol.

USES & PROPERTIES Ripe seeds are extracted for grape seed oil, used as antioxidant and venotonic. Leaves have been used against diarrhoea, poor circulation and bleeding. Skins of red grapes are a source of resveratrol. Red wine has health benefits when used in moderation (the French paradox).

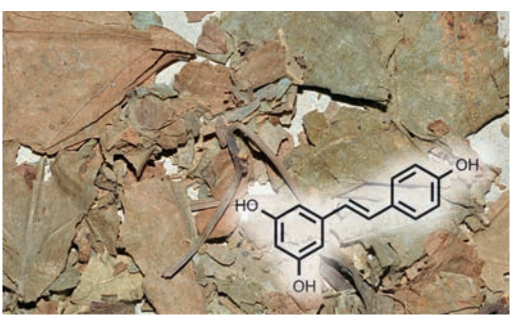
ORIGIN Mediterranean region. Widely cultivated.

BOTANY Deciduous woody climber; stems with tendrils; leaves lobed; flowers small; fruit a berry.

CHEMISTRY Oligomeric proanthocyanidins (pycnogenols) in seeds (80–85%); glucose (20%) and alcohol (to 14%) when fermented; **resveratrol** (to 4%); anthocyanins (cyanidin and petunidin).

PHARMACOLOGY Seed oil and anthocyanins are antioxidant (free-radical scavenging), antimutagenic and reduce capillary fragility. Resveratrol is active *in vitro* (but clinical evidence is lacking).

TOXICOLOGY The lethal dose of ethanol is 5–8 g/kg body weight in adults and 3 g/kg in children.



Vitis vinifera L. (Vitaceae); *vigne* (French); *Weinrebe* (German); *vite* (Italian)

Warburgia salutaris

pepperbark tree

CLASSIFICATION TM: Africa. AHP.

USES & PROPERTIES The stem bark (or nowadays also the leaves) are used as a general tonic and panacea to treat coughs, colds, bronchitis and oral thrush (traditionally for headache, influenza, rheumatism, malaria, venereal diseases, chest complaints, gastric ulcers and toothache). Leaves and bark have a sharp peppery taste. Traditionally, cold water infusions were taken as expectorants or powdered bark smoked to treat coughs and colds. Tablets (200 mg of leaf powder) are available.

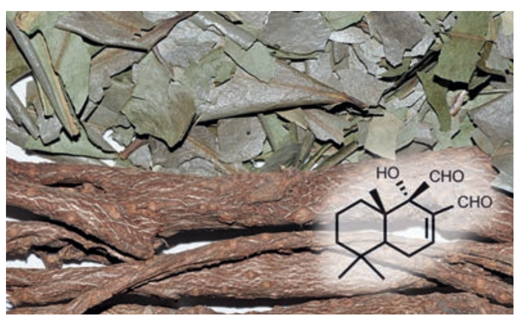
ORIGIN Africa. Trees have been over-exploited for bark but are grown on a small commercial scale.

BOTANY Evergreen tree (to 10 m); leaves glossy; flowers green; fruit a green to black berry.

CHEMISTRY Several drimane sesquiterpenoids (**warburganal**, polygodial); also mannitol.

PHARMACOLOGY Warburganal and other reactive dialdehydes have demonstrated antibacterial and anti-ulcer activities. Mannitol is diuretic and has been used as a sweetener for diabetics.

TOXICOLOGY No serious side effects are known.



Warburgia salutaris (Bertol.f.) Chiov. (Canellaceae); *isibhaha* (Zulu); *warburgia* (French); *Warburgia*, *Pfefferrindenbaum* (German); *warburgia* (Italian)

Withania somnifera

winter cherry • ashwagandha

CLASSIFICATION Cell toxin, mind-altering (III). TM: Asia (India), Africa. Pharm., WHO 4, HMPC, clinical studies+.

USES & PROPERTIES The roots (often called "Indian ginseng") are an important general tonic and adaptogen in Ayurvedic medicine, used for a wide range of ailments, including stress and fatigue. The leaves are used topically for wound healing.

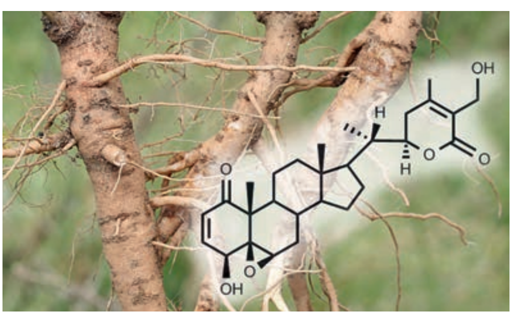
ORIGIN Africa, southeastern Europe and Asia.

BOTANY Shrublet (to 1 m); roots fleshy; leaves velvety; fruit a red berry, enclosed in a papery calyx.

CHEMISTRY Free steroids of the ergostane type, the so-called withanolides: **withaferin A** is a major compound. Also alkaloids (withasomnine).

PHARMACOLOGY The withanolides are linked to anti-inflammatory, antibiotic, immunomodulating, cytotoxic, antitumour and cholesterol-lowering activities. The alkaloids are sedative and hypnotic. Clinical studies showed efficacy in treating physical and psychological stress.

TOXICOLOGY Existing data indicate very low oral toxicity. No serious side effects are known.



Withania somnifera (L.) Dunal (Solanaceae); *withania* (French); *Schlafbeere*, *Withania* (German); *ashwagandha* (Hindi); *witania*, *ginseng indiano* (Italian)

Xysmalobium undulatum

uzara • milk bush

CLASSIFICATION Cell toxin (Ib). TM: Africa (South Africa), Comm.E+.

USES & PROPERTIES Dried roots (*Uzarae radix*) are used mainly to treat non-specific acute diarrhoea. An initial dose of 1 g (75 mg of total glycosides) is followed by 45–90 mg of glycosides per day. Many traditional uses have been recorded, including diarrhoea, colic, stomach cramps, headache, dysmenorrhoea and as diuretic for oedema. Powdered root is applied to treat wounds.

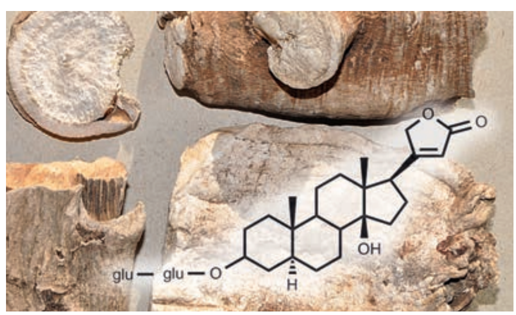
ORIGIN Southern Africa. Cultivated since 1904.

BOTANY Deciduous perennial herb with milky latex; leaves opposite; flowers yellowish brown; fruit an inflated capsule; seeds with long hairs.

CHEMISTRY Cardiac glycosides: **uzarin** (a glycoside of uzarigenin) is the main compound.

PHARMACOLOGY Uzarin stops diarrhoea by a spasmolytic effect on visceral smooth muscles, thus inhibiting intestinal mobility.

TOXICOLOGY Uzarin-type glycosides have a low oral toxicity but can be lethal when injected. Persistent diarrhoea requires medical intervention.



Xysmalobium undulatum R. Br. [Apocynaceae formerly Asclepiadaceae)]; *ishongwe* (Zulu); *uzara* (French); *Uzara* (German); *uzara* (Italian)

Zingiber officinale

ginger

CLASSIFICATION TM: Asia, Europe. Comm.E+, ESCOP 1, WHO 1, PhEur8, HMPC., clinical trials+. DS: anti-emetic.

USES & PROPERTIES The fresh or dried rhizome (*Zingiberis rhizoma*) is used to treat post-operative nausea and travel sickness. Daily dose: 2–4 g. Widely used (e.g. Ayurveda, TCM) for many ailments, including nausea, colic, stomach pain, fever and coughs. Ginger is an important spice.

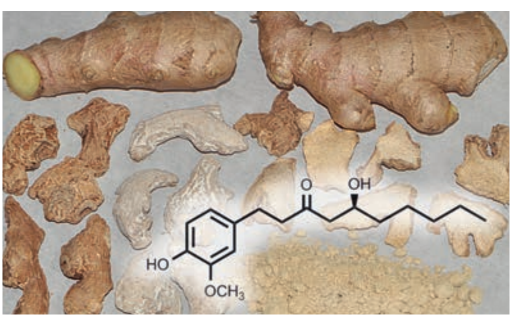
ORIGIN Asia. Probably an ancient Indian cultigen.

BOTANY Perennial herb (to 1 m) with branched rhizomes; leaves large; flowers yellow and purple.

CHEMISTRY Diterpene lactones (galanolactone); sesquiterpenes (zingiberene, curcumene); pungent gingerols: gingerol (= **6-gingerol**), the main compound; essential oil (camphene, β-phellandrene).

PHARMACOLOGY Clinical studies support the anti-emetic use. Also: anti-inflammatory, anti-microbial, antiparasitic, hypoglycaemic, cholesterol-lowering, immunomodulating, carminative, cholagogic, anti-ulcerogenic, antispasmodic and antioxidant.

TOXICOLOGY Ginger is edible and safe to use.



Zingiber officinale Roscoe (Zingiberaceae); *gingembre* (French); *Ingwer* (German); *zenzero* (Italian); *jengibre* (Spanish)

Ziziphus jujuba

Chinese date • jujube tree

CLASSIFICATION Mind-altering. TM: Asia (China). WHO 3. DS: functional food.

USES & PROPERTIES The ripe fruit, fresh or dried (*Jujubae fructus*), is a functional food and general tonic in China, eaten to improve health, to gain weight and to treat upper respiratory tract infections and allergies. Seeds are used to treat insomnia and nervous conditions. Chinese dates are a popular snack and health food in many countries.

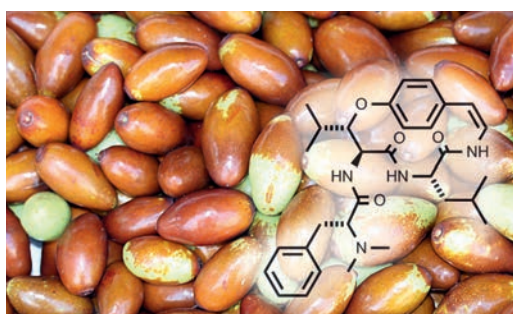
ORIGIN Europe and Asia. A fruit crop in China.

BOTANY Shrub or small tree (to 6 m); stems spiny; leaves glossy; flowers yellowish; fruit a drupe.

CHEMISTRY Seeds: peptide alkaloids: **frangufoline** (= sanjoinine A) is the main compound. Fruit pulp: triterpenoid saponins, flavonoids and mucilage.

PHARMACOLOGY The cyclopeptide alkaloids (especially frangufoline) have strong sedative and hypnotic effects. Mucilage is demulcent while the saponins are secretolytic. Fruits seem to act as a tonic by strengthening the immune system, increasing endurance and improving liver function.

TOXICOLOGY Fruits are non-toxic and nutritious.



Ziziphus jujuba Mill. [= *Z. vulgaris* Lam.] (Rhamnaceae); *jujubier* (French); *Jujube*, *Brustbeerbaum* (German); *giuggiolo comune* (Italian)

Glossary of botanical, chemical, medical, pharmacological and toxicological terms

Abiotic: not associated with living organisms
Abortifacient: a substance that causes abortion
Absolute lethal concentration (LC_{100}): lowest concentration of a substance that kills 100% of test organisms or species under defined conditions; this value is dependent on the number of individuals used in its assessment
Absorbed dose: amount of a substance absorbed into an organism or into organs and tissues of interest
Absorption: active or passive uptake of a substance through the skin or a mucous membrane; substances enter the bloodstream and are transported to other organs
Accepted risk: probability of suffering disease or injury which is accepted by an individual
Accidental exposure: unintended contact with a substance resulting from an accident
Accumulation: successive additions of a substance to a target organism, or organ, which leads to an increasing amount of the chemical in the organism or organ
ACE: angiotensin converting enzyme; important target for the treatment of cardiac insufficiency
Acetylcholine: a neurotransmitter that binds to nicotinic (nACh-R) or muscarinic (mACh-R) receptors
Acetylcholine esterase inhibitor: a substance that inhibits acetylcholine esterase (AChE) and thus the breakdown of acetylcholine to acetate and choline
Acidosis: pathological condition in which the pH of body fluids is below normal and therefore the pH of blood falls below the reference value of 7.4
Acne: chronic skin condition resulting from the inflammation of sebaceous glands and hair follicles
Acute: a symptom or condition that appears suddenly (and lasts for a short period; minutes or hours)
Acute toxicity test: experimental animal study to determine which adverse effects occur in a short time (usually up to 14 days) after a single dose of a substance or after multiple doses given in up to 24 hours
Adaptogen: a substance with a non-specific action that causes improved resistance to physical and mental stress
Adaptogenic tonic: *see* Adaptogen
Addiction: physical or psychological dependence on a substance for the sake of relief, comfort, stimulation, or exhilaration; often with craving when the drug is absent
Additive: a substance that is added to a mixture (typically for taste, colour or texture)
Additivity: the effect of a combination of two or more individual substances is equivalent to the sum of the expected individual responses
Adduct: new chemical species AB, formed by direct combination of two separate molecular entities A and B
Adenocarcinoma: malignant tumour originating in glandular epithelium or forming recognisable glandular structures
Adenoma: an abnormal benign growth of glandular epithelial tissue
Adenylyl cyclase: enzyme of signal transduction; catalyses the formation of the second messenger cAMP from ATP
Adjuvant: a substance added to a mixture to modify the activity of the active ingredient in a predictable way
Administered dose: a defined quantity given orally or parenterally
Administration: application of a known amount of a chemical in a reproducible manner and by a defined route
Adrenalin: the hormone that binds to adrenergic receptors; causes the "fight or flight" response
Adrenergic (sympathomimetic): a substance that binds to adrenergic neuroreceptors and produces an effect similar to normal impulses (caused by adrenaline, noradrenaline) of the sympathetic nervous system; antagonists are sympatholytics
Adsorption: enrichment of substances on surfaces
Adulterant: an undesirable ingredient found in a commercial product
Adulteration: non-allowed substitution of a substance or materials in a drug or food by another, usually being inactive or toxic
Aesthenia (astenia): diminishing strength and energy; weakness
Aetheroleum: essential (volatile) oil
Aetiology: science dealing with the cause or origin of disease
Aglycone: the non-sugar part of a glycoside (after removal of the sugar part)
Agonist: substance that binds and activates a cellular receptor
AIDS: acquired immunodeficiency syndrome, a condition (weakened immune system) caused by HIV (a retrovirus)
Albuminuria: presence of albumin from blood plasma in the urine
Alcoholic extract: soluble fraction of plant material obtained after extraction with ethanol
Alkaloid: chemical substance containing nitrogen as part of a heterocyclic ring structure; often highly toxic or mind-altering
Alkylating agent: reactive secondary metabolite which introduces an alkyl substituent into DNA, proteins or other molecules; DNA alkylation can lead to mutations and cancer
Alkylation: reactive secondary metabolites forming covalent bonds with DNA and proteins
Allergen: an antigenic substance that triggers an allergic reaction (hypersensitivity)
Allergy: a hypersensitivity to allergens (often pollen or reactive secondary metabolite) that causes rhinitis, urticaria, asthma and contact dermatitis
Allopathy: a medicine system using substances that cause an effect different to those caused by the condition under treatment
Alopecia: loss of hair
Alzheimer's disease: *see* Dementia
Amarum: a bitter substance that stimulates the secretion of digestive juices
Ames test: *in vitro* test for mutagenicity using mutant strains of the bacterium *Salmonella typhimurium*. The test can be carried out in the presence of a given microsomal fraction (S-9) from rat liver to allow metabolic transformation of mutagen precursors to active derivatives
Amino acid: chemical substances that form the building blocks of proteins ("proteinogenic amino acids")
Amoebiasis: a (sub-)tropical protozoan infection with *Entamoeba histolytica*

Amoebicidal: a substance that kills amoebae
Anaemia (anemia): reduced number of red blood cells in the blood, often causing pallor and fatigue
Anaesthetic: a substance that causes localised or general loss of feeling or sensation; general anaesthetics produce loss of consciousness; local anaesthetics render a specific area insensible to pain
Analeptic: a substance that stimulates the central nervous system
Analgesic: a substance that relieves pain without loss of conscience
Anaphrodisiac: a substance that reduces sexual desire
Anaphylactic shock: a severe, life-threatening form of a general allergic reaction to an antigen or hapten to which a person has previously been sensitised
Aneuploid: missing or extra chromosomes or parts of chromosomes
Angina pectoris: severe pain in the chest
Anorectic: a substance that suppresses appetite
Anoxia: total absence of O_2; refers sometimes to a decreased oxygen supply in tissues
Antagonist: inhibitor at cellular receptors; blocks the activity of an endogenous ligand; reverses or reduces the effect modulated by an agonist
Anthelmintic: a substance that kills or expels intestinal worms
Anthraquinones: secondary metabolites with an anthracene skeleton; anthrones show strong laxative effects
Anthroposophic: a philosophy that links health to internal life force and energy
Anti-arrhythmic: a substance that counteracts irregular heartbeat
Anti-asthmatic: a substance that alleviates the spasms of asthma
Antibacterial: a substance that kills or inhibits the growth of bacteria
Antibiotic: a substance that kills or inhibits the growth of microorganisms
Antibody: specific protein produced by the immune system (an immunoglobulin molecule), which can bind specifically to an antigen or hapten which induced its synthesis
Anticholinergic: a substance that blocks the parasympathetic nerve impulse
Anticoagulant: a substance that prevents blood from clotting
Anticonvulsant: a substance that prevents or relieves convulsions
Antidepressant: a substance that alleviates depression
Antidiabetic: a substance that prevents or alleviates diabetes
Antidiuretic: a substance that prevents or slows urine formation
Antidote: a substance that counteracts the effect of a potentially toxic substance
Anti-emetic: a substance that prevents vomiting
Antifungal: a substance that kills or inhibits the growth of fungi
Antigen: substance which induces the immune system to produce a specific antibody or specific cells
Antihistamine: a substance that improves allergic symptoms by blocking the action of histamine
Antihydrotic: a substance that reduces perspiration
Antihypertensive: a substance that reduces high blood pressure
Anti-inflammatory: a substance that causes relief of inflammation
Antimetabolite: a substance structurally similar to a metabolite, which competes with it or replaces it, and thus prevents or reduces its normal function
Antimicrobial: a substance that kills or inhibits the growth of microorganisms
Antimitotic: a substance that prevents or inhibits cell division (mitosis)
Antimycotic: *see* Antifungal
Anti-oedemic: a substance that prevents swelling
Antioxidant: a substance that is able to protect cells or counteract the damage caused by oxidation and free oxygen radicals (reactive oxygen species, ROS)
Antiparasitic: a substance that kills parasites
Antiphlogistic: a substance that prevents inflammation
Antipruritic: a substance that alleviates or prevents itching
Antipyretic: a substance that alleviates fever
Antirheumatic: a substance that relieves the symptoms of rheumatism
Antiseptic: a substance that stops or inhibits infection
Antispasmodic: a substance that reduces muscular spasms and tension
Antitumour: a substance that counteracts tumour formation or tumour growth
Antitussive: a substance that reduces the urge to cough
Anuria: the inability to urinate
Anxiety: symptoms of fear not caused by any danger or threat
Aperitif: a drink that stimulates the appetite
Aphasia: loss or impairment of the power of speech or writing, or of the ability to understand written or spoken language or signs, due to a brain injury, disease or drugs
Aphrodisiac: a substance that increases sexual desire
Apnoea (apnea): cessation of breathing
Apoptosis: programmed cell-death leading to a progressive fragmentation of DNA and disintegration of cells without causing inflammation
Aqueous extract: soluble fraction of plant material obtained after extraction with water
Aril: fleshy edible structure attached to a seed and aiding its dispersal by animals
Aromatherapy: the medicinal use of aroma substances by inhalation, bath, massage, etc.
Aromatic bitter: a partly volatile substance that promotes appetite and digestion by stimulating the secretion of digestive juices
Arrhythmia: any deviation from the normal rhythm of the heartbeat
Arteriosclerosis: accumulation of fatty deposits in the blood vessels causing them to narrow and harden, resulting in heart disease or stroke
Arthritis: inflammation of joints
Asphyxiant: substance that blocks the transport or use of oxygen by living organisms
Asthma: chronic respiratory disease characterised by bronchoconstriction, excessive mucus secretion and oedema of the pulmonary alveoli, resulting in difficulty in breathing out, wheezing and coughing
Astringent: a substance (often tannins) that reacts with proteins in wounds, on the surface of cells or membranes, resulting in a protective layer and causing contraction
Ataxia: loss of muscle coordination leading to unsteady or irregular walking or movement
Atherosclerosis: pathological condition; changes of arterial walls that lead to arteriosclerosis
Atrophy: wasting away of the body or of an organ or tissue

Autonomic nervous system: that part of the nervous system that regulates the heart muscle, smooth muscles and glands; it comprises the sympathetic nervous system and the parasympathetic nervous system
Autopsy: post-mortem examination of the organs and body tissue to determine cause of death
Ayurvedic medicine: traditional medicine in India
Bactericide: substance that kills bacteria
Bacteriostatic: a substance that prevents the multiplication of bacteria
Bacterium: a microorganism consisting of a single cell surrounded by a cell wall; DNA is circular; bacteria do not have internal membrane systems or a nucleus
Base pairing: complexation of the complementary pair of polynucleotide chains of nucleic acids by means of hydrogen bonds between complementary purine and pyrimidine bases, adenine (A) with thymine (T) or uracil, cytosine (C) with guanine (G)
Benign: (1) not cancerous, not malignant since tumour does not form metastases and has still positional control. (2) disease without persisting harmful effects
Benign prostatic hyperplasia: a non-cancerous enlargement of the prostate that may interfere with urination
Benzodiazepine receptor: binding site for benzodiazepines at the GABA receptor; target for several sedatives, tranquillisers and alcohol
Berry: fleshy fruit with many seeds (*see* Drupe)
Beta-carotene: an orange plant pigment that is converted in the body to vitamin A
Bidesmosidic saponins: saponins with two sugar chains
Bile: a bitter fluid excreted by the liver via the gall bladder that helps to digest fats
Biliary dyskinesia: inability to secrete bile
Bilirubin: orange-yellow pigment, a breakdown product of haem-containing proteins (haemoglobin, myoglobin, cytochromes), it is excreted in the bile by the liver
Bioaccumulation: when harmful substances enter the ecosystem, some of them move through the food chain, by one organism eating another. In the end, substances accumulate, sometimes in high concentration in the top consumer or predator (often humans)
Bioactivation: any metabolic conversion of a xenobiotic to a more toxic derivative (e.g. pyrrolizidine alkaloids)
Bioassay: an experiment in which test organisms are exposed to varying concentrations of a substance. The response of the test organism is determined as a function of experimental conditions
Bioavailability: amount of a substance that is available for pharmacological or toxicological response after absorption
Biomembrane: permeation barrier around every cell or cellular compartments consisting of phospholipids, cholesterol and membrane proteins
Biopsy: excision of a small piece of living tissue for microscopic or biochemical examination and diagnosis
Bitter: a substance that stimulates the secretion of digestive juices
Bitter tonic: a substance that promotes appetite and digestion by stimulating the secretion of digestive juices
Bitterness value: that concentration at which a bitter substance can still be tasted (bitterness value of 100 000: when one part of the substance in 100 000 parts of water still tastes bitter)
Blood–brain barrier: blood vessels of the brain are covered with especially tight endothelial tissues, so that only selective substances can enter the brain
Blood purifier: a substance that causes the removal of impurities from the bloodstream (outdated term)
Bract: leaf-like structure inserted at the base of a flower or flower stalk
Bradycardia: pulse under 60 beats per minute
Bronchitis: inflammation of the mucous membranes of the bronchial tubes
Bronchodilatory: a substance that expands air passage through the bronchi and reduces bronchial spasm
Bruise: a non-bleeding injury to the skin
Bulbus: dried bulbs
Cachexia: weight loss due to chronic illness or prolonged emotional stress
Calyx: outer circle of leaf-like structures surrounding a flower (usually green)
Cancer: various types of malignant cells that multiply out of control
Candidiasis: infection with the fungus *Candida albicans*
Carcinogen: a substance that may cause cancer
Carcinogenicity: a multistage process leading to abnormal cell growth and cell differentiation; during initiation cells undergo mutations, during promotion mutated cells are stimulated (e.g. by co-carcinogens) to progress to cancer
Carcinoma: malignant growth of epithelial cells
Cardiac glycoside: a steroidal glycoside that inhibits NA^+, K^+ ATPase and thereby indirectly increases the strength or rhythm of the heartbeat
Cardiotonic: a substance that has a strengthening or regulating effect on the heart
Cardiotoxic: harmful to heart cells
Carminative: a substance that reduces flatulence
Catabolism: process of breakdown of complex molecules into simpler ones, often providing biologically available energy in form of ATP
Catalyst: a compound that speeds up the rate of a reaction
Catarrh: inflammation of mucous membranes
Catechol-*O*-methyltransferase (COMT): enzyme which inactivates neurotransmitters with a phenolic OH group (dopamine, noradrenaline, serotonin) through methylation
Cathartic: laxative, purgative
Catkin: cluster of small naked (apetalous) flowers
Chemotherapy: treatment of cancer with cytotoxic substances
Chiral: if the mirror image of a substance is not superimposable, it is called chiral
Cholagogue: a substance that stimulates the flow of bile from the gall bladder
Cholekinetic: a substance that stimulates the release of bile by contraction of the gall bladder and bile ducts
Choleretic: a substance that stimulates the liver to produce bile
Cholesterol: the most common steroid (fat-like material) found in the human body; important for membrane fluidity and as a precursor for steroid hormones; high cholesterol levels are associated with an increased risk of coronary diseases
Cholinesterase inhibitor: a substance that inhibits the action of cholinesterase (AChE); AChE catalyses the hydrolysis of acetylcholine (ACh) esters: a cholinesterase inhibitor causes hyperactivity in parasympathetic nerves
Chromosomal aberration: abnormal chromosome number or structure
Chronic: occurring over a long period of time (>1 year)
Chronic ailment: a condition that extends over a long period
Chronic exposure: continued exposure over an extended period of time

Chronotoxicology: science of the influence of biological rhythms on the toxicity of substances
Cirrhosis: liver disease defined by increased fibrous tissue, with loss of functional liver cells, and increased resistance to blood flow through the liver portal
Clinical trials: the development of new drugs consists of four phases: 1. preclinical studies, 2. clinical studies phase I, 3. clinical studies phase II and 4. clinical studies phase III
CNS: central nervous system
Co-carcinogen: a substance that amplifies the effect of a carcinogen or promotes tumour development
Colic: abdominal pains, caused by muscle contraction of an abdominal organ, accompanied by nausea, vomiting and perspiration
Commission E: recommendations of a group of German experts regarding the usefulness and efficacy of plant drugs
Concentration: the amount of a given substance in a given volume of air or liquid
Concentration–response curve: graph of the relation between exposure concentration and the magnitude of the resultant biological change
Condyloma: warts of the genital-anal region (caused by viruses of the Papilloma group)
Conjugate: derivative of a substance formed by its combination with chemicals such as acetic acid, glucuronic acid, glutathione, glycine, sulphuric acid, etc.
Conjunctiva: the mucous membranes of the eyes and eyelids
Conjunctivitis: inflammation of conjunctiva
Constipation: lack of bowel movement leading to prolonged passage times of faeces
Contact dermatitis: inflammatory condition of the skin resulting from dermal exposure to an allergen or an irritating chemical
Contaminant: any kind of adverse substance that contaminates water, air or food
Contraindication: condition that makes some particular treatment improper or undesirable
Corpus luteum: endocrine body in the ovary that secretes oestrogen and progesterone
Cortex: dried bark
Covalent bond: a bond created between two atoms when they share electrons
Crohn's disease: chronic inflammation of the intestinal tract
Cumulative effect: mutually enhancing effects of repeated doses of a harmful substance
Cutaneous: relating to the skin
Cyanogenic glucoside: secondary metabolite that is activated upon wounding, releasing the toxin HCN
Cyanosis: bluish coloration, especially of the skin and mucous membranes and fingernail beds; occurs when oxygenation is deficient and reduced haemoglobin is abundant in the blood vessels
Cyclooxygenase: key enzyme of prostaglandin biosynthesis converting arachidonic acid into prostaglandins
Cystitis: inflammation of the bladder
Cytochrome P-450: important haemoprotein which has the task to hydroxylate many endogenous and exogenous substrates (which are later conjugated and excreted). The term includes a large number of isoenzymes which are coded for by a superfamily of genes
Cytoplasm: basic compartment of the cell (surrounded by the plasma membrane) in which nucleus, endoplasmic reticulum, mitochondria and other organelles are imbedded
Cytostatic: a substance that slows down cell growth and multiplication
Cytotoxic: a substance that is toxic to cells, i.e. damages cell structure or function
Decoction: watery extract obtained by boiling
Decongestant: a substance that removes mucus from the respiratory system and opens the air passages so that breathing becomes easier
Dementia: loss of individually acquired mental skills; Alzheimer's disease is a severe form of dementia
Demulcent: a substance that soothes the mucous membranes (sometimes the term is restricted to internal membranes; *see* Emollient)
Dependence: psychic craving for a drug or other substance which may or may not be accompanied by a physical dependency
Depression: psychic disturbance, often associated with low concentrations of dopamine and noradrenaline
Dermal: referring to the skin
Dermal absorption: absorption through the skin
Dermatitis: inflammation of skin (e.g. by contact dermatitis)
Detergent: a substance capable of dissolving lipids
Detoxification: biochemical modification which makes a toxic molecule less toxic
Developmental toxicity: adverse effects on the embryo or growing foetus
Diabetes mellitus: abnormally high blood sugar levels caused by lack of insulin
Diaphoretic: a substance that increases sweating (profuse perspiration)
Diarrhoea: abnormally frequent discharge of watery stool (more than three times per day)
Dietary supplement: a substance that is marketed and sold as a "healthy" food item but not as a therapeutic agent
Diffusion: the process by which molecules migrate through a medium and spread out evenly
Digitate: compound leaf with leaflets arising at the same point (like fingers on a hand)
Disulphide bridge: a bond between two SH-groups, e.g. in a protein
Diuresis: discharge of urine
Diuretic (aquaretic): a substance that increases the volume of urine
DNA: deoxyribonucleic acid, the biomolecule in cells that stores the genetic information; composed of two complementary nucleic acid strands bonded by G-C and A-T pairs
Doctrine of signatures: old concept of traditional medicine assuming that the form or colour of a plant could indicate its medicinal application
Dosage: dose expressed as a function of the organism being dosed and time, for example mg/kg body weight/day
Dose: the amount of a substance to which a person or test organism is exposed; the effective dose depends on body weight
Dose-response curve: graph of the relationship between dose and the degree of changes produced
Dropsy: outdated term for oedema
Drug: term for a therapeutic agent, but also commonly employed for abused substances
Drug-resistance: having a (often acquired) resistance against a drug, by developing modified targets, increasing the degradation of an active compound or by exporting it out of a cell
Drupe: fleshy fruit with a single seed

Dysentery: inflammation of the colon; often caused by bacteria (shigellosis) or viruses, accompanied by pain and severe diarrhoea
Dysmenorrhoea: abnormal or painful menstruation
Dyspepsia: indigestion
Dysplasia: abnormal development of an organ or tissue
Dyspnoea: difficult breathing
Dysuria: painful urination
Eczema: acute or chronic inflammation of the skin with redness, itching, papules, vesicles, pustules, scales, crusts or scabs
Effective concentration (EC): EC_{50} is the concentration that causes 50% of maximal response
Effective dose (ED): ED_{50} is the dose that causes 50% of maximal response
Electronegative: atoms that draw electrons of a bond toward itself (e.g. oxygen)
Elixir: a nonspecific term generally applied to a liquid alcoholic preparation, emulsion or suspension
Embryotoxicity: any toxic effect on the conceptus as a result of prenatal exposure during the embryonic stages of development, including malformations, malfunctions, altered growth, prenatal death and altered postnatal function
Emesis: vomiting
Emetic: a substance causing vomiting
Emollient: a substance that soothes and softens the skin
Endocrine: pertaining to hormones or to the glands that secrete hormones directly into the bloodstream
Endoplasmic reticulum: endomembrane system in which proteins are modified post-translationally
Endorphins: peptides made by the body with similar activities as morphine
Endothelia: layer of cells lining the inner surface of blood and lymphatic vessels
Enteritis: inflammation of the intestines
Entheogen: an intoxicating or hallucinogenic substance that is taken to bring on a spiritual experience
Enzyme: protein that catalyses a chemical reaction, e.g. the hydrolysis of acetylcholine
Epidemiology: science that studies the occurrence and causes of health conditions in human populations; scientists try to find out whether a factor (e.g., nutrient, contaminant) is associated with a given health effect
Epigastric: referring to the upper-middle region of the abdomen
Epilepsy: chronic brain condition characterised by seizures and loss of consciousness
Epileptiform: occurring in severe or sudden spasms, as in convulsion or epilepsy
Epithelia: cell layer covering the internal and external surfaces of the body
Epitope: any part of a molecule that carries an antigenic determinant
Ergot: a fungus (*Claviceps purpurea*) that infects grasses (especially rye) and produces pharmacologically active alkaloids
Ergotism: poisoning by eating ergot-infected grain
Erythema: redness of the skin produced by congestion of the capillaries
Essential oil (=volatile oil): mixture of volatile terpenoids and phenylpropanoids responsible for the taste and smell of many plants, especially spices
Ethnobotany: study of how different human cultures use plants for medicinal and other purposes
Excretion: elimination of chemicals or drugs from the body, mainly through the kidney and the gut. Volatile compounds may be eliminated by exhalation. In the GI tract elimination may take place via the bile, the shedding of intestinal cells and transport through the intestinal mucosa
Expectorant: a substance that increases mucous secretion or its expulsion from the lungs; distinction between secretolytics and secretomotorics
Exposure: contact with a substance by swallowing, breathing, or directly through skin or eye; we distinguish between short-term and long-term exposure
Extract: a concentrated preparation (semi-liquid, solid or dry powder) of the soluble fraction of plant material
Familial Mediterranean fever: a condition with recurrent attacks of fever and pain
Febrifuge: a substance that reduces fever
Fibrinolytic: the ability of some proteolytic enzymes to dissolve fibrin in blood clots, facilitating wound healing
Febrile: relating to fever
First-pass effect: biotransformation of a chemical in the liver (after absorption from the intestine and before it reaches the systemic circulation)
Flatulence: accumulation of excessive gas in the intestines
Flos: dried flowers
Flu: *see* Influenza
Fluid extract: an alcohol–water extract concentrated to the point where, e.g., 1 ml equals 1 g of the original herb
Fluor albus (=leukorrhoea): white or yellow vaginal discharge
Folium: dried leaves
Food allergy: hypersensitivity reaction to chemicals in the diet to which a person has previously been exposed and sensitised
Forced diuresis: clinical method of stimulating diuresis, with the aim of achieving increased clearance of a toxic substance in urine
Frame-shift mutation: point mutation deleting or inserting one or two nucleotides in a gene, shifting the normal reading frame and causing the formation of functionless proteins
Free radical: an unstable form of oxygen molecule that can damage cells and cellular macromolecules
Fructus: dried fruits
Functional food: a food item with some pharmacological activity in addition to nutritional benefits
Galactogogue: a substance that stimulates milk secretion
Galenical preparations: preparations of herbal drugs, such as tinctures, lotions, extracts etc. (often interpreted as referring to non-surgical medicine)
Gallstone: a solid or semi-solid body in the gall bladder or bile duct
Gallotannin: polyphenol present in many medicinal plants; forms hydrolysable tannins (esters of gallic acid with sugars)
Gargle: a fluid used as throat wash
Gastritis: inflammation of the stomach
Gastroenteritis: inflammation of the gastrointestinal tract, associated with nausea, pain and vomiting
Genetic toxicity: damage to DNA by a mutagen, causing mutations and altered genetic expression (mutagenicity). Non-repaired mutations in somatic cells are inherited to daughter cells whereas mutations in germ cells can reach the next generation
Gingivitis: inflammation of the gums
Glaucoma: an eye disease characterised by increased intra-ocular pressure
GLC: high resolution gas-liquid chromatography (a technique used to analyse volatile chemical compounds and extracts)

Glumes: outer bracts of a grass spikelet
Glucosinolate: secondary metabolite that becomes activated upon wounding of a plant, releasing active isothiocyanate
Glycoprotein: protein that carries sugar groups
Glycoside: a chemical substance that yields at least one simple sugar upon hydrolysis
GMP: good manufacturing practice; a manufacturing system that complies with the highest standards of hygiene, safety and quality
Gout: increased uric acid level in blood and sporadic episodes of acute arthritis
Granulation: new cell layers (in the form of small granular prominences) over capillaries and collagen in a wound
GRAS: abbreviation for "generally regarded as safe", the status given to foods and herbal medicines by the American Food and Drug Administration (FDA)
Gravel: small concretions in the bladder or kidney
Haematoma: local accumulation of clotted blood
Haematuria: blood in the urine
Haemodialysis: removal of toxins from the blood through dialysis, using an artificial kidney (allowing the diffusion of toxins from the blood)
Haemolysis: the disruption of red blood cells and release of haemoglobin in blood
Haemoperfusion: removal of toxins from the blood with the aid of a column of charcoal or adsorbent resin
Haemorrhage: profuse bleeding
Haemorrhagic nephritis: blood in the urine
Haemorrhoids (=piles): painful and swollen anal veins
Haemosorption perfusion: passage of a patient's blood through a set of columns filled with a haemosorbent (activated charcoal, ion-exchange resin, etc.); the purpose of the procedure is to remove a toxic substance from the organism, particularly in an emergency
Haemostatic: a substance that reduces or stops bleeding
Haemostyptic: a substance that reduces or stops bleeding
Hallucinogen: a substance that induces the perception of objects which are not actually present
Hazard: capability of an agent to cause adverse effects
Heartburn: uncomfortable burning sensation in the chest, rising towards the throat (due to the return of stomach acid into the oesophagus)
Hepatitis: inflammation of the liver
Hepatotoxic: toxic to the liver
Herbalist: a person with experience in herbal medicine and/or herbal therapy
Herpes simplex: localised infection on the lips or genitalia caused by the herpes virus
HIV: human immunodeficiency virus that causes AIDS
Hodgkin's disease: a cancer of lymph cells that originates in one lymph node and later spreads to other organs
Homeopathy: a medicine system using minute amounts of substances that cause in a healthy person the same effect (symptoms) than those caused by the condition under treatment
Hormone: a substance released into the bloodstream that affects organ systems elsewhere in the body
HPLC: high performance liquid chromatography (a technique used to analyse chemical compounds and extracts)
Hydrogen bond: an attraction between a hydrogen atom (H) on an electronegative atom (mostly N or O)
Hydrolysis: breaking down a molecule by addition of water; in cells hydrolases (glucosidases, lipases, DNAses) catalyse this reaction
Hydrophilic substance: a substance soluble in water but not in oil
Hydrophobic substance: a substance that is repelled by water, but soluble in lipids
Hyperaemia (hyperemia): abnormal blood accumulation in a localised part of the body
Hyperlipidemia: characterised by enhanced lipid levels in the blood; triglycerides (>160 mg/100 ml) and cholesterol (>260 mg/100 ml)
Hyperplasia: abnormal growth of normal cells in a tissue or organ
Hypersensitivity: allergic reaction of a person to chemicals to which they had been exposed previously
Hypertension (hypertonia): high blood pressure (>140/90 mm Hg)
Hypertonic solution: abnormally high salt levels having a higher osmotic pressure than blood or another body fluid
Hypertrophy: abnormal increase in size of an organ (cell numbers remain constant)
Hypnotic: a substance that induces sleep
Hypoglycaemic: abnormally low level of blood sugar
Hypothermia: low body temperature
Hypotonia/hypotension: low blood pressure (<105/60 mm Hg)
Hypoxia: abnormally low oxygen content or tension in the body
Icterus: jaundice; deposition and retention of bile pigment in the skin
Immune stimulant: a substance capable of improving the immune system
Immunosuppression: reduction of the immune response
In vitro: in the laboratory or test tube
In vivo: in a living animal or human
Incidence rate: measure of the frequency of new events occurring in a population
Inflammation: localised swelling, redness and pain as a result of an infection or injury
Inflorescence: flower cluster
Influenza (flu): an acute and highly contagious disease caused by viruses that infect mucous membranes of the respiratory tract
Ingestion: swallowing (eating or drinking) of chemicals; after ingestion chemicals can be absorbed from the GI tract into the bloodstream and distributed throughout the body
Inhalation: exposure to a substance through breathing it; if taken up from the lungs a substance can enter the bloodstream
Inhibitory concentration (IC): IC_{50} is the concentration that causes 50% inhibition
Inorganic agent: material that consists of elements or inorganic compounds
Inotropic: a substance that stimulates the contraction of muscles, e.g. of the heart
Insomnia: inability to sleep
Insulin: a hormone made in the pancreas that controls the level of glucose in the blood
Intercalation: planar and lipophilic compounds can intercalate between base stacks of DNA; this leads to frame shift mutations (resulting in inactive proteins)
Intoxication: (1) Poisoning with clinical signs and symptoms (2) Drunkenness from ethanol-containing beverages or other compounds affecting the central nervous system
Ion channel: membrane protein that can form water-containing pores so that mineral ions can enter or leave cells

Ionic bond: a bond created when two atoms trade electrons and then attract each other due to their opposing charges (e.g. NH_3^+-groups form ionic bonds to COO^--groups)
Iridoids: a subgroup of monoterpenoids, with iridoid glucosides, secoiridoids and secologanin
Irrigation therapy: rinsing the urinary tract by means of a diuretic substance that increases urine flow
Irritant: a substance causing irritation of the skin, eyes or respiratory system
Isothiocyanate: secondary metabolites released from glucosinolates upon hydrolysis; exhibits strong skin irritating properties
Itch (=pruritus): skin irritation
Jaundice: yellow coloration of skin and mucosa; caused by abnormally high level of bile pigments in the blood
Kampo medicine: traditional Japanese medicine
Lacrimator: substance which can irritate the eyes and cause tear formation
Lactation: production and secretion of milk by female mammary glands
Latency: time period from the first exposure to a substance until the appearance of biological effects
Lavage: irrigation or washing out of the stomach, intestine or the lungs
Laxative: substance that causes evacuation of the intestinal contents
LD_{100}: lethal dose that kills all (100%) of the individuals in a test group
LD_{50}: lethal dose that kills 50% of the individuals in a test group
Lethal: deadly; fatal; causing death
Leukaemia: malignant disease of the blood-forming organs
Leukopenia: low white blood cell count
Leukorrhea: vaginal discharge of white or yellowish fluid
Ligand: substance that binds to a receptor in a specific way like a key in a lock
Lignum: dried wood
Liniment: ointment for topical application
Lipid: a substance soluble in non-polar solvents; insoluble in water
Lipid-lowering: a substance that lowers triglyceride or cholesterol levels in blood
Lipophilic (=hydrophobic): a substance soluble in oil or a non-polar solvent
Lowest-observed-adverse-effect-level (LOAEL): lowest concentration of a substance which causes an adverse effect
Lowest-observed-effect-level (LOEL): lowest concentration or amount of a substance which causes any biological effects
Lysosome: cytoplasmic organelle containing hydrolytic enzymes
Maceration: preparation made by soaking plant material
Malaise: slight feeling of bodily discomfort
Malaria: a parasitic disease caused by *Plasmodium* parasites; it is transmitted by mosquitoes
Malignant: a disease which gets progressively worse and results in death if not treated, or a cancer with uncontrolled growth and metastasis
Mania: emotional disturbance characterised by an expansive and elated state (euphoria), rapid speech, flight of ideas, decreased need for sleep, distractibility, grandiosity, poor judgement and increased motor activity
MAO inhibitor: inhibitor of monoamine oxidase that degrades the neurotransmitters adrenaline, noradrenaline, dopamine and serotonin
Mastitis: inflammation of the breast
Mastodynia: pain in the swollen female breasts
Materia medica: the various materials (from plants, animals or minerals) that are used in medicine (healing)
Maximum tolerable dose (MTD): highest amount of a substance that does not kill test animals (LDo)
MDR: multiple drug resistance; caused by overexpression of *p*-glycoprotein, an important ATP-driven transporter at biomembranes, which pumps out lipophilic xenobiotics
Melanoma: a tumour of skin and mucosa arising from the pigment-producing cells
Menopause: permanent cessation of menstruation caused by decreased production of female sex hormones
Menorrhagia: abnormally severe menstruation
Metabolic syndrome: a dietary ailment associated with obesity and diabetes
Metastasis: movement of cancer cells from one part of the body to another, starting new tumours in other organs
Microtubules: linear tubular structures of higher cells, formed from tubulin dimers; essential for cell division and vesicular transport processes
Micturition: urination
Migraine: recurrent condition of severe pain in the head accompanied by other symptoms (nausea, visual disturbance)
Mineralocorticoid: the steroid of the adrenal cortex (aldosterone) that regulates salt metabolism
Minimum lethal dose (LD_{min}): lowest amount of a substance that may cause death
Miosis: abnormal contraction of the pupil to less than 2 mm
Mitochondria: important compartment of eukaryotic cells; site of the Krebs cycle and respiratory chain (production of ATP); mitochondria have their own DNA, replication, transcription and ribosomes
Mitogen: chemical which induces mitosis and cell proliferation
Mitosis: cell division
Monoamine oxidase (MAO): the enzyme that catalyses the removal of amine groups (e.g. dopamine, noradrenaline)
Monodesmosidic saponins: saponins with one sugar chain
Morbidity: any form of sickness, illness and morbid condition
Mucilage: solution of viscous (slimy) substances (usually polysaccharides) that form a protective layer over inflamed mucosal tissues
Mucolytic: a substance that dissolves mucous, e.g. in the bronchia
Mucosa: mucous tissue layer on the inside of the respiratory or gastrointestinal tract
Mucus: clear, viscose secretion formed by mucous membranes
Multiple sclerosis: disorder of the CNS caused by a destruction of the myelin around axons in the brain and spinal cord that lead to various neurological symptoms
Mutagenic: a substance that induces genetic mutations; resulting in alterations or loss of genes or chromosomes
Myalgia: non-localised muscle pain
Mycotoxin: toxin produced by a fungus
Mydriasis: dilation of the pupil of the eye
Na^+, K^+-ATPase: important ion pump of animal cells; pumps Na^+ out of the cell and K^+ into the cell; is inhibited by cardiac glycosides
Narcotic: a substance that produces insensibility or stupor, combined with a sense of well-being; more specifically an opioid, any natural or synthetic drug that has morphine-like activity

Naturopathy: a holistic system of healing that emphasises the body's inherent power of regaining balance and harmony
Necrosis: death of cells or tissue, usually accompanied by an inflammation
Neoplasm: new and abnormal formation of a tumour by fast cell proliferation
Nephritis: kidney inflammation, accompanied by proteinuria, haematuria, oedema and hypertension
Nephrotoxic: a substance that is harmful to the kidney
Neuralgia: severe pain along nerve ends
Neuritis: inflammation of nerves
Neuron: nerve cell
Neuropathy: general term for diseases of the central or peripheral nervous system
Neurotoxin: substance with adverse effects on the central and peripheral nervous system; such as transient modulation of mood or performance of CNS
Neurotransmitters: signal compounds in synapses of neurons that help to convert an electric signal into a chemical response; important neurotransmitters are acetylcholine, noradrenaline, adrenaline, dopamine, serotonin, histamine, glycine, GABA, glutamate, endorphins and other peptides
Neurovesicle: small vesicles in the presynapse that are filled with neurotransmitters
Non-protein amino acid (NPAA): secondary metabolite that is an analogue of a proteinogenic amino acid; if incorporated into proteins, the latter are usually inactivated
No-observed-adverse-effect-level (NOAEL): greatest concentration or amount of a substance, which causes no detectable adverse alteration
Noxious substance: harmful substance
Nutritional supplement: a preparation that supplies additional nutrients or active compounds to the body that may not be obtained by the normal diet
Nutritive: nourishing, nutritious
Nycturia: nightly urge to urinate
Nystagmus: involuntary, rapid, rhythmic movement of the eyeball
Oedema (edema): swelling of tissue due to an accumulation of fluids, often caused by kidney or heart failure
Oestrogen (estrogen): a female sex hormone
Ointment: semisolid medicinal preparation that is used topically
Oleum: non-volatile oil; fat
Oliguria: elimination of a small amount of urine in relation to fluid intake
Ophthalmic: relating to the eye
Opium: dried latex of *Papaver somniferum* with several alkaloids, especially morphine
Oral: by mouth (p.o., *per os*)
Organelle: nanomachine or membrane-embraced compartment within a cell that has a specialised function, e.g., ribosome, peroxisome, lysosome, Golgi apparatus, mitochondrion and nucleus
Organic (bio-organic): terms used for products that are grown and processed without the use of artificial chemicals (wild-harvested materials usually qualify as organic)
Organic compound: molecules made of carbon and hydrogen atoms, often containing oxygen and nitrogen in addition
Osteoporosis: a reduction in bone mass, resulting in fractures
OTC: over the counter, a drug that is sold without prescription
Otitis: inflammation of the ear
Oxidation: a reaction that adds oxygen atoms to a molecule or when electrons are lost to a molecule
Oxytocic: speeding up of parturition
Oxytocin: a hormone of the pituitary gland that stimulates lactation and induces labour
Pancytopenia: deficiency of all three cellular components of the blood (red cells, white cells, and platelets).
Panicle: compound flower cluster comprising two or more racemes on a common stalk
Palpitation: noticeable regular or irregular heartbeat
Paraesthesia: abnormal sensation, as burning or prickling
Paralysis: loss or impairment of muscle activity
Parasympathetic nervous system: that part of the nervous system that slows the heart rate, increases intestinal (smooth muscle) and gland activity, and relaxes sphincter muscles
Parasympatholytic: anticholinergic substance that induces effects resembling those caused by interruption of the parasympathetic nerve (e.g. tropane alkaloids)
Parasympathomimetic: cholinomimetic substance that induces effects resembling those caused by stimulation of the parasympathetic nervous system
Parenteral administration: administration of medicinal substances by injection (i.v. = intravenous; i.m. = intramuscular; s.c. = subcutaneous) or intravenous drip
Paresis: weak paralysis
Parkinson's disease: a progressive neurological disease (caused by a degeneration of the *Substantia nigra* and a reduction of dopamine concentrations) marked by lack of muscular coordination and mental deterioration
Parkinsonism: one of several neurological disorders manifesting in unnaturally slow or rigid movements
Pathogen: a microorganism that may cause disease
Percutaneous: absorption through the skin
Periodontitis: inflammation of the area around a tooth
Peristalsis: waves of involuntary contraction in the digestive system
Peritoneal dialysis: clinical procedure of artificial detoxification in which a toxic substance from the body is absorbed into a liquid that has been pumped into the peritoneum
Pesticide: substance (such as fungicide, insecticide, herbicide) used to kill agricultural pests and pathogens
Petal: each of the segments of the corolla of a flower, which are modified leaves and are typically brightly coloured
***p*-gp:** *p*-glycoprotein; an important ATP-driven transporter at biomembranes, which pumps out lipophilic xenobiotics
Pharmaceuticals: drugs, medical products, medicines, or medicaments
Pharmacodynamics: the study of how active substances work in the body; e.g., whether they bind to a receptor
Pharmacogenetics: the study of the influence of hereditary genetic factors on the effects of drugs on individual organisms
Pharmacognosy: the study of herbal drugs, their identification, properties and uses
Pharmacokinetics: the study of how active substances are absorbed, moved, distributed, metabolised and excreted
Pharmacology: the study of the nature, properties and uses of drugs (see pharmacodynamics, pharmacokinetics); includes the study of endogenous active compounds
Pharmacopoeia (pharmacopeia): an official, authoritative publication listing all the various drugs that may be used

Phase 1 reaction: enzymic modification of a xenobiotic or drug by oxidation, reduction, hydrolysis, hydration, dehydrochlorination or other reactions
Phase 2 reaction: conjugation of a substance, or its metabolites from a phase 1 reaction, with endogenous hydrophilic molecules, making them more water-soluble that may be excreted in the urine or bile
Phenotype: the expressed structural and functional characteristics which depend on genotype and environmental conditions
Phlegm: catarrhal secretion or sputum
Phorbolester: diterpene from Euphorbiaceae and Thymelaeaceae, resembling diacylglycerol in structure and therefore activates protein kinase C
Phosphodiesterase: enzyme of signal transduction; inactivates cAMP or cGMP
Phospholipase C: enzyme of signal transduction; splits inositol phosphates to IP3 and diacylglycerol (DAG)
Phospholipids: phosphorylated lipids that are building blocks of cell membranes
Photochemotherapy: the use of phototoxic (UV-activated) furanocoumarins to treat skin ailments
Photo-irritation: skin inflammation due to light exposure, caused by metabolites which were formed in the skin by photolysis
Photosensitisation: increasing sensitivity to sunlight
Phototoxicity: adverse effects of compounds activated by light exposure (e.g. furanocoumarins)
Phytomedicine: *see* Phytotherapy
Phytotherapy: application of plant drugs or products derived from them to cure diseases or to relieve their symptoms
Phytotoxicity: adverse effects of compounds to plants
Pinnate: compound leaf with a main axis and one or more pairs of leaflets plus a terminal leaflet
Piscicide: toxin used to kill fish
Placebo: drug preparation without active ingredients, which cannot be distinguished from the original drug; used in placebo-controlled clinical trials
Placebo effect: an improvement of a health condition that cannot be ascribed to the treatment used
Plasma (blood plasma): cell-free liquid part of blood which surrounds the blood cells and platelets
PMS: premenstrual syndrome; can occur a few days before menstruation with symptoms of irritability, changing mood, insomnia, headache, swollen breasts, cramping and oedema
Pneumonitis: inflammation of the lung
Point mutation: exchange of a single base pair in DNA
Poison: toxicant that causes immediate death or illness even at very low doses
Potentiation: the response to a combination of active substances is greater than expected from the individual compounds (synergism)
Poultice: a semisolid mass of plant materials in oil or water applied to the skin
ppb: parts per billion, 1 μg in 1 kg
ppm: parts per million, 1 mg in 1 kg
Precursor: substance from which another molecule is formed
Prescription drug: a drug that requires a prescription from a physician
Procarcinogen: compound which has to be metabolised before it can induce a tumour
Prodrug: a substance that is converted to its active form within the body
Prophylactic: a substance that prevents disease
Prostaglandins: a group of physiologically active substances within tissues that cause stimulation of muscles and numerous other metabolic effects; important for inflammation processes
Prostate: a gland at the base of the male bladder that secretes a fluid that forms part of semen (stimulating sperm motility)
Prostatitis: bacterial infection of the prostate (*also see* Benign prostate hyperplasia)
Protein kinases: enzymes that phosphorylate other proteins which become activated or inactivated by this modification; important are protein kinase A and protein kinase C
Proteinuria: excretion of excessive amounts of protein in the urine
Pruritus: itching
Psoriasis: inherited skin condition caused by an enhanced growth of dermal cells (keratocytes) resulting in the production of dandruff
Psychosis: mental disorder characterised by personality changes and loss of contact with reality
Psychotropic: a substance that affects the mind or mood
Pulmonary: referring to the lungs
Purgative: *see* Laxative
PUVA: therapy for eczema, psoriasis and other skin ailments combining the drug psoralen and long-wave ultraviolet light
Pyretic (pyrogen): a substance that induces fever
Raceme: flower cluster of stalked flowers, with the youngest ones at the tip
Radix: dried roots
Raphe: a longitudinal ridge on the side of some seeds
Rate: frequency of events during a specified time interval
Reactive oxygen species, ROS: *see* Antioxidant; ROS are thought to be involved in the development of several health disorders (arteriosclerosis, cancer, dementia) and ageing
Receptor: protein (often a membrane protein) that has a binding site for another molecule ("ligand"); important for signal transduction in cells
Relaxant: a substance that reduces tension
Renal: referring to the kidneys
Repellent: compounds used to repel herbivores or predators
Replication: duplication of DNA prior to cell division
Reproductive toxicology: adverse effects of chemicals on the embryo, foetus, neonate and prepubertal mammal and the adult reproductive and neuro-endocrine systems
Resin: amorphous brittle substance resulting from a plant secretion
Resina: resin
Resorption: uptake of a substance through the skin or a mucous membrane (*see* Absorption)
Re-uptake inhibitor: inhibitors of transporters for the neurotransmitters dopamine, noradrenaline and serotonin at presynaptic and vesicle membrane
Rheumatism: general term referring to painful joints
Rhinitis: inflammation of the mucosa of the nose
Rhizoma: dried rhizomes; underground stem
Ringworm: a fungal infection of skin
Risk: probability of manifestation of a hazard under specific conditions
Roborant: tonic or strengthening mixture
Rodenticide: pesticide used to kill rodents
Rubefacient: a substance (counter-irritant) that causes reddening of skin
Saluretic: a substance that increases the concentration of salts in urine

Saponins: glycosides of triterpenes and steroids; the aglycone is usually lipophilic, whereas the saponins are amphiphilic with detergent properties; distinguished are monodesmosidic saponins with one sugar chain and bidesmosidic saponins with two sugar chains
Saturated fats: fats with fatty acids without double bonds (animal fats, coconut oil, etc.)
Saturnism: intoxication caused by lead
Scar tissue: new cell growth following injury
Sclerosis: excessive hardening of an organ due to growth of fibrous tissue
Secondary metabolites: chemical substances of plants (usually of low molecular weight) with a high structural diversity that are used as defence or signal compounds by the plants producing them. Several secondary metabolites have a restricted occurrence in the plant kingdom; in contrast, primary metabolites are essential and present in all plants
Secretolytic: a substance that leads to a better solubilisation of mucus and favours its discharge
Secretomotoric: a substance that stimulates movement of cilia on bronchial membranes, which helps to expel mucus
Sedative: a substance that calms the nerves (tranquilliser)
Semen: seeds
Sepal: calyx lobe; leaf-like structure surrounding a flower bud
Serrate: toothed margin with teeth directed forward as in a saw blade
Serum (blood): water-soluble protein fraction of the blood that remains after clotting
Sesquiterpene lactone: terpene with 15 C atoms; its exocyclic methylene group can bind to SH-groups of proteins or glutathione
Sessile: without a stalk
SH-group: functional group in proteins that can form disulphide bonds with other proteins
Side effect: activity of a drug other than that desired for beneficial pharmacological effect
Simple: term used for a herb that is used on its own
Sitz-bath: an immersion bath used for medicinal purposes
Solvent abuse: inhalation of volatile solvents, with the intent to become intoxicated (dangerous for liver and CNS)
Soporific: a substance that induces or promotes sleep
Spasm: involuntary contraction of muscles
Special extract: extract that is enriched in the active principle whereas unwanted compounds have been discarded (can be patented)
Spike: elongated inflorescence with sessile flowers
Spondylitis: inflammation of vertebrae
Steam distillation: a method of selectively extracting volatile compounds and oil from plant material by boiling or steaming in water, followed by condensation
Stomachic: a substance that promotes appetite and digestion
Styptic: a substance applied externally to stop bleeding by contracting the tissue and blood vessels
Subacute: form of repeated exposure or administration not long enough to be called “long-term” or “chronic”
Substrate: a molecule that binds to an enzyme and then undergoes a chemical reaction
Sudorific: a substance that causes sweating
Sympathetic nervous system: that part of the nervous system that accelerates the heart rate, constricts blood vessels and raises blood pressure
Sympatholytic: substance that blocks signal transmission from the adrenergic (sympathetic) postganglionic fibres to effector organs
Sympathomimetic: substance that induces effects resembling those of impulses transmitted by the postganglionic fibres of the sympathetic nervous system
Symptom: subjective perception of a disease or of effects induced by a toxin
Synapse: neurons are connected with other neurons or target tissues via synapses where the action potential is converted into a chemical signal (neurotransmitter)
Syndrome: summary of symptoms occurring together; it often characterises a particular disease-like state
Synergistic: the phenomenon that the combined effect of two or more substances is greater than the sum of their individual effects (*see* Potentiation)
Syrup: a sugary solution intended for oral administration (e.g. cough syrup)
Systemic lupus erythematosus, SLE: an autoimmune disease in which the body’s immune system attacks healthy tissue; can affect the skin, joints, kidneys, brain and other organs
Tachycardia: pulse over 100 beats per minute
Tachypnoea: fast breathing
Tannins: secondary metabolites with several phenolic OH-groups, that can form hydrogen and ionic bonds with proteins, thereby altering their conformation; distinguished are gallotannins and catechol tannins, which derive from catechin or epicatechin
Target: any component of the human body that can be affected by a drug
TCM: traditional Chinese medicine; oldest therapeutic system of mankind that is still in use and esteemed
Tea: an infusion made by pouring boiling water over a measure quantity of dried plant material and leaving it for a while to steep
Teratogen: a substance given to pregnant women that causes abnormal growth and malformations in an embryo
Terpenoids: a very large group of secondary metabolites, including monoterpenes (with 10 carbons), sesquiterpenes (15 C), diterpenes (20 C), triterpenes (30 C), steroids (27 C or less), tetraterpenes (40 C)
Testosterone: the male sex hormone
Tetanic: referring to tetanus, characterised by tonic muscle spasms
Therapeutic margin/window: difference between therapeutic and toxic doses
Thrush: a fungal infection of mucous membranes marked by white patches (*see* Candidiasis)
Tincture: an extract of medicinal plant material made with alcohol (ethanol) or a mixture of alcohol and water
Tinnitus: noise in the ear (ringing, buzzing, roaring or clicking)
Tisane: herbal tea (often made from flowers) that is not as strong as an infusion
Tonic: a substance that maintains or restores health and vigour (usually taken over a lengthy period); also term for tension, especially muscular tension
Topical application: external application (on the skin)
Toxicant: chemicals producing adverse biological effects of any nature
Toxicology: science that studies toxins and their effects in humans or animals
Toxification: metabolic activation of a potentially toxic substance
Toxin: a harmful biogenic substance or agent causing injury in living organisms as a result of physicochemical interactions
Transcription: process of copying the base sequence of a gene into mRNA

Translation: process of copying the base sequence of mRNA into the amino acid sequence of proteins in the ribosome
Transporter: a membrane protein that catalyses the transport of a molecule from one side of a biomembrane to the other side
Tuber: dried tubers
Tuberculosis: a bacterial disease caused by *Mycobacterium tuberculosis* that affects the lungs and other organs (often chronic and fatal if not treated with antibiotics)
Tumour (tumor): an abnormal growth of tissue (benign or malignant)
Ulcer: an inflamed lesion on the skin or on a mucous membrane
Umbel: cluster of stalked flowers, all arising from the same point
Unsaturated fats: fats with fatty acids with double bonds between the carbon atoms
Uptake: absorption of a chemical into the body, a cell, or into the body fluids by passage through membranes
Urinary calculi: concretions in the urethra
Urticaria: transient reaction of the skin characterised by smooth, slightly elevated patches that are redder or paler than the surrounding skin; often with severe itching
Varicose veins: abnormally distended veins
Vasoconstrictor: a substance that causes a narrowing of the blood vessels and reduces blood flow
Vasodilator: a substance that causes an increase in the internal diameter of blood vessels and enhanced blood flow
Venom: animal toxin usually employed for self-defence or predation; mostly delivered by a bite or sting
Venous tone: the firmness of the walls of veins
Ventricular fibrillation: irregular heartbeat characterised by uncoordinated contractions of the ventricle
Vermifuge: a substance that kills or expels intestinal worms
Vertigo: dizziness
Vesicant: a substance that compounds produce blisters on the skin
Vesicle: a subcellular container in the cell to store chemicals, e.g. neurotransmitters are stored in neurovesicles
Virus: infectious complex of macromolecules that contain their genetic information either as DNA or RNA; viruses need host cells for replication and the formation of new viral particles
Virustatic: a substance that inhibits the multiplication of viruses
Volatile oil: various terpenoids that evaporate easily (they add taste and smell to many plants)
Vomit: the expulsion of matter from the stomach via the mouth
Vulnerary: a substance that heals external wounds
Wild-crafting: the collection of medicinal material from natural plant populations in a sustainable way
Wild-harvesting: the collection of medicinal material from natural plant populations with or without considering their sustainable use
Withdrawal effect: negative feelings following withdrawal of a drug on which a person has become dependent
Xenobiotic: foreign compound absorbed by animals or humans
Yeasts: simple eukaryotic cells (belonging to the fungal kingdom), containing a nucleus, organelles and compartments surrounded by membranes

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Index

Plant names and page numbers in **bold** indicate main entries; page numbers in ***bold italics*** indicate illustrated plants or chemical compounds.

abedul 120
Abendländischer Lebensbaum 259
abhaya 258
Abies 56
abietic acid ***56***
abrin 27, 91, ***93***
Abrus precatorius *27*, ***91***, **93**
abrusosides 93
Absinth 113
absinthe 113
absinthe chinoise 114
Absinthii herba 113
absinthin ***113***
Abyssinischer Tee 130
acacia del Senegal 93
Acacia senegal 9, 29, **93**
Acacia spp. 75
acacie gomme arabique 93
acai berry 18, **163**
acai oil 76
Açaí-Beere 163
açaizeiro 163
Acanthaceae 85, 86, 106, 188
acemannan ***75***, ***102***
acetaldehyde 109
acetic acid ***76***
acetylacteol 139
acetylandromedol 57
acetylcholine 264
acetyldigoxin 20
acetylindicine 177
2′-acetylneriifoline 133
achillea millefoglio 94
Achillea millefolium **94**
Achillea spp. 54
achillicin 94
Achyranthes spp. 58
ackee 89, **121**
Ackerschachtelhalm 160
Acmella oleracea 251
Acokanthera oppositifolia 25, ***27***
aconit napel 94
aconite 10, ***94***
aconitine 20, 23, 26, ***79***, ***94***, 177
aconito 94
Aconitum napellus 10, 20, 23, 26, **94**
Aconitum spp. 79
Acoraceae 95
acore vrai 95
acorenone ***95***
Acorus calamus **95**
acridone alkaloids 86
acronine ***86***
Acronychia baueri 86
acronycine 86
Actaea racemosa 16, **139**
actaein ***139***
actée à grappet 139
acylglycerides 29
Adansonia digitata 19, **95**
adansonie d' Afrique 95
adelfa 206
Adenia digitata 27
Adenium multiflorum 96
Adenium obesum 9, 26, **96**
Adenium obesum var. *multiflorum* 96
Adenium obesum var. *obesum* 96
Adhatoda vasica 188
Adhatodae vasicae folium 188
Adlerfarn 230
adonide 96
adonide du printemps 96
Adonidis herba 96
Adonis spp. 62
Adonis vernalis 20, **96**
adoniside 20
Adoxaceae 241
adulterants 40
aerial parts 28
aescin 20, 97
aesculetin 20
aesculin ***66***, 167
Aesculus hippocastanum 17, 20, 66, **97**
aetheroleum 29
Aethusa cynapium 138
Affenbrotbaum 95
aflatoxin 25
Aframomum melegueta **97**
African cherry 9
African Herbal Pharmacopoeia 9
African horehound 119
African medicine 8
African myrrh 143
African potato 9, 18
African rue 22, **214**
African Traditional Medicine 8, 32
African wild olive 209
African wormwood 9, **113**
Afrikanische Teufelskralle 175
Afrikanischer Wermut 113
Agathosma betulina 9, **98**
Agathosma crenulata 98
agave 71
Agave tequilana 71
aglio 101
aglio orsino 101
Agni casti fructus 270
agnocasto 270
agracejo 120
agrimonia 98
Agrimonia eupatoria 20, 70, **98**
Agrimonia pilosa 98
Agrimonia procera 98
Agrimoniae herba 98
agrimoniin ***70***, 98, 99, ***166***, 226, 242
agrimony 70
agrimophol 20
agripalma 192
agripaume 192
agroclavine ***80***
Agropyri repentis rhizoma 159
Agropyron repens 159
Agrostemma githago **99**
agrostin 99
aigremoine gariot 98
ail blanc 101
ail des ours 101
airelle à gros fruits 264
airelle myrtille 265
airelle rouge 265
Aizoaceae 244
ajacine 26
ajenjo 113
ajmalicine 20, ***81***
ajmaline 20, ***81***
ajo 101
ajo de oso 101
ajowan 12
Ajuga spp. 58
ajugol ***192***
ajugoside 192
akee 121
akee d'Afrique 121
Akeepflaume 121
alanine ***88***
alantolactone ***54***, ***185***
alcachofera 150
alcanfor 140
alcaravea 129
Alcea rosea 104
Alcea spp. 74
alchemilla 99
Alchemilla spp.70
Alchemilla vulgaris 99
Alchemilla xanthochlora **99**
Alchemillae herba 99
alchimille 99
alcohol 22, 23, 271
alder buckthorn 233
alearrhofa 150
Alepidea 57
Aleppo rue ***48***, 239
Aleurites fordii **100**
alevrite 100
alfa-alfa 200
alfalfa 200
algarrobo 133
algin 115
alginate 115
alginic acid 115
alkaloids 16, 36, 44, 78–87
alkamides 16, 17, 73
allantoin 20, ***254***
Alliaceae 89, 100, 101
allicin ***89***, ***101***
Allii cepae bulbus 100
Allii sativi bulbus 28, 101
Allii sativi pulvus 101
Allii ursini bulbus 101
Allii ursini herba 101
alliin ***89***, 101
Allium cepa 12, 17, 28, 89, **100**
Allium sativum 16, 28, **101**
Allium ursinum 19, **101**, 144
allyl isothiocyanate 20, ***90***, ***111***
almendro 227
almond 12, **227**
almorta 190
Aloe barbadensis 102
Aloe capensis 102
aloe del Capo 102
Aloe ferox 9, 19, 29, **102**
Aloe spp. 72
Aloe vera 12, ***13***, 18, 29, **102**
aloe vera 18, **102**
Aloe vera gel 75, 123
aloe-emodin 234
aloe-emodin anthrone 102
aloes feroce 102
aloes vrai 102
aloin ***72***, ***73***, ***102***
Aloysia citrodora 19, 51, **103**
Aloysia triphylla 103
Alpinia galanga 103
Alpinia officinarum **103**
Alraune 198
Alstroemeria spp. 71
altea 104
Althaea officinalis 75, **104**
Althaeae radix 104
amabiline 122
amalika 218
amamelide 174
amandier 227
Amanita muscaria 22, ***25***, 26
Amanita phalloides 26
amanitin 26
amaranth seed oil 58
Amaranthaceae 60, 135
amarogentin ***52***, 170
amarum 102, 131, 132, 202, 231
Amaryllidaceae 78, 100, 101, 121, 168, 205
amaryllidaceae alkaloids 78, 168
ambelline 78
Ambrosia elatior 91
ameo mayor 104
American arbor-vitae 259
American aspen 225
American blueberry 265
American cranberry 264
American ginseng 212
American mandrake 223
American spikenard 15, 18, **108**
Amerikanische Espe 225
Amerikanische Narde 108
Amerikanische Traubensilberkerze 139
Amerikanischer Faulbaum 234
amino acids 88
α-amino-β-oxalyl aminopropionic acid 89
amiomaior 104
amio-vulgar 104
amla 218
amlak 218
Ammi majus 21, **104**
Ammi visnaga **270**
Ammi visnagae fructus 270
ammodendrine ***84***
3,11-amorphadien 164
Amorphophallus konjac 75
ampelopsin ***180***
amphetamine ***84*, **130
amritoside 229
Amsinckia 85
Amur cork tree 217
amurensin 217
Amur-Korkbaum 217
amygdalin ***90***, ***227***, ***228***
anabasine 20**,** 156, ***207***
Anabasis aphylla 20
Anacardiaceae 65, 235, 245
Anadenanthera peregrina 14, 23, 78, **105**
anagyrine ***85***
analysis of compounds 36
Anamirta cocculus 21, 54
Ananas 105
Ananas comosus 19, 20, 91, **105**
Ananas sativa 105
ananasso 105
androgens 58
Andrographidis paniculatae herba 106
Andrographis paniculata 13, 20, 21, **106**
andrographolide 20, ***106***
andromedotoxin ***57***
Anemone spp. 71
aneth 106
Anethi aetheroleum 106
Anethi fructus 106
Anethi herba 106
anethole 50, ***64*, **65
trans-anethole ***166***, ***184***, ***219***
Anethum graveolens **106**
Anethum sowa 106
aneto 106
angel's trumpet 14, 22, 25, **123**
angelic acid ***77***
angelica 107
angelica 66, 77, 107
Angelica archangelica 66, 77, **107**
Angelica atropurpurea 107
Angelica dahurica 107
Angelica sinensis 12, **107**
Angelicae fructus 107
Angelicae herba 107
Angelicae radix 107
Angelicae sinensis radix 107
angelicin ***66***, ***107***
angelique Chinoise 107
angelique de Chine 107
anice stellato 184
anice verde 219
Anis 219
anis étoilé 184
anis vert 219
p-anisaldehyde ***76***
anisatin ***54***, 184
anise 29, **219**
Anisi fructus 29
Anisi stellati frutus 184
anisillo 255
anisodamine 20

anisodine 20
Anisodus tanguticus 20
Ankyropetalum gypsophiloides 60
Annonaceae 82
Anserinae herba 225
Anthemis nobilis 134
anthocyanins 17, 18, 44, 67–69, 178, 163, 264, 265, 271
Anthoxanthum odoratum 66
anthraquinones 72, 233
Anthriscus 67
anthroposophical medicine 10
antiarin 27
Antiaris toxicaria 27
aphrodisiac 10
Apiaceae 28, 50, 52, 54, 57, 66, 67, 73, 77, 104, 106, 107, 108, 129, 132, 138, 144, 145, 152, 165, 166, 193, 216, 219, 220, 243, 270
apigenin ***67***, 213
Apii fructus 108
apiin 216
apio 108
apiol ***64***, 108, ***216***
Apium graveolens **108**
Apocynaceae 52, 62, 63, 81, 82, 86, 96, 133, 179, 203, 206, 232, 252, 259, 268, 272
Apocynum spp. 62
apomorphine 20
aporphine 82
apples 71
apricot vine 213
Aquifoliaceae 183
Arabian coffee 142
arabino-galactans, 260
arabinose ***93***, 104
Araceae 76, 114, 154
Arachis hypogaea 91
arak 240
Aralia elata 108
Aralia japonica 60
Aralia mandshurica 108
Aralia racemosa 15, 18, **108**
Araliaceae 60, 73, 108, 159, 176, 212
araloside A ***60, 108***
arancio amaro 141
arandano commun 265
arbol de las perlas 204
arbol de los escudos 170
arbol de seso 121
arbre à lait 259
arbre aux serpents 232
arbre fricasse 121
arbre-a-encens 122
arbutin ***72***, ***109***, 169, 262
archangel 107
archangelica 107
archangelique 107
arctic root 235
Arctii radix 109
arctinal ***73***, ***109***
Arctium lappa 73, **109**
Arctium majus 109
Arctium minus 109
Arctium tomentosum 109
Arctopus spp. 57
Arctostaphylos uva-ursi **109**
Ardisia japonica 20
Areca catechu 13, 20, 22, 84, **110**
areca nut 110
Arecaceae 110, 163, 248
arecaidine ***84***, 110
arecoline 20, 22, ***84***, ***110***
arenarin 176
arequier 110
Argemone mexicana 110
Argemone ochroleuca 23, **110**
argentina anserina 225
argentine 225
arginine ***88***, ***217***
argousier 179
Argyreia 80
arhar 124
aristolochia 111
Aristolochia clematitis **111**
Aristolochiaceae 73, 111
Aristolochiae herba 111
aristolochic acid I ***111***
aristoloquia 111
Aristotle 10
armoise d'Afrique 113
Armoracia lapathifolia 111
Armoracia rusticana 90, **111**
Armoraciae radix 111
arnica 10, **112**
Arnica chamissonis 54, 112
Arnica fulgens 112
Arnica montana 10, 54, **112**
Arnicae flos 112
Arnika 112
aro gigaro 114
aroeira 245
aroin 26
aromatherapy 10, 29, 32, 50
aromatic acids 76
aronga 175
Aronia 69
Aronia melanocarpa 19, **112**
aronie a fruits noirs 112
Aronstab 114
arpagofito 175
arreteboeuf 210
artabsin 113
artemether 20, 114
Artemisia absinthium 23, 51, 53, **113**
Artemisia afra 9, **113**
Artemisia annua 12, 16, 20, 54, **114**
Artemisia argyri 20
Artemisia cina 55
Artemisia maritima 21, 55
Artemisia spp. 35
Artemisia vulgaris ***55***, 113
Artemisiae africanae herba 113
artemisinin 16, 20, 42, ***54***, ***114***
artesunate 54
artichaut 150
artiglio del diavolo 175
Artischocke 150
Arum maculatum 26, **114**
arum tachete 114
arveira 245
Arzneibaldrian 266
asafoetida 12, ***13***, **165**
Asant 165
β-asarone 95
Asarum europaeum 111
ascaridol ***50***, 51, ***135***
Asclepiadaceae 179, 272
Asclepias tuberosa ***59***
ascophylle 115
Ascophyllum nodosum 19, **115**
ascorbic acid 74, ***77***, 95
ase fétide 165
ashwagandha 13
ashwagandha 16, 22, **272**
Asian ginseng 212
asiatic acid ***132***
Asiatic flea seeds 221
asiaticoside 17, 20, ***60***, 132
Asiatischer Wassernabel 132
Aspalathi linearis herba 115
aspalathin ***68***, ***115***
aspalathus 115
Aspalathus linearis 9, 19, 33, 68, **115**
Asparagaceae 116, 121, 144, 155, 238
Asparagi radix 116
asparagine ***88***, ***116***, 217
asparago 116
asparagus 116
Asparagus officinalis **116**
aspartic acid ***88***
asperge 116
aspergillus 25
Aspergillus flavus 25
asperuloside 222
Asphodelaceae 72, 102, 123
aspirin 10, 20, 42, 165, 239
assafetida 165
assenzio 113
Asteraceae 50, 52, 54, 57, 63, 66, 67, 73, 74, 85, 94, 109, 112, 113, 114, 124, 125, 129, 131, 134, 137, 138, 150, 157, 158, 173, 176, 185, 199, 247, 249, 251, 252, 255, 256, 257, 263
asthma weed 194
Astracantha gummifera 12
astragale 116
Astragali radix 116
astragalo 116
astragaloside A ***116***
astragalus 116
Astragalus gummiferum 75
Astragalus membranaceus **116**
Astragalus spp. 82
Atractylis gummifera 57
atractyloside ***57***, ***125***
Atropa belladonna 10, 20, 22, 26, ***48***, **117**
Atropa spp. 87
atropine 10, 20, 22, 23, 26, 27, 35, ***87***, 117, 151, 182, 246
atroscine 246
aubépine 146
aubour 189
aucubin ***52***, ***221***, 222, 267
Aufgeblasene Lobelie 194
aunée 185
Aurantii pericarpium 29, 141
aurones 67
Australian chestnut ***79***, 82
Australian lemon myrtle 51
Australian traditional medicine 14
autumn crocus 25, 28, ***79***, **143**
avellana d'India 110
avena 117
Avena sativa 19, **117**
Avenae 80
Avenae fructus 117
Avenae herba recens 117
Avenae stramentum 117
Avenzoar 12
Avicenna 12
avoine 117
avorniello 189
Ayahuasca 119
ayahuasca 14, 22, **119**
Ayurvedic medicine 12–13, 47, 86
Azadirachta indica 13, **118**
azadirachtin ***118***
azafrán 146
azulejo 131
azulenes 134
ba jiao xian 184
baby's breath 174
bacc 95
Bach flower remedies 10, 11
Bach, Edward 11
Backhousia citriodora 51
Bacopa 118
bacopa de Monnier 118
Bacopa monnierii **118**
bacopaside 118
bacoside A & B ***118***
badiane de Chine 184
badiane du Japon 184
Badiano, Juan 14
baeocystine 23
bai shao yao 12, 211
bai zhi 107
baicalin ***246***
Baikal skullcap 246
Baikal-Helmkraut 246
Ballonblume 222
balloon flower 222
Ballota africana 119
Ballota foetida 119
ballota nera 119
Ballota nigra 56, **119**
Ballotae nigrae herba 119
ballote 119
ballotenol ***56***, ***119***
balm of Gilead 29, 225
balota 119
balsam poplar 225
Balsam tolutanum 205
Balsaminaceae 72
balsamo del Tolu 205
balsams 29
Banisteriopsis argentea 78
Banisteriopsis caapi 14, 22, **119**
Banisteriopsis rusbyana 78
Banisteriopsis spp. 81
baobab 19, **95**
baobab africano 95
baobab del Africa 95
Barbados aloes 102
barbaloin 102
barbarasco 267
bardana 109
Bardanae folium 109
Bardanae radix 109
bark 28
Barlauch 101
barley 16, 19, **180**
Barosma betulina 98
Barosmae folium 98
Basilic sacre 208
basket willow 239
bastard star anise 184
bathing 34
baumier de Tolu 205
Baumtabak 207
bear's garlic 19, **101**
bearberry 109
Beech, Wooster 14
been 204
Behaarter Knorpelbaum 136
behen oil 19, 204
behenic acid ***204***
belladonna 117
belladonna 117
Belladonnae folium 117
Belladonnae radix 117
belladonne 117
ben 204
Ben Cao Gang Mu 12
ben oil 19, 204
ben oleifere 204
ben tree 204
Benediktenkraut 131
bengkudu 203
benzaldehyde 109
benzodiazepines 221
benzoic acid 29, 76, 77, 124, 205
benzoin 14, ***15***
benzyl benzoate 20, ***205***
benzyl glucosinolate 262
benzyl isothiocyanate ***240***, 262
Berberidaceae 67, 82, 120, 223
Berberidis cortex 120
Berberidis fructus 120
Berberidis radici cortex 120
Berberidis radix 120
berberine 20, ***82***, 110, ***120***, 135, ***145***, 181, 197, ***217***
Berberis aquifolium **197**
berberis commun 120
Berberis vulgaris 20, **120**
berbero 120
bergamot oil 141
bergapten ***66***, ***104***, 153
bergenin 20
Bergwohlverleih 112
berro de huerta 192
Besenginster 150
beta glucan 18
Beta vulgaris 71
betacyanins 68
betalains 68
betanidin 69
betanin ***69***
betel nut 13, 22, 35, 84, 110
betel vine 22, 110
Betelnusspalme 110
betonicine 94
Betula alba 20
Betula pendula **120**
Betulaceae 120

Betulae cortex 120
Betulae folium 120
Betulae gemmae 120
Betulae pix 120
betulinic acid 20
betulla bianca 120
bhunimba 106
bianco spino 146
biflavonoids 170
Bignoniaceae 72, 188
bilberry 19, **265**
Billia hippocastanum 89
bilobalide ***54***, 170
Bilsenkraut 182
biochanin A 261
birch 120
birthwort 111
bisabolane 148
α-bisabolene ***134***
α-bisabolol 16, 20, ***53***, ***199***
Bischofskraut 270
bishop's weed 104
bismalva 104
bitter aloe 19, **102**
bitter apple 141
bitter lettuce 22
bitter orange 141
bitter secoiridoids 17
bitter tea 32
bitter tonic 102, 113, 164, 175, 176, 231
Bitterklee 202
Bittermelone 141
Bitterorange 141
Bittersüßer Nachtschatten 250
bittersweet 28, **250**
black chebulic 258
black chokeberry 19, **112**
black cohosh 15, 16, **139**
black cumin 208
black horehound 56, **119**
black mint 255
black mustard 90, ***91***
black myrobalan 258
black nightshade 250
black seed 19, **208**
black snakeroot 139
blackberry 238
blackcurrant 19, **236**
blackthorn 228
bladder tea 32
bladder wrack 19, 115
Blasser Sonnenhut 157
Blaubeere 265
Blauer Eisenhut 94
Blaugrüner Tabak 207
Blaugummibaum 161
blessed thistle 131
bleuet 131
Blighia sapida 89, **121**
blond psyllium 221
bloodroot 16, **242**
blue cornflower 131
blueberry 19
bluegum 14, 51, **161**
Blutwurz 226
bogbean 202
bois amer 231
bois de Chine 100
bois de gaïac 173
bois de vie 173
bois jentil 151
bois joli 151
boldine ***83***, ***216***
boldo 14, **216**
Boldo 216
Boldo folium 216
bolsa de pastor 127
Bombacaceae 95
bonaga 210
bonhomme 205
Boophone disticha 9, 22, **121**
borage 122
borage seed oil 19
Boraginaceae 69, 85, 122, 177, 254
boragine 122
Boraginis flos 122
Boraginis herba 122
Borago officinalis 19, **122**
Bornarea spp. 71
borneol 20, ***50***, 113, 173, 211
bornyl acetate 266, 220
borraja 122
Borretsch 122
borsa del pastore 127
Boswellia carteri 122
Boswellia sacra 9, 29, **122**
α-boswellic acid ***122***
botanicals 15, 46
boton de oro 96
bouleau blanc 120
bourdaine 233
bourrache 122
bourse-a-pasteur 127
bovoside 25
Bowiea volubilis 25
bowienine 25
bracken fern 230
brahmi 118
brahmi 132
bramble 238
Brasilian cocoa 213
Brassica campestris ***59***
Brassica nigra 20, 90, ***91***
Brassica rapa ***59***
Brassica spp. 89
Brassicaceae 62, 90, 111, 127, 192
Brassicales 90
Brazilian cocoa 19
Brazilian cress 14
Brechnussbaum 253
Brechwurzel 229
broad-leaved peppermint gum 51
Brombeere 238
bromelain 20, 91, ***105***
Bromelainum crudum 105
Bromeliaceae 105
brouillard 174
brucine 26, 253
Brugmansia 123
Brugmansia suaveolens 14, 22, 25, **123**
Brustbeerbaum 273
Bryonia dioica ***59***
bucaneve 168
Bucco 98
buchu 9, **98**
buchu camphor 98
buckthorn 19, **179**, **233**
buckwheat 164
bufadienolides 25, 26, 62, 155, 177
bufotenin 23, ***78***, ***105***
bugleweed 16, **197**
bugrane epineuse 210
bulb 28
bulbine 123
Bulbine 123
Bulbine frutescens **123**
bulbus 28
Bunium persicum 208
buphanidrin 22, ***121***
burdock 73, **109**
burn jelly plant 123
burnet 242
burning bush 153
Bursae pastoris herba 127
Burseraceae 50, 52, 122, 143
Büschelbohne 148
bushman poison bulb 9, 22, **121**
bushman's poison 25, ***27***
busserole officinale 109
butcher's broom 238
butterbur 16, 77, **215**
sec-butyl propenyl disulfide ***165***
3-butylphthalide 108, 193
butyric acid ***76***
Buxaceae 86
buxamine E ***86***
Buxus spp. 86
caapi 119
cacao 14, 19, 22, 69, **258**
Cacao oleum 258
cacao real 258
Cacao semen 258
cacaotier 258
cacaoyer 258
Cactaceae 78, 195
cade juniper 53
α-cadinene ***53***
α-cadinol ***124***
caféier d'Arabie 142
cafeto 142
caffè 142
caffeic acid 16, 17, ***77***, 158, 166, 225, 268
caffeine 20, 22, 23, ***84***, 125, ***142***, ***183***, ***213***, 258
caiano 124
Cajanus cajan **124**
calabar bean 9, 25, 81, **218**
Calabarbohne 218
calabaza 147
calamene 262
calamo aromatico 95
calamus 95
calcium oxalate ***154***
Calea ternifolia 22
calendola 124
calendula 124
Calendula officinalis **124**
Calendulae flos 124
Calendulae flos sine calyce 124
Californian poppy ***79***
Callilepis laureola 57, **125**
Camellia sinensis 12, 19, 20, 21, 23, 32, 77, 84, **125**
camfora 140
camomilla 199
camomilla romana 134
camomille 199
camomille romaine 134
Campanulaceae 73, 74, 194, 222
campesterol ***59***, 227
camphene ***50***, 51, 95, 256, 273
camphor 20, 29, ***50***, 51, 94, 113, ***140***, 173, 237, 256
camphor tree 51, **140**
Camphorae aetheroleum 29
camphrier du Japon 140
camptotheca 126
camptotheca 126
Camptotheca acuminata 20, 21, 81, **126**
camptothecin 20, ***81***, ***126***
camu camu ***19***
Canadian aspen 225
Canadian goldenrod 251
canamo 127
canapa indiana 127
canapa selvatica 168
Canavalia ensiformis 89
L-canavanine ***89***, 193, 200
cancer bush 193
cancer tree 126
Canella winterana ***15***, **126**
Canellaceae 126, 271
canelle de Ceylan 140
canellier 140
canelo de Ceilán 140
Cannabaceae 127, 181
cannabinoids 22, 127
cannabis 22, 23, 34, 127
Cannabis indicae herba 127
Cannabis sativa 13, 21, 22, **127**
cannella 140
cannelle blanche 126
canola oil 59
Canon Medicinae 12
Cape aloe 9, 19, **102**
Cape Herbal Medicine 8
Capparaceae 90
Caprifoliaceae 90, 241
capsaicin 16, 20, ***128***
capsella 127
Capsella bursa-pastoris **127**
capsianoside ***56***
Capsici fructus 128
Capsici fructus acer 128
Capsicum anuum 128
Capsicum frutescens 15, **128**
Capsicum spp. 16, 20
capsule 30
capucine grande 262
caraway 12, **129**
caraway seed oil 51
carbohydrates 74
β-carboline 23, 22, 214
carboxylic acids 76
carcade 178
carciofo 150
cardamom 13, **158**
Cardamomi aetheroleum 158
Cardamomi fructus 158
cardamomier 158
cardamomo 158
cardanol 245
cardenolides 26, 27, 62, 96, 133, 162, 206, 259
cardiac glycosides 25, 26, 27, 41, 48, 59, 62, 96, 133, 144, 154, 155, 162, 252, 272
cardiaco 192
cardioactive glycosides 27
cardo mariano 249
cardo santo 131
Cardui mariae fructus 29, 249
carduo mariano 249
Carica papaya 20, 21, 91, **128**
Caricaceae 128
Caricae papayae succus 128
carminative tea 32
carnosic acid ***241***
carnosol 241
carob powder 19
carob seed gum 75
carob tree 133
carota 152
carotene 18, 20, 63, ***152***
α-carotene ***63***
β-carotene 18, ***63***, 179, 195, 237
carotenoids 18, 63, 128, 162, 179, 195, 237
carotol 53
carotte 152
caroubier 133
Carpobrotus edulis 77
carrageenans ***136***
carragheen 136
carrot 63, 66
carrot juice 19
carrot seed oil 53
carrubio 133
cartamo 129
carthame 129
Carthami flos 129
Carthami oleum 129
carthamine 129
Carthamus tinctorius 12, 19, **129**
Carum carvi 12, 51, **129**
carvacrol ***50***, 51, 159, ***210***, 260
carveol 129
carvi 129
Carvi aetheroleum 129
Carvi fructus 129
carvone ***50***, 51, ***106***, ***129***, 159
Caryophyllaceae 60, 99, 174, 178, 244
Caryophyllales 68
α-caryophyllene 208
β-caryophyllene ***53***, 94, 97, ***208***, 255
Caryophylli aetheroleum 255
Caryophylli flos 28, 255
cascara sagrada 234
cascara sagrada tree 234
cascaroside ***234***
cassaine 26
cassava ***91***
Cassia acutifolia 248
Cassia angustifolia 248
Cassia senna 248
cassis 236
castagna amare 97
castalagin 232
castano de Indias 97
castanospermine 79, ***82***
Castanospermum australe ***79***, 82
casticin 270

castor oil 29
castor oil plant 9, 25, 29, ***91***, **236**
cat's claw 14, **263**
catalpol ***52***, ***222***, 267
catechin gallates 226
catechin tannins ***98***, 187, 226
catechins 18, 20, 67, ***69***, 98, 125, 174, 183, 213, 224, 232
catechol ***64***
catha 130
Catha edulis 9, 23, 84, **130**
catharanthine 130
Catharanthus roseus 21, 81, **130**
cathine 23
cathinone 23, ***84***, ***130***
cayenne 15
cebada 180
cebolla 100
cedronella 201
Celastraceae 62, 130, 162
celerei 108
celery 108
celery seed oil 53
celidonia 135
cell toxin 25
celliamine 26
cellulose 74
centaura menor 132
Centaurea benedicta 54, **131**
Centaurea cyanus **131**
centaurea minore 132
Centaurii herba 132
Centaurium erythraea **132**
Centella asiatica 13, 17, 20, 60, 65, 118, **132**
Centellae asiaticae herba 132
Centellae folium 132
centinodia 224
Cepae bulbus 28
cephaeline ***83***, 229
Cephaelis ipecacuanha 229
cepharanthine ***83***
Ceratonia siliqua 19, 75, **133**
Cerbera manghas 133
Cerbera odollam 13, 27, **133**
cerberin ***133***
Cestrum parqui 14
Cetraria islandica 17, **134**
Cetrariae lichen 134
cetraric acid ***134***
cevadine 26
Ceylon cinnamon 140
Ceylon-Zimtbaum 140
chaconine 86
chacruna 22
chai 12, 32, 125
chai 125
chalcones 67, 68, 129, 176
Chamaemelum nobile 28, 77, **134**, 199
chamazulene 53, 173, 199
chamomile 10, 16, 28, 53, **199**
Chamomilla recutita 199
Chamomillae romanae aetheroleum 134
Chamomillae romanae flos 28, 134
chanvre 127
chanvre bâtard 168
chardon bénit 131
chardon Marie 249
chaste tree 16, **270**
chaudron 205
chavicol 22
Chebula-Myrobalane 258
chebulic acid ***70***, ***258***
chebulic myrobalan 258
chebulin 258
chebulinic acid 258
checkerberry 169
Cheiranthus 62
chélidoine 135
Chelidonii herba 135
chelidonine ***83***, ***135***
Chelidonium majus 83, **135**
chemotypes 44
chene blanc 232
chénopode anthelmintique 135
Chenopodii aetheroleum 135
Chenopodium ambrosioides 14, ***15***, **135**
Chenopodium ambrosioides var. *anthelminticum* 135
che-qian-zi 221
cherry laurel 228
cherry pie 177
chia 19
chickling vetch 190
chicorée sauvage 138
Chicorii herba 138
Chicorii radix 138
chicory 54, 75, **138**
chieh keng 222
chiendent officinal 159
Chilean cardinal flower 22
Chilean false heath 164
Chili 128
chilli pepper 15, 16, **128**
china rossa 139
Chinae cortex 28
Chinese agrimony 98
Chinese angelica 107
Chinese anise 184
Chinese bellflower 222
Chinese date 19, **273**
Chinese goldthread 145
Chinese medicine 12
Chinese mock-barberry 16, **245**
Chinese motherwort 192
Chinese rhubarb 234
Chinese rubber tree 162
Chinese wolfberry 19, **195**
Chinese wormwood 16, **114**
Chinesische Beerentraube 245
Chinesische Engelwurz 107
Chinesische Pfingstrose 211
Chinesischer Bocksdorn 195
Chinesischer Goldfaden 145
Chinesischer Tragant 116
Chinesisches Helmkraut 246
Chinesisches Spaltkölbchen 245
chiodi di garofano 255
chlorogenic acid ***65***, ***77***, 183, 239, ***241***, 243
chocolate 14, 19
chokeberry 19
cholesterol ***58***
Chondrodendron spp. 83
Chondrodendron tomentosum 14, 21, 26, **136**
Chondrus crispus 75, **136**
Christmas cherry ***87***
Christuspalme 236
chrysantemo 137
chrysanthediol A ***137***
chrysanthème des fleuristes 137
Chrysanthemi flos 137
chrysanthemum 137
Chrysanthemum cinerariifolium 21, **137**
Chrysanthemum ×morifolium **137**
chrysanthenyl acetate 113, 256
chrysophanol 123, 234
chuan xin lian 106
chymopapain 20
cicerchia 190
cichoric acid ***65***, ***158***
Cichorium intybus 65, 75, **138**
cicoria 138
cicuta aquatica 138
Cicuta maculata 138
cicuta maggiore 144
Cicuta virosa **138**
Cicutae herba 138
cicutol 138
cicutoxin ***138***
cigué aquatique 138
cigué tachée 144
cilantro 145
cimicifuga 139
Cimicifuga racemosa 15, 16, **139**
Cimicifugae racemosae rhizoma 139
cimicifugoside 139
cimigenol 139
Cinchona ledgeriana 21
Cinchona officinalis 139
Cinchona pubescens 14, **139**
Cinchona spp. 28
Cinchona succirubra 139
Cinchonae cortex 139
cinchonidine 85
1,8-cineole 17, ***50***, 51, 94, 113, 140, ***158***, ***161***, 200, 237, 270
cinerognola 135
cinnamaldehyde ***140***
cinnamates 256
cinnamic acid 29, ***77***, 205
Cinnamomi camphorae aetheroleum 140
Cinnamomi ceylanici cortex 140
Cinnamomum camphora 29, 51, **140**
Cinnamomum verum 13, **140**
Cinnamomum zeylanicum 140
cinnamon bark 126
cinnamon bark tree 13, **140**
Cinnamonum camphora 20
cipolla 100
cissampeline 20
Cissampelos pareira 20
Cistus creticus 56
Cistus ladanifer 56
citral ***50***, 51, 103, 201
citric acid ***76***, 256
citronella 149
citronella oil 53
citronellal ***50***, 51, ***201***
citrouille 147
Citrullus colocynthis 59, **141**
Citrullus lanatus 141
Citrus aurantium 29, **141**
Citrus aurantium subsp. *aurantium* 141
Citrus aurantium subsp. *bergamia* 141
Citrus spp. 20
citumbulo 203
Clausena 81
clavero 255
Claviceps purpurea 22, 26, 80
Cleistanthus collinus 26
cleisthanin A, B 26
climbing lily 25, **171**
climbing potato 25
clinical studies 42
Clivia miniata ***79***
clove oil 53
clove tree 14, 28, **255**
cluster bean 19, **148**
Cnici benedicti herba 131
cnicin ***54***, ***131***
Cnicus benedictus 54, 131
coca 161
coca plant 14, 22, 87, **161**
Cocae folium 161
cocaine 20, 22, ***87***, ***161***
cocal 161
cocalier 161
cocomero asinino 157
Cocos nucifera 71
coda di cavallo 160
codeine 20, 23, ***83***, 212
Codex de la Cruz-Badiano 14
Coffea arabica 9, 20, 22, 84, **142**
Coffeae semen 142
Coffeae tostae carbo 142
coffee tree *9*, 22, **142**
cohoba 105
cola 142
Cola acuminata 84, **142**
Cola nitida 84
cola nut tree 142
Colae semen 142
colatier 142
Colchicaceae 79, 143, 171
colchicaine amide 20
Colchici semen 143
Colchici tuber 143
Colchici tuber 28
colchicine 20, 25, 26, ***27***, ***79***, ***143***, ***171***
colchico 143
Colchicum autumnale 20, 25, 28, ***79***, **143**
colchique d'automne 143
colocynth 141
coloquinthe 141
coloquintide 141
cólquico 143
coltsfoot 263
colubrine 26
column chromatography 36
Combretaceae 258
comfrey 85, **254**
Commiphora molmol 143
Commiphora myrrha 9, 29, **143**
common agrimony 98
common ash 167
common barberry 120
common bean 217
common broom 150
common centaury 132
common clubmoss 196
common fig ***48***
common ivy 176
common mallow 198
common melilot 201
common oak 232
common ragwort 247
common snowdrop 168
common storax 29
common valerian 266
Compendium of Simple Medicaments and Foods 12
concombre sauvage 157
condensed tannins 69, 110, 166, 189, 224, 232, 264, 265
conhydrine 26
γ-coniceine 144
conifers 50
coniine 26, ***84***, ***144***
Conium maculatum 10, 11, 26, 84, **144**
conjunctival application 34
conocarpan 189
consolida maggiore 254
Consolida regalis 26
contaminants 40, 99
Convallaria majalis 20, 101, **144**
Convallaria spp. 62
Convallariaceae 62, 144
Convallariae herba 144
convallatoxin 20, ***144***
Convolvulaceae 80, 185
α-copaene 262
coptide chinois 145
Coptidis rhizomae 145
Coptis chinensis **145**
Coptis japonica 21, 145
Coptis teeta 145
Coptis trifolia 145
coral pea *91*, **93**
coral tree ***87***
corchorin 26
Corchorus olitorius 26
coriander 66, **145**
coriandolo 145
coriandre 145
Coriandri aetheroleum 145
Coriandri fructus 145
Coriandrum sativum **145**
corkwood duboisia 22, **156**
corm 28
corn cockle 99
corn oil 59
Cornaceae 126
cornin 268
cornmint 51
Cornus officinalis ***48***
cortex 28
cortisone ***58***, 61
Corydalis ambigua 21

Corynanthe yohimbe 214
costunolide ***54***
cottide 145
cotton ***53***
Cotyledon orbiculata 62, ***63***
Cotyledon spp. 62
couchgrass 159
coucou 226
p-coumaric acid **77**
coumarin 26, 65, ***66***, ***201***
coumaroylputrescine ***65***
cowbane 138
cowberry 19, **265**
cowslip 226
crab's eye vine 93
crack willow 239
cranberry 11, 19
Crassulaceae 62, 235
Crataegi folium cum flore 146
Crataegus laevigata 146
Crataegus monogyna 17, 70, **146**
Crataegus pinnatifida 146
Crataegus spp. 69
cravo de defuncto 255
cren 111
crescione 192
p-cresol ***64***
crespino 120
cress 19, **192**
cresson alénois 192
cresson d'Inde 262
cresson de Para 251
cresta di gallo 167
crocetin ***63***, ***146***
Croci stigma 28, 146
crocin 63
crocus autumnale 143
Crocus sativus 28, 63, **146**
Crotalaria sessiliflora 21
Crotalaria spp. 85
Crotalarieae 85
crotin 27, 147
Croton flavens 57
croton oil 77
croton revulsif 147
Croton tiglium 14, 27, 77, **147**
crotone 147
crotonic acid ***147***
crotonide 27, 147
cryogenine 23
cryptoxanthin ***63***
cuckoo pint 26
Cucurbita pepo 59, **147**
Cucurbitaceae 59, 89, 141, 147, 157
cucurbitacin B ***59***, ***141***
cucurbitacin E 157
cucurbitacin I ***157***
cucurbitacins 59, 141
Cucurbitae peponis semen 147
cucurbitine 147
Culpeper, Nicholas 10
cumino tedesco 129
cupana 213
Cupressaceae 52, 187, 259
Cupressus spp. 187
Curaçao aloe 102
curare 136
curare alkaloids 24
curare vine 26, **136**
curarine 26
curbana 126
curcanoleic acid 186
curcin 186
Curculigo latifolia 20
curculin 20
curcuma 148
Curcuma domestica 148
Curcuma longa 13, 20, 66, **148**
Curcumae longae rhizoma 148
curcumene 273
curcumin 20, 66, ***148***
curcusone A ***186***
curcusone C 186
curly-cup gumweed 173
cuskohygrine 22
Cyamopsis senegalensis 148
Cyamopsis tetragonolobus 19, 75, **148**
Cyani flos 131
cyanidin 18, ***69***, ***131***, 236, 271
cyanidin 3-*O*-galactoside ***112***, ***265***
cyanidin-3-*O*-glucoside ***163***
L-β-cyanoalanine ***89***
cyanogenic glucosides 26, 27, 88, 90, 91, 114, 154, 194, 213, 228, 230, 261, 262
Cycadaceae 89
Cycadales 89
Cycas spp. 89
cyclobuxine D ***86***
cyclopamine 267
cyclopia 149
Cyclopia genistoides 21, **149**
Cyclopia intermedia 149
Cyclopia subternata 149
cymarin 27, ***96***
D-cymarose 96
Cymbopogon citratus **149**
Cymbopogonis citrati herba 149
p-cymene ***50***, 95, 210
Cynara cardunculus **150**
Cynara scolymus 20, 150
Cynarae folium 150
cynarin 20, ***150***, ***157***
cynaropicrin 150
cynoglossine 177
cysteine ***88***
cytise faux ébénier 189
Cytisi scoparii herba 150
cytisine ***85***, ***189***
Cytisus scoparius 21, 85, **150**
cytotoxins 24
da guo yue jie 264
da huang 12, 234
da zao 12
dai hoang 234
daidzein ***68***, 171, 230, 261
daidzin 230
Dalmatiner Insektenblume 137
Dalmation chrysanthemum 137
Damask rose 12
damiana 14, 15, **262**
Damiana 262
Damiana diffusa var. *aphrodisiaca* 262
Damianae folium 262
damnacanthal ***203***
dandelion 54, 75, **257**
dang gui 12, **107**
dantron 20
Daphne genkwa 21
Daphne mezereum 26, 57, **151**
Daphneae cortex 151
daphnetoxin ***57***, ***151***
daphnin 26, 151
Datura metel 21
Datura spp. 34, 35, 87
Datura stramonium 14, 23, 27, ***87***, **151**
Dauci carotae fructus 152
Dauci carotae herba 152
Dauci carotae radix 152
Daucus carota 19, 20, 63, **152**
Daucus carota subsp. *carota* 152
Daucus carota subsp. *sativa* 152
De Lobel, Matthias 10
De Materia Medica 10
deadly nightshade 10, 22, 26, ***48***, **117**
dead-man's tree 26
death camas 26
death cap 26
decoction 30
decoctum 30
dehydrolycopodine 196
delcosine 26
delphinidin 18, ***69***, 236, 264, 265
delphinine 26
Delphinium elatum 26
demecolcine 20
Dennstaedtiaceae 230
dent de lion 257
deoxyschizandrine 245
derris 152
Derris eliptica 21, **152**
derris root 152
deserpidine 20
desert rose 9, 26, **96**
desert tea *22*, **160**
designer drugs 22
deslanoside 20
devil's claw 9, 16, 28, **175**
devil's dung 165
N,N-diallyllysergic acid amide 80
L-α-γ-diamino butyric acid 89
diarylheptanoids 66
Dichapetalaceae 153
Dichapetalum cymosum 27, **153**
dictame blanc 153
dictamine 27, ***86***, ***153***
Dictamnus albus **153**
Dictamnus fraxinella 153
didrovaltrate 17, 23, 266
Dieffenbachia maculata 154
Dieffenbachia seguine **154**
Dieffenbachie 154
diente de leon 257
dietary fibre 18, 75
dietary supplements 46
Digenea simplex 21
digitale laineuse 154
digitale lanata 154
digitalin 20
Digitalis lanata 20, 21, **154**
Digitalis lanatae folium 154
Digitalis lutea 154
Digitalis purpurea 20, 26, 62, 154
Digitalis spp. 62
digitoxin 20, 26, ***62***, ***154***
digoxin 20, 26, 154
dihydrofoliamenthin ***202***
3-butyl-4,5-dihydrophthalide 108
dihydrotagetone ***50***, ***255***
1,8-dihydroxyanthracene glycosides 233
2,3-dihydroxybenzoic acid ***76***
2,4-dihydroxybenzoic acid ***77***
dill 106
Dill 106
dillapiole 106
dimeric ellagitannins 238
N,N-dimethyltryptamine ***78***
N,N-dimethyltyramine ***78***
dioscin 61
dioscorea 155
Dioscorea elephantipes ***61***
Dioscorea villosa 20, 61, **155**
Dioscoreaceae 155
Dioscoreae tuber 155
Dioscorides 10, 198
dioscorine 155
diosgenin 20, ***61***, 116, ***155***, ***261***
diosmin 98
diosphenol ***98***
Diptam 153
Dipterocarpaceae 50, 52
Dipteryx odorata 66
distillation 36
diterpene alkaloids 79, 94,
diterpene lactones 16, 55, 56, 106, 170, 199, 273
diterpene pseudoalkaloids 27, 257
diterpenes 16, 22, 27, 50, 56, 57, 119, 173, 192, 211, 236, 237, 257, 270
diterpenoid alkaloids 26
diterpenoids 27, 56, 57, 100, 186, 240, 241
dittamobianco 153
dittany 153, 210
diviner's sage 240
Djamboe folium 229
N-N-DMT 22, 23
5-MeO-DMT 23
DNA fingerprinting 39
Docecad 80
docetaxel ***80***, 257
doctrine of signatures 8
dog rose 237
Dornige Hauhechel 210
dosage 40
dosage forms 30
dosas 13
douce-amère 250
downy hemp-nettle 168
Drachenblutbaum 175
dream herb 22
Drimia maritima 10, 21, 28, 62, **155**
Drimys aromatica 53
Drosera peltata 156
Drosera ramentacea 156
Drosera rotundifolia **156**
Drosera spp. 72
Droseraceae 72, 156
Droserae herba 156
droserone ***72***, ***156***
drumstick tree 204
du zhong 162
Duboisia 156
Duboisia hopwoodii 14
Duboisia myoporoides 22, **156**
Duboisia spp. 87
duboisie 156
dulcamara 250
Dulcamarae stipites 28, 250
early goldenrod 251
Ebers Papyrus 12, 198
Ecballium elaterium **157**
ecdysone ***58***
echinacea 15, 16, **158**
echinacea 158
Echinacea angustifolia 73, 157
Echinacea pallida 17, **157**
Echinacea purpurea 15, 65, **158**
Echinacea spp. 16, 65, 73
Echinaceae pallidae radix 157
Echinaceae purpureae herba 158
Echinaceae purpureae radix 158
échinacée 157, 158
echinaceine ***73***, 157, 158
Echinops kebericho 8
Echium spp. 69
Echte Aloe 102
Echte Barentraube 109
Echte Goldrute 251
Echte Kamille 199
Echte Vanille 266
Echter Alant 185
Echter Buchweizen 164
Echter Dost 210
Echter Erdrauch 167
Echter Galgant 103
Echter Kreuzdorn 233
Echter Lavendel 191
Echter Salbei 241
Echter Steinklee 201
Echter Sternanis 184
Echter Thymian 260
Echtes Johanniskraut 182
Echtes Mädesüß 165
Echtes Tausendgüldenkraut 132
Ecstasy 22, 195
edera 176
edera velenosa 235
efedra 160
Efeu 176
efficacy 42
eglantier 237
Egyptian lupin ***87***
Eibe 257
Eibisch 104
Eingriffeliger Weißdorn 146
Einjahriger Beifus 114
Eisenkraut 268
ela 13, 158
elder 241
elderberry tree 241
Eleagnaceae 179
eléboro blanco 267
elecampane 185

elecampane camphor 185
elemicin ***64***, 204
elephant's foot ***61***
Elettaria cardamomum 13, **158**
eleuthero 159
Eleutherococci radix 159
Eleutherococcus senticosus ***48***, **159**
éleuthérocoque 159
eleutheroside D ***159***
elfdock 54, **185**
elicriso arenario 176
ellagic acid ***70***, 76, ***225***, 229
ellagitannins 70, ***99***, 165, 166, 174, 218, 226, 232, 238, 242, 258
elleboro verde 177
elymoclavine 80
Elymus repens 75, **159**
Embelia schimperi 8
emblic 218
emetine 20, ***83***, ***229***
emodin ***233***, 234
emodinanthrone 233
empathogens 22
endod 60, ***61***
enebro común 187
eneldo 106
enemas 34
Engelstrompete 123
Engelwurz 107
English walnut 186
English yew 26, ***27***, **257**
enothera 209
entheogens 22
enula campana 185
Ephedra 160
ephedra 22, **160**
Ephedra sinica 12, 22, **160**
Ephedra spp. 20, 21, 84
Ephedraceae 160
Ephedrae herba 160
Ephedrae radix 160
ephedrine 20, 22, ***84***, ***160***
epicatechin 18, ***69***, 175, 213
epicutaneous application 35
epigallocatechin gallate ***125***
epigallocatechins 18
epine-vinette 120
epoxypseudoisoeugenol ***220***
Equisetaceae 160
Equiseti herba 160
equiseto dei campi 160
equisetolic acid 160
Equisetum arvense **160**
Equisetum palustre 160
erba di San Giovanni 182
erba fragolina 243
ergine 23, 80, ***185***
erginine 23
ergocristine 80
ergometrine 23, ***80***
ergostane 16
ergot 22, ***25***, 26
ergot alkaloids 22, 23, 26, 80
ergotamine 26, ***80***
Ericaceae 57, 72, 109, 169, 264, 265
erniaria 178
Erysimum 62
erysovine ***83***
Erythrina alkaloids 83, 87
Erythrina caffra 83
Erythrina lysistemon 83, ***87***
Erythronium 71
erythrophleine 26
Erythrophleum suaveolens 9, 26
Erythroxylaceae 161
Erythroxylon novogranatense 161
Erythroxylum coca 14, 20, 22, 87, **161**
Eschscholzia californica ***79***, 83
eseramine 25
eseridine 81
esparrago 116
espino albar 146
espino cerval 233
espino cerval de mar 179
essential oil 10, 16, 17, 23, 27, 29, 32, 35, 36, 38, 48, 50, 51, 52, 64, 66, 77
estradiol ***58***
estragole ***6***
estramonio 151
ethanol 22, ***71***
ethylmaltol 213
etoposide 20, 223
eucalipto 161
Eucalypti aetheroleum 161
Eucalypti folium 161
eucalypto 161
eucalyptol 51, 140, 161, 200
eucalyptus 161
Eucalyptus dives 51
Eucalyptus globulus 14, 51, **161**
Eucalyptus spp. 77
eucommia 162
Eucommia ulmoides **162**
Eucommiaceae 162
Eucommiae cortex 162
eudesmic acid ***77***
eugenol 20, 22, 23, 50, ***64***, 65, 126, 140, 204, 208, 229, ***255***
eugenyl acetate 255
Eukalyptus 161
Euonymus europaeus **162**
Euonymus spp. 62
euphorbe des jardiniers 163
Euphorbia peplus 21, 57, **163**
Euphorbiaceae 57, 63, 89, 90, 100, 147, 163, 186, 236
European ash 167
European barberry 120
European box 86
European goldenrod 251
European medicine 10
European mistletoe 269
European spindle 162
European squill 28, 62
Eurycoma longifolia 14
Euterpe oleracea 18, 76, **163**
evening primrose 16, **209**
evening primrose oil 19, 209
evobioside 162
evomonoside ***162***
evonine 162
evonoside 26, 162
extract 30
extraction 36
extractum 30
Fabaceae 60, 66, 67, 72, 82, 84, 85, 89, 90, 91, 93, 105, 115, 116, 124, 133, 148, 149, 150, 152, 171, 172, 189, 190, 193, 200, 201, 205, 210, 217, 218, 230, 253, 256, 261
Fabiana imbricata **164**
Fabiane 164
fabiane imbriquée 164
fabianine ***164***
Facherlilie 121
Fagaceae 232
fagarine ***86***
fagiolo 217
Fagopyri herba 164
fagopyrine 164
Fagopyrum esculentum 21, **164**
falcarinol ***73***, 176
Falscher Jasmin 169
false hellebore 267
false morels 26
fan qie 196
Farberdistel 129
farfara 263
farfaraccio 215
Farfarae folium 263
farfaro 263
farnesol ***52***
fatty acids 16, 18, 29, 76, 147, 171, 192, 237, 248, 249
fatty oil 29
Faulbaum 233
fava del Calabar 218
felce aquilina 230
Feldstiefmütterchen 269
Fenchel 166
fenchone 166
fennel 29, **166**
fenouil 166
fénugrec 261
fenugreco 261
fenugreek 12, 16, 19, 29, 75, **261**
Ferula assa-foetida 12, ***13***, **165**
Ferula communis ***77***
Ferula foetida 165
férule persique 165
ferulic acid ***77***, 167, 225
Festucaceae 80
feve de Calabar 218
fève de soja 171
feverfew 16, 55, **256**
ficin 91
Ficus carica ***48***
Ficus glabrata 91
Fieberklee 202
field horsetail 160
fieno-greco 261
figwort **53**
Filipendula ulmaria 20, 64, **165**
Filz-Königskerze 267
finocchio 166
fioraliso 131
five elements 12
Flachs 194
flame lily 26, ***27***, **171**
flavan-3-ol ***69***, 215
flavanes 176
flavanolignans 17, 249
flavanols 176, 258
flavanones 18, 67, 68
flavones 67, 134, 149, 152
flavonoids, 16, 17, 18, 38, 44, 48, 64, 67, 69, 73, 94, 98, 103, 112, 120, 124, 127, 129, 131, 132, 146, 150, 152, 160, 161, 162, 163, 164, 166, 167, 168, 170, 172, 173, 176, 178, 179, 180, 182, 183, 186, 197, 191, 192, 193, 196, 197, 198, 199, 201, 202, 206, 208, 209, 211, 213, 215, 216, 218, 222, 225, 226, 228, 229, 230, 235, 236, 237, 238, 239, 241, 243, 246, 248, 251, 253, 255, 257, 258, 259, 260, 265, 267, 269, 270, 273
flavonol glycosides 170
flavonols 18, 67
flax 16, 19, **194**
flax seeds 75
flea seeds 221
fleawort 221
Fleischfarbene Passionsblume 213
fleur de la passion 213
fleur des dames 177
Flohkraut 221
flos 28
flowers 28
fluoroacetic acid 153
fluorocitrate 153
fly agaric 22, 23, ***25***, 26
Foeniculi fructus 29, 166
Foeniculum vulgare 29, **166**
Foenugraeci semen 29, 261
Folia Bucco 98
folium 28
Folium Nelumbinis 206
foraneve 168
formic acid ***76***
formononetin 139, 210, ***261***
forskolin ***56***
fougere aigle 230
four humours 10
four temperaments 10
foxglove 26
Fragaria vesca 70, **166**
Fragariae folium 166
fragola di bosco 166
fragrant agrimony 98
fraisier des bois 166
frangola 233
frangufoline ***273***
Frangula alnus 233
Frangulae cortex 233
frangulin A ***72***
frangulins 233
frankincense 10, 29, 122
frankincense tree 9, **122**
frassino 167
fraxinelle 153
fraxinellon 153
Fraxini cortex 167
Fraxini folium 167
Fraxinus excelsior **167**
Fraxinus ornus 74, 167
Fraxinus rhynchophylla 20
French bean 217
frêne élevé 167
fresera 166
fresno 167
Fritillaria 71
fructans 75, 116, 254
fructose ***74***
fructus 28
Fruhlings-Adonisroschen 96
fruit 28
fruit miraculeux 254
Fucaceae 115
Fuchs, Leonhart 10
fucoidan 115
Fucus vesiculosus 19, 115
fumaria 167
Fumaria officinalis **167**
Fumariae herba 167
fumaric acid 167
fumarine 167
fumaroprotocetraric acid 134
fumeterre officinale 167
fumitory 167
functional foods 18
furanocoumarins 48, 66, 104, 107, 152, 153, 166, 220, 239, 270
furanoeudesma-1,3-diene ***143***
furanoquinoline alkaloids 27, 153, 239
furanoquinolines 86
fusain d'Europe 162
fusaria commune 162
Gagea 71
galactans 136
galactomannans 75, 261
galactose ***74***, 93, 104, ***133***, 148
3-*O*-galactoside ***264***
galacturonic acid ***75***, ***104***
galanga 103
Galangae rhizoma 103
galangal 103
galangin ***103***
galangols 103
galanolactone 273
galanthamine 20, ***78***, ***168***, 205
*galanthe des neige*s 168
Galanthi bulbus 168
galanthine 168
Galanthus nivalis **168**
Galanthus woronowii 20, 78, 168
Galen 10
Galenic medicine 10
Galeopsidis herba 168
galéopsis douteux 168
Galeopsis dubia 168
Galeopsis ochroleuca 168
Galeopsis segetum **168**
Galium odoratum ***65***, 66
gallic acid ***64***, ***70***, ***77***, 215
gallotannins 70, 98, 139, 165, 218, 224, 238
gamma-linoleic acid 16, ***122***
gamma-linolenic acid 209, 236

gan cao 172
gandul 124
Gansefingerkraut 225
gao liang jiang 103
garden angelica 107
garden artichoke 150
garden burnet 242
garden cress 19, **192**
garden huckleberry 250
garden sage 241
garden thyme 260
gardenia ***53***
Gardenia jasminoides ***53***
gargling 34
garlic 16, 28, **101**
garlic oil 101
Gartenbohne 217
Garten-Chrysantheme 137
Gartenkresse 192
Gartenkürbis 147
Gartensalbei 241
Gartenwolfsmilch 163
gas chromatography 38
gas-liquid chromatography 38
Gattefosse, Rene 10
gattilier agneau-chaste 270
gatuna 210
Gaultheria procumbens 15, 21, **169**
Gaultheria spp. 57
Gaultheriae aetheroleum 169
Gaultheriae folium 169
gaulthérie du Canada 169
gayuba del pays 109
ge gen 230
Gefahrliche Aloe 102
Gefleckter Schierling 144
gel 29, 32
Gelbe Narzisse 205
Gelber Enzian 170
Gelber Hohlzahn 168
Gelber Oleander 259
Gelber Schellenbaum 259
Gelbes Katzenpfötchen 176
Gelbwurzel 148
Gelsemiaceae 81, 82, 169
gelsemicine 82
Gelsemii rhizoma 169
gelsemine 27, ***82***, ***169***
gelsemino 169
Gelsemium sempervirens 15, 27, 82, **169**
Gemeine Esche 167
Gemeine Heckenrose 237
Gemeine Nachtkerze 209
Gemeine Pestwurz 215
Gemeine Quecke 159
Gemeiner Andorn 199
Gemeiner Baldrian 266
Gemeiner Beinwell 254
Gemeiner Löwenzahn 257
Gemeiner Seidelbast 151
Gemeiner Wolfstrapp 197
Gemeines Schneeglöckchen 168
genêt à balai 150
genévrier sabine 187
geniévrier 187
geniposidic acid ***162***
genistein ***68***, 171, 210, 261
Gentiana lutea 17, 52, **170**
Gentianaceae 52, 132, 170
Gentianae radix 170
gentiane jaune 170
gentiopicrin ***52***, ***170***
gentiopicroside 52, 170
gentioside 170
gentisin 170
genziana maggiore 170
Geraniaceae 215
geranial 51, 103, ***149***
geraniol ***50***
Geranium robertianum ***71***
Gerard, John 10
germacrene D 186
German chamomile 134, **199**
germander ***55***
germerine 267
Gerste 180
gesse blanche 190
Geum urbanum ***71***
Gewohnliche Berberitze 120
Gewöhnliche Mahonie 197
Gewohnliche Osterluzei 111
Gewöhnlicher Frauenmantel 99
Gewohnlicher Jaborandistrauch 219
Gewohnlicher Maiapfel 223
Gewöhnlicher Wacholder 187
Gewöhnliches Pfaffenhütchen 162
Gewöhnliches Seifenkraut 244
Gewürznelkenbaum 255
ghaap 19, **179**
giant fennel 77
giatrofa catartica 186
Giftblatt 153
Giftiger Wasserschierling 138
Giftjasmin 169
Giftsumach 235
Gigartinaceae 136
gilled mushroom 26
ginepro 187
ginestra scopareccia 150
gingembre 273
ginger 16, 19, 28, 66, **273**
ginger oil 53
gingerenone A ***66***
6-gingerol ***66***, ***273***
gingerols 16, 103, 273
gingli 249
ginkgo 16, **170**
ginkgo 170
Ginkgo 170
Ginkgo biloba 16, 28, 54, 56, **170**
ginkgo biloba 170
Ginkgo folium 28
Ginkgoaceae 170
Ginkgo spp. 65
ginkgolic acids 170
ginkgolide B ***56***, ***170***
ginkgolides 16
ginseng 17, **212**
Ginseng 212
ginseng de Sibérie 159
ginseng indiano 272
Ginseng radix 212
ginseng root ***13***
ginsenoside Rg_1 ***212***
ginsenosides 17
gipsywort 197
girasole del Peru 177
giroflier 255
gitalin 20
githagenin ***99***
githagin 99
gittaione 99
giuggiolo comune 273
giusquiamo nero 182
glaucaroubin 20
glaucine 20
Glaucium flavum 20
glaziovine 20
Glinus lotoides 8
globe artichoke 150
Glockenbilsenkraut 246
Gloriosa spp. 79
Gloriosa superba 20, 26, ***27***, **171**
gloriosine 26
β-glucans 16, 180
Glucksbaum 126
glucocorticoids 61
glucofrangulin A & B ***233***
glucomannans 75
glucoscillaren A 155
glucose ***74***, 271
glucosinolates 90, 91, 111, 127, 192, 204, 240
glucotropaeolin ***192***, ***262***
D-glucuronic acid ***75***, 93, 104
glutamate 190
glutamic acid ***88***
glutamine ***88***
β-N-γ-L-glutamyl-aminopropionic acid 89
glycans 75
glyceollin II 68
glyceraldehyde ***74***
glycine ***88***
Glycine max 19, 68, **171**
glycoproteins 102
glycosides 17
glycyrrhetinic acid ***172***
Glycyrrhiza glabra 20, 28, 61, **172**
Glycyrrhiza uralensis 172
glycyrrhizic acid 61, 172
glycyrrhizin 20, ***61***
Gnidia kraussiana 27
gnidicin 27
gnididin 27
gnidilatidin 27
gnidilatin 27
gniditrin 27
go ji 12
goemon noir 115
goitrin ***90***
goji berry 19, **195**
golden chain 189
golden rain 189
goldenrod 251
goldenseal 15, **181**
Goldregen 189
gomisin 16, 245
Gossypium hirsutum ***53***
Gossypium spp. 20
gossypol 20
gotu kola 13, 118, 132
gou qi zi 195
gouet macule 114
gouteron 109
goyave 229
goyavier 229
grains of paradise 97
gramigna canina 159
gramine ***117***
Graminis rhizoma 159
Granatapfelbaum 231
Granati pericarpium 29, 231
grand ammi 104
grand boucage 220
grand raifort 111
grand sureau 241
grande absinthe 113
grande camomille 256
grande consoude 254
grande pimprenelle 242
grande-éclaire 135
grani de melegueta 97
grano saraceno 164
granules 30
grape vine 12, 19, 22, 71, **271**
grass pea 190
grateron 109
grayanotoxin-I 57
greater burdock 109
greater burnet 242
greater burnet saxifrage 220
greater celandine 135
greater galangal 103
Grecian foxglove 154
green cestrum 14
green hellebore 177
green lily 26
green tea 19, 77, 125
grenadier 231
Griechischer Bockshornklee 261
griffe du diable 175
griffonia 17, **172**
Griffonia 172
Griffonia simplicifolia 17, **172**
grindélia 173
Grindelia camporum 173
Grindelia squarrosa **173**
Grindeliae herba 173
grindelic acid ***173***
Grose Bibernelle 220
Grose Klette 109
groseille a maquereau indienne 218
Große Brennnessel 264
Große Kapuzinerkresse 262
Große Käsepappel 198
Große Knorpelmohre 104
Großer Wiesenknopf 242
Großfrüchtige Moosbeere 264
Grossulariaceae 236
grosteae 80
Grüne Nieswurz 177
Grüner Kardamom 158
guaiac 53, **173**
Guaiaci lignum 173
Guaiaci resina 173
guaiaco 173
guaiacol 20, ***64***, 173
α-guaiaconic acid 173
Guaiacum officinale 20, 53, **173**
guaiazulene 53, ***173***
guaiol 173
guajacum 173
Guajakholzbaum 173
guajaverin ***229***
guar 148
guar 19, **148**
guaran 148
guaraná 14, 19, 23, **213**
guarana 213
Guarana-Strauch 213
Guarbohne 148
guar-phali 148
guava 229
guava tree 14, **229**
guayaba 229
Guayavebaum 229
gui blanc 269
guimauve 104
gum 29
gum acacia 93
gum arabic 29, 32, 75, 93
gum arabic tree 9, **93**
gummi 29
Gummi acaciae 29
Gummikraut 173
Gummiulme 162
gutta-percha 63, 162
guvacine 110
guvacoline 110
guwar 148
Gymnema sylvestre 20
gymnemic acid 20, 180
gynocardin 213
gypsogenic acid 178
gypsogenin 99, ***174***, 244
gypsophila 174
Gypsophila arrostii 60
Gypsophila bicolor 60
Gypsophila graminifolia 60
Gypsophila paniculata **174**
Gypsophilae radix 174
gypsophile 174
Gyromitra esculenta 26
haba de Calabar 218
haemanthamine 78, 168
Hafer 117
Hagenia abyssinica 9
Hahnemann, Samuel 10
hai ba ji 203
hallucinogens 8, 10, 14, 22, 25, 26, 78, 80, 81, 83, 84, 105, 113, 117, 119, 121, 123, 151, 156, 182, 185, 195, 198, 204, 212, 214, 244
Hamamelidaceae 174
Hamamelidis folium et cortex 174
Hamamelis 174
hamamélis de Virginie 174
Hamamelis virginiana 15, 17, **174**
hamamelitannins 174
Hanf 127
Hangebirke 120
harakeke 14
haricot 217
haridra 13
haritaki 258
harmala 23, **214**
Harmalae semen 214
harmaline 119
harman alkaloids 23, 214
harmel 214
harmine ***81***, ***119***, ***214***
haronga 175
Haronga 175

Haronga madagascariensis 175
harongana 175
harpagide ***175***
Harpagophyti radix 28, 175
Harpagophytum procumbens 9, 16, 28, 52, **175**
harpagoside ***52***, 175
Harungana madagascariensis **175**
Harunganae madagascariensis cortex et folium 175
harunganin ***175***
hashish 127
hastatoside 268
hawthorn 17, **146**
he ye 206
heartsease 269
Hebe stricta 14
Hedera helix 17, 61, **176**
hederacoside C ***176***
Hederae folium 176
hederagenin 200
hei guo xian lei hua qiu 112
Heidelbeere 265
Heimia salicifolia 23
heimine 23
helenalin ***54***, ***112***
Helenii rhizoma 185
helenin 185
helianol 137
Helichrysi flos 176
helichrysin A ***176***
Helichrysum arenarium **176**
heliotrine ***85***
Heliotrop 177
heliotrope 177
héliotrope 177
heliotropine 177
Heliotropium arborescens **177**
Heliotropium peruvianum 177
Heliotropium spp. 85
hellebore 26
hellébore vert 177
helleborin 26, 177
Helleborus niger 177
Helleborus spp. 62
Helleborus viridis 26, **177**
hellebrin 26, ***177***
Helmsleya amabilis 20
helveticoside 26
hemiterpenes 50
hemp 23
hemsleyadin 20
henbane 23, 26, **182**
henna 12, ***13***, **191**
Hennae folium 191
Hennastrauch 191
henné 191
hennè 191
herb of grace 239
herb Robert ***71***
herba 28
herba tota 28
herbal medicines, commercial 10
herbal pharmacopoeias 46, 47
Herball 10
herbe aux cure-dents 270
herbe aux puces 221
herbe d´absinthe 113
herbe d'anserine 225
herbe St. Jacques 247
Herbstzeitlose 143
herniaire 178
Herniara hirsuta 178
Herniaria glabra **178**
Herniariae herba 178
herniary 178
heroin 212
Herzgespann 192
hesperetin 18, ***67***
hesperidin 20, 67
heuningbostee 149
Hevea brasiliensis 63
hexane 29
Hibisci flos 28, 178
Hibiscus 178
hibiscus 9, 28, 33, **178**
hibiscus acid ***178***
Hibiscus sabdariffa 9, 19, 28, 33, 76, **178**
hibiscus tea 19
hiedra 176
hiedra venenosa 235
Hieracium pilosella 66
hierba doncella 268
hierba japonera 244
highbush blueberry 265
high-performance liquid chromatography 38
higo de mastuero 128
Hildegard of Bingen 10
hinojo 166
Hippocastanaceae 97
Hippocastani cortex 97
Hippocastani folium 97
Hippocastani semen 97
Hippocrates 10
Hippophae fructus 179
Hippophae oleum 179
Hippophae rhamnoides 19, **179**
Hirtentaschel 127
histamine ***264***
histidine ***88***
Historia Stirpium 10
hodulcine 1 180
holism 10
hollyhock 104
holy basil 208
holy thistle 131
homeopathy 10
homoeopathy 10
honeybush tea 149
hong hua 129
Honigbusch 149
Hoodia 179
hoodia 19, **179**
Hoodia gordonii 19, **179**
hop plant 28, **181**
Hopfen 181
Hordeae 80
hordenine ***78***, ***180***
Hordeum spp. 78
Hordeum vulgare 16, 19, **180**
horse chestnut 17, 66, **97**
horseradish 90, **111**
horsetail 160
houblon 181
Hovenia dulcis 19, **180**
hu ma 249
huacatay 255
huang bai 217
huáng bò 217
huang lian 145
huang qi 116
huáng qín 246
huang-chi 116
huánglián 145
Huflattich 263
α-humulene 97
humulone 181
Humulus lupulus 28, **181**
Hundsrose 237
hunting poison 9, 24
huo ma ren 127
Huperzia serrata 20
huperzine A 20, 196
Hyacinthaceae 62, 155
hydrangea 66
Hydrangea macrophylla 21, 66
Hydrangeaceae 66
hydrastine 20, ***181***
hydrastis 181
Hydrastis canadensis 15, 20, **181**
Hydrastis rhizoma 181
hydrocinnamic acids 16, 197
hydrocotyle 132
hydrocotyle asiatique 132
hydrocyanic acid ***90***
hydrogen cyanide 90, 227, 228
Hydrophyllaceae 65
hydroquinone ***72***
2-hydroxy-1,4-naphthoquinone 191
2-hydroxy-4-methoxybenzaldehyde 203
hydroxybenzoic acid ***76***, 124
hydroxycinnamic acid 77, 197
8-hydroxyflavone ***168***
18-hydroxyquassin 231
5-hydroxytryptamine 78
5-hydroxytryptophan 17, ***172***
hygiene 40
hyoscine 123, 156, 198
Hyoscyami folium 182
Hyoscyami radix 182
Hyoscyami semen 182
hyoscyamine 21, 22, 23, 25, 26, 27, ***87***, 123, ***151***, ***182***, 198
L-hyoscyamine ***117***, ***246***
Hyoscyamus niger 21, 23, 26, **182**
Hyoscyamus spp. 21, 87
hyperforin 17, 73, 182
Hypericaceae 72, 175, 182
Hyperici herba 28, 182
hypericin 17, ***73***, 175, ***182***
Hypericum perforatum 28, 73, 76, **182**
Hypericum revolutum 17
hyperoside ***120***, 241
hypoglycin ***89***, ***121***
hypophyllanthin 218
Hypoxidaceae 183
Hypoxidis tuber 28
Hypoxis 183
hypoxis 28, **183**
Hypoxis hemerocallidea 9, 18, 28, 59, **183**
Hypoxis rooperi 183
hypoxoside ***183***
hyssop ***55***
Hyssopus officinalis ***55***
iaborandi 219
Ibn al-Baytar 12
Ibn Zuhr 12
ibogaine ***81***
ibotenic acid 26
Icacinaceae 82
Iceland moss 17, **134**
idrocotile 132
if 257
igname sauvage 155
ihlmvu 125
Ilex paraguariensis 14, 23, 84, **183**
Illiciaceae 184
Illicium anisatum 54, **184**
Illicium japonicum 184
Illicium religiosum 184
Illicium verum **184**
immortelle des sables 176
impala lily 96
imperatorin 107
impila 125
Impila 125
incenso 122
incienso 122
Indian date 256
Indian ginseng 272
Indian gooseberry 218
Indian hemp 127
Indian mulberry 19, **203**
Indian pennywort 17, **132**
Indian snakeroot 13, **232**
Indian tobacco 15, **194**
Indianertabak 194
indicine ***177***
Indigofera spicata 89
Indische Maulbeere 203
Indisches Basilikum 208
Indisches Lungenkraut 188
indole alkaloids 17, 25, 26, 27, 78, 81, 130, 169, 172, 185, 214, 218, 232, 247, 263, 268
indolizidine alkaloids 82, 218
L-indospicine ***89***
infusion 30
infusum 30
ingenol mebutate 21, ***57***, ***163***
ingenol-3-angelate 163
ingestion 34
Ingwer 273
inhalation 30
injection 34
Inka tea 72
inkomfe 183
insoluble fibre 18
instant tea 30
Integrative Medicine 12
intermedine 254
Inula helenium 54, **185**
inulin 74, ***75***, 109, 185
ionone 124, 174
ipecac 229
ipecacuana 229
ipecacuanha 229
Ipecacuanhae pulvis normatus 229
Ipecacuanhae radix 229
iperico 182
ipomée 185
Ipomoea argyrophylla 80
Ipomoea spp. 14, 80
Ipomoea tricolor **185**
Ipomoea violacea 80, 23, 185
Iridaceae 72, 89, 146
iridoid glucosides 52, 162, 168, 175, 190, 192, 222, 265, 267, 268, 270
iridoids 23, 48, 52, 53, 132, 167, 168, 169, 188, 190, 268
irinotecan 21, 126
Irisch Moos 136
Irish moss 75, **136**
ishongwe 272
isibhaha 271
Isländisches Moos 134
isoallicin ***100***
isoalliin 100
isobutylamide 251
isocorydine 216
isocupressic acid ***56***, 187
isoeugenol 204
isoflavones 67, 68, 116, 149, 152, 210, 230, 261
isoflavonoids 67, 68, 171, 200, 201, 261
isofraxidin 159, 167
isoleucine ***88***
isolichenin 134
isoliquiritigenin ***68***
isomenthone 98
isopetasin 16, 215
isoprene ***50***
isoquinoline alkaloids 22, 23, 78, 79, 82, 110, 121, 136, 143, 167, 171, 181, 197, 2015, 212, 217, 229, 242
isorhamnetin 18
isorhamnetin-3-*O*-glucoside 124
isosalipurposide 176
isothiocyanates 18
isovanillin ***203***
isovitexin 213
ispaghula 75
isphagula 221
ivy 17, **176**
jaborandi 219
Jaborandi folium 219
jackbean 89
Jacobaea vulgaris **247**
jacobine 247
Jakobskreuzkraut 247
jalousie 196
Japanese angelica tree 60
Japanese anise 184
Japanese arrowroot 230
Japanese pagoda tree 253
Japanese raisin tree 19, **180**
Japanese rose 19
Japanischer Rosinenbaum 180
Japanischer Schnurbaum 253
Japanischer Sternanis 184
jasmin sauvage 169
Jatropha curcas **186**
jatrophin 186
jengibre 273
jessamine 27
Jesuit tea 135
jia du xing cai 192
jia ma chi xian 118
Jimson weed 23, **151**
Johannisbrotbaum 133

ju hua 137
Juglandaceae 72, 186
Juglandis folium 186
Juglandis fructus cortex 186
Juglans nigra 186
***Juglans regia* 186**
juglone ***72***, ***186***
juice 30
Jujubae fructus 273
Jujube 273
jujube fruit 19
jujube tree 273
jujubier 273
Juncaginaceae 90
juniper 29, **187**
Juniperi fructus 29, 187
Juniperus communis 29, **187**
Juniperus oxycedrus 53
Juniperus sabina 27, 51, **187**
jusquiame noire 182
Justicia adhatoda 21, 86, **188**
Justicia paniculata 106
jute mallow 26
kacip fatimah 14
kaempferol 18, ***68***, 160, 225, 267
Kaffeestrauch 142
Kahles Bruchkraut 178
kainic acid 21
Kakaobaum 258
Kalanchoe 62
Kalmegh 106
kalmegh 13, **106**
Kalmia 57
Kalmus 95
kalonji 19, **208**
kamala 206
Kampferbaum 140
kampo 12, 46
Kanadische Blutwurzel 242
Kanadische Gelbwurzel 181
kanna 244
kanna 9, **244**
kanwal 206
Kap-Aloe 102
Kardamompflanze 158
karkadé 178
karkade 19
karra 26
karya gum 75
Kathstrauch 130
Katzenbart 211
Katzenkralle 263
ent-16-kauren-19-oic acid ***57***
kava 221
kava kava 14, 17, 23, 28, **221**
kava pyrones 221
kavain 23
kava-kava 221
Kava-kava rhizoma 28
kawa lactones 23
kawain 21, ***221***
Kawapfeffer 221
kemponashi 180
Keulen-Bärlapp 196
khat ***9***, 23
khat tree 130
khella 270
Khellakraut 270
khellin 21, ***66***, 270
khesari 190
kigelia 188
***Kigelia africana* 188**
kigelin ***188***
Kinakvanne 107
Kinesisk angelikarot 107
king of bitters 106
kirayat 106
Kirschlorbeer 228
Kitab al-taysis 12
Kleiner Odermennig 98
Kleines Fettblatt 118
Kleines Immergrün 268
knipholone ***123***
Knoblauch 101
Knorpeltang 136
Knotentang 115
knotgrass 224
knotswier 115
knotted wrack 19, **115**
knotweed 224
Kohlpalme 163
Kokastrauch 161
Kolabaum 142
Koloquinte 141
Koriander 145
Korkholz 156
Kornblume 131
Kornrade 99
koromiko 14
kouai tsao 180
kougoed 9, 23, 244
kowhai 14
***Krameria lappacea* 189**
Krameria spp. 70
Krameria triandra 189
Krameriaceae 189
kraom 14
kraussianin 27
Krebs cycle 76, 153
krimpsiekte 62
Kronsbeeren 265
Krotonölbaum 147
Kruydtboeck 10
Kuchenzwiebel 100
kudzu 230
kudzu vine 230
Kudzubohne 230
kumis kutjing 211
Kummel 129
Kurkuma 148
la menta 202
la mu 204
labdane ***56***, 106, 119, 173
Labisia pumila 14
***Laburnum anagyroides* 189**
lace flower 104
lactic acid ***76***
lactose 75
Lactuca virosa 22, 54, ***55***
lactucarium 54
lactucin 22, ***54***, 55, ***138***
lactucopicrin 22, ***54***, 55
ladanum 56
lady's mantle 99
laetrile ***90***, 227
Lakritze 172
laloi 102
lamalbide ***190***
Lamiaceae 50, 51, 52, 56, 65, 90, 119, 168, 190, 191, 192, 197, 199, 201, 202, 208, 210, 211, 223, 237, 240, 241, 246, 260, 270
Lamii albi flos 190
Lamii albi herba 190
***Lamium album* 190**
lanatosides 21, 26
lapacho 14
Lapacho tea 72
lapachol 188
lappaphens 109
large cranberry 17, **264**
large-leaved lime 260
larkspur 26
Larrea divaricata 21
Lathyrus latifolius 89
Lathyrus sativus 89, **190**
Lathyrus sylvestris 89
Latin American traditional medicine 14
Latua pubiflora 27
Lauraceae 54, 82, 140
laurel-cerezo 228
lauric acid ***248***
laurier jaune 259
laurier rose 206
laurier-cerise 228
lauroceraso 228
lavanda 191
lavande 191
***Lavandula angustifolia* 191**
Lavandula officinalis 191
Lavandula vera 191
Lavandulae aetheroleum 191
Lavandulae flos 191
lavender 191
lawsone ***191***
Lawsonia inermis 12, ***13***, **191**
laxative tea 32
L-DOPA 21
leaf 28
Leberwurstbaum 188
lecithin 171
Lecithinum ex soja 171
lectins 17, 24, 25, 27, 36, 88, 91, 93, 99, 114, 147, 162, 186, 217, 236, 264, 269
Ledum 57
legno santo 173
Lein 194
leiocarposide ***251***
lelobine 22
lemon balm 201
lemon verbena 19, 51, **103**
lemon wood 245
Lemongras 149
lemongrass 149
lemongrass oil 53
lengana 113
leño de santalo citrino 243
lent lily 205
leocardin 192
Leonotis spp. 56
Leonuri herba 192
leonurine 192
***Leonurus cardiaca* 192**
Leonurus heterophyllus 192
Leonurus sibirica 192
Leonurus spp. 56
lepidine 192
Lepidium sativum 9, 19, **192**
Lepiota helveola 26
lesser galangal 103
lesser periwinkle 268
Lessertia frutescens 21, **193**
lethal dose 24
lettuce 54
lettuce opium 54
Leucaena leucocephala 89
leucine ***88***, 217
Leucojum aestivum 78
leurosine 81
Levant storax 29
Levant wormseed 55
Levistici radix 193
levistico 193
***Levisticum officinale* 193**
Li Shi-Zhen 12
lian 206
lian zi 206
lian zi xin 206
Libellus 14
lichen d'Islande 134
Lichen islandicus 134
lichene islandico 134
lichenin 134
lichenolic acids 134
licio 195
licopodio clavato 196
licorice 172
lidocaine 161
Liebstöckel 193
lierre commun 176
lierre grimpant 176
lignan glycoside 26, 240
lignans 16, 67, 109, 131, 159, 162, 173, 189, 194, 218, 223, 240, 245, 249
lignin 67
lignum 28
Lignum vitae 173
lignum vitae 173
ligustico 193
Ligusticum levisticum 193
ligustilide ***107***, ***193***
ligustroside 209
Liliaceae 72, 76, 79, 86, 89
Lilium 71
lily-of-the-valley 101, **144**
lime tree 75, **260**
limoncina 103
limonene ***50***, 51, 98, ***103***, 106, 108, 129, 141, 153, 211, 270
limonin 141
lin 194
Linaceae 67, 90, 194
linalool ***50***, 51, 95, 141, ***145***, 191
linalyl acetate ***191***
linamarin 91, ***194***
linctus 30, 32, 74
linden 260
linear monoterpenoids 50
lingonberry 19, **265**
Lini semen 194
liniment 31
lino 194
linoleic acid ***129***, 147, 179, 194, 209
linolenic acid 171, 179, 194
linseed 19, **194**
Linum 67
Linum usitatissimum 16, 19, 75, **194**
lipophilic 50
Lippia citriodora 103
Lippiae triphyllae aetheroleum 103
Lippiae triphyllae folium 103
liquen islandico 134
Liquidambar orientalis 29
Liquidambar spp. 29
Liquidambar styraciflua 29
Liquiritiae radix 28, 172
liquiritin 172
liquirizia 172
liquorice 28, 61, **172**
lirio de los valles 144
lis de Malabar 171
lithospermic acid ***197***
livèche 193
llanten menor 222
lobelia 194
Lobelia inflata 15, 21, **194**
Lobelia spp. 84
Lobelia tupa 22
Lobeliae herba 194
lobélie enflée 194
lobeline 21, 22, ***84***, ***194***
lobinine 22
locoweed 82
Loganiaceae 52, 81, 253
Lonchocarpus nicou 21
long kui 250
longistylin 124
long-stamened orthosiphon 211
Lophophora williamsii 14, 23, 84, **195**
Lorbeerkirsche 228
lords and ladies 26, **114**
lotion 31
Lotononis spp. 85
Lotosblume 206
lotus 206
lovage 193
lozenge 31
LSA 185
LSD **80**, 185
lucerne 19, **200**
lunasin 171
lungwort ***71***
lupanine ***85***, 87
lupinine ***85***
Lupinus albus ***87***
luppolo 181
Lupuli glandula 181
Lupuli strobulus 28, 181
lupulo 181
lupulone 181
lutein 18, ***63***
luteolin 67, 213
luzerne 200
Luzerne 200
lyciet 195
Lycii fructus 195
Lycii radicis cortex 195
Lycium barbarum 195
Lycium chinense 12, 19, **195**
lycoctonine 26

lycopene 18, ***63***, 179, ***196***, 237
Lycopersicon esculentum 19, 63, **196**
Lycopi herba 197
lycopode en massue 196
Lycopodiaceae 196
Lycopodiales 196
Lycopodii herba 196
lycopodine ***196***
Lycopodium clavatum 20, **196**
Lycopodium vulgare 196
Lycopus europaeus 16, **197**
Lycopus lucidus 197
lycorine ***78***, 79, 168, ***205***
Lycoris squamigera 20
lysergic acid amide 23, 80, 185
lysergic acid diethylamide 185
lysine ***88***, 180
Lythraceae 191, 231
lythrine 23
ma bian cao 268
ma huang 12, 160
macambo 126
mace 14
maceratio 32
maceration 32
Maclura pomifera 26
Madagascar periwinkle 130
madagascin 175
Madagaskar-Immergrun 130
madecassic acid 132
Maggikraut 193
magic mint 23, **240**
magic mushroom 23
Magnoliaceae 54, 82
Mahonia aquifolium 15, **197**
mahonie a feuilles de houx 197
mai ya 180
maidenhair tree 28, **170**
Maidis stigmas 28
Maiglöckchen 144
maize 28
Malabar nut 188
Malagettapfeffer 97
malagueta 97
Malarbar-Nuss 188
Malaysian traditional medicine 14
malic acid 76, 256
mallow *7*, 75, **198**
malonic acid ***76***
Malpighiaceae 78, 81, 119
maltol ***213***
maltose ***75***
Malus domesticus 71
malva 198
malva riondela 198
Malva spp. 74
Malva sylvestris 7, 75, **198**
Malva sylvestris subsp. *mauritiana* 198
Malvaceae 95, 104, 142, 178, 198, 258, 260
Malvae flos 198
Malvae folium 198
malvavisco 104
malvidin 18, ***69***, 77, 198, 265
malvin ***198***
Mandelbaum 227
mandorla 227
Mandragora 87
Mandragora officinarum 23, 26, **198**
mandragora primaverile 198
mandragore 198
mandrake 23, 26, **198**
Mangifera indica 21
mangiferin 21, ***149***
Manihot esculenta ***91***
manna 167
manna ash 74
Manna canellata 167
mannitol 74, ***75***, 167, 179, 271
mannose 74, 133, ***148***
manta de lobo 197
manzanilla romana 134
maonia commune 197
Maori traditional medicine 14
margosa 118
margousier 118
Mariendistel 249
marigold 124
marijuana 13, 23, 110, **127**, 262
marjoram 210
marrobio 199
marronnier d'Inde 97
marrube blanc 199
marrubiaside 192
Marrubii herba 199
marrubiin ***56***, ***199***
marrubio 199
marrubio d'acqua 197
Marrubium vulgare 56, 119, **199**
marshmallow 75, **104**
mastication 34
mastruco 192
maté 14, 23, **183**
Mate 183
matè 183
Mate folium 183
Materia Medica 10, 198
matricaria 256
Matricaria chamomilla 10, 16, 20, 28, 53, 54, 134, **199**
Matricaria recutita 199
Matricariae aetheroleum 199
Matricariae flos 28, 199
mauve sauvage 198
may apple 223
meadow saffron 143
meadowsweet 165
medicagenic acid ***178***, ***200***
Medicago sativa 19, **200**
Medicago sativae herba 200
medicinal essence 32
medicinal oil 32
medicinal spirits 32
Medizinal-Rhabarber 234
Meerrettich 111
Meerrettichbaum 204
Meerträubel 160
Meerzwiebel 155
melaleuca 200
Melaleuca alternifolia 14, 17, **200**
Melaleucae aetheroleum 200
Melanthiaceae 267
Melegueta pepper 97
Meliaceae 118
mélilot officinal 201
Meliloti herba 201
meliloto 201
melilotoside 201
Melilotus alba 201
Melilotus officinalis 66, **201**
melissa 201
***Melissa officinalis* 201**
Melissa officinalis subsp. *officinalis* 201
Melissae aetheroleum 201
Melissae folium 201
mélisse 201
melograno 231
Melonenbaum 128
membranous milk vetch 116
Menispermaceae 54, 82, 136
menta piperina 202
Mentha arvensis 51
Mentha ×piperita 17, 29, 51, **202**
Mentha spicata 51
Mentha spp. 21
Menthae piperitae aetheroleum 29, 202
Menthae piperitae folium 202
menthe poivrée 202
menthol 17, 21, ***50***, 51, ***202***
Menyanthaceae 52, 202
***Menyanthes trifoliata* 202**
Menyanthidis folium 202
5-MeO-DMT 23
mescal 195
mescaline 23, ***84***, ***195***
mesembrenol 23, ***82***, 244
mesembrenone ***82***
mesembrine 23, ***82***, ***244***
Mesembryanthemum tortuosum 23, 82, 244
Meskalkaktus 195
Mespilus arbutifolia var. *melanocarpa* 112
metabolic toxins 24
metabolomics 39
methiin ***101***
methionine ***88***
methods of administration 34
6-methoxyaromadendrin-3-*O*-acetate 68
6-methoxyharmaline 23
5′-methoxyhydnocarpin ***197***
5-methoxypsoralen 104
4-methoxysecurinine 218
6-methoxytaxifolin ***68***
methyl salicylate 21, 165, ***169***, 224, ***247***, ***269***
2-methyl-3-buten-2-ol ***181***
3-methylamino-L-alanine ***89***
4-methylcatechol ***64***
S-methylcysteine sulfoxide ***89***
methyleugenol 208
2-methyltetrahydro-β-carboline 22
N-methyltyramine ***78***
methysticin 23, 221
Methysticodendron 123
Metrosideros excelsa 14
Mexican marigold 255
Mexican poppy 110
Mexikanische Studentenblume 255
mezerein 26, 151
mezereo 151
mézeréon 151
mezereon 26, **151**
Middle Eastern medicine 12
Middle Eastern Traditional Medicine 12
milenrama 94
milfoil 94
milk bush 272
milk-thistle 10, 17, 29, **249**
milkweed 163
milky latex 8
millefeuille 94
Millefolii flos 94
Millefolii herba 94
millepertuis perforé 182
mimosine ***89***
mind-altering drugs 22
miracle fruit 19, **254**
miraculin 21, 254
miraculous berry 19, **254**
mirobalano 218
mirra 143
mirtillo 265
mirtillo palustre 264
mirtillo rosso 265
Mistel 269
mistletoe 11, 17, 91, **269**
miswak 240
Mitragyna speciosa 14
mixture 32
mkombela 203
MMT 22
modeccin 27
Modern Day Encyclopaedia of Chinese Materia Medica 12
molène faux-phlomis 267
Momordica cochinchinensis 196
monatin 21
Mönchspfeffer 270
***Mondia whitei* 203**
Monimiaceae 82, 216
monk's pepper 56, 270
monkshood 23, 26, **94**
monocrotaline 21
monocyclic monoterpenoids 50
monodesmosides 176
monofluoroacetate 27
monofluoroacetic acid ***153***
monomethyl hydrazine 26
monopreparation 32
monosaccharides 74
monoterpene indole alkaloids 26
monoterpenes 22, 27, 50
monoterpenoids 29
monotropitin 165
monounsaturated fatty acids 18
mora de la India 203
Moraceae 63
morelle furieuse 117
morelle noire 250
Morinda citrifolia 19, **203**
moringa leaf 19
Moringa oleifera 19, **204**
Moringa stenopetala 9
Moringaceae 90, 204
morning glory 14, 23, **185**
morphinane alkaloids 82
morphine 20, 21, 23, ***83***, ***212***
motherwort *55*, 192
mountain ash 74
mouse-ear hawkweed 66
mousse d'Irlande 136
moustache de chat 211
msoba 250
mu do 124
mu huang 23
mucilage 16, 74, 75, 104, 122, 123, 159, 192, 194, 198, 221, 222, 224, 243, 254, 260, 261, 263, 267, 269, 273
Mucuna deeringiana 21
Mucuna pruriens 78
muérdago 269
mughetto 144
muguet 144
mugwort 113
mullein 267
multiple therapies 44
mundi 203
mungurawu 203
Murraya spp. 81
muscarine 26
muscimol 22, 26
Muskatnussbaum 204
mustard oils 88, 90, 91, 110, 111, 240, 262
mustard tree 240
Mutterkraut 256
muzigadial ***126***
myrcene ***50***
Myrciaria dubia ***19***
Myricaceae 50, 52
myricetin 18
Myristica fragrans 14, 23, **204**
Myristicaceae 50, 52, 78, 204
Myristicae aetheroleum 204
Myristicae arillus 204
Myristicae semen 204
myristicin 23, ***64***, 184, ***204***, 216
myrobalan 13
myrobalan noire 258
Myrobalanenbaum 218
Myrobalani fructus 258
Myroxylon balsamum 14, 20, **205**
Myroxylon balsamum var. *balsamum* 29
Myroxylon balsamum var. *pereirae* 205
myrrh 9, 10, 29
myrrh tree 143
Myrrha 29, 143
myrrhe 143
Myrrhe 143
Myrtaceae 161, 200, 229, 255
myrtille rouge 265
Myrtilli fructus 265
myrtillin ***265***
myrtle ***51***
Myrtus communis 51
naphthoquinones 72, 156, 186, 188, 191
naranjo amargo 141
narciclasine 78
narciso trombone 205
narcisse jaune 205
Narcissus nivalis 78

Narcissus pseudonarcissus 78, **205**
narcotics 13
narcotine 212
naringenin 18, ***67***, ***141***
nasal drops 32
nasturtium 19, **262**
nasturzio 262
naucleopsis 26
Naucleopsis spp. 26
neem 13, **118**
neem tree 118
Neembaum 118
nelumbo 206
Nelumbo nucifera **206**
Nelumbonaceae 206
nem 118
neoandrographolide 21
neochlorogenic acid ***65***
neohesperidin 141
neolignans 189
neoquassin 231
neoruscogenin 238
neral 51, 103, 149
Nerium oleander 26, 62, **206**
nerol ***50***
nerprun purgatif 233
nerve tea 32
nettle 10, 227
neurotoxins 24
New Kreüterbuch 10
New Zealand flax 14
Nicotiana glauca **207**
Nicotiana spp. 21
Nicotiana tabacum 14, 23, 85, **207**
nicotine 21, 22, 23, 35, ***85***, 156, ***207***
Niederliegende Scheinbeere 169
nielle des champs 99
nigella 208
Nigella sativa 19, 59, **208**
nigelle 208
nigelline 208
nim 118
Nimbaum 118
niopo 105
Nitrariaceae 214
nobilin 134
nocciolo delle streche 174
noce 186
noce moscata 204
noce vomica 253
noix muscade 204
noix vomique 253
noni tree 19, **203**
Nonibaum 203
nono 203
non-polar solvent 29
non-protein amino acids 89, 193
nonu 203
nordihydroguaiaretic acid 21
L-D-norephedrine 22
norhyoscine 123
nornicotine 23, 156
norpseudoephedrine 21, 22
North American traditional medicine 14
norviburtinal 188
noscapine 21, 212
Notholirion spp. 71
noyer royal 186
NPAAs *see* non-protein amino acids
nuciferine ***206***
nudicauline 26
nuez esere 218
nuez moscada 204
nutmeg tree 14, 23, **204**
nutraceuticals 18
nux vomica 26, **253**
Nymphaeaceae 206
Nyssaceae 126
oak 28, **232**
oats 19, **117**
obebioside 26, ***96***
observational studies 42
ocimene ***50***, 255
Ocimi sancti herba 208
Ocimum basilicum 208
Ocimum tenuiflorum **208**
Ocotea glazovii 20
Ocotea spp. 83
1-octylacetate 122
odollam tree 26, **133**
Oenanthe crocata 138
Oenothera biennis 16, 19, **209**
Oenotherae biennis oleum 209
oestrogen-producing plants 58
oignon 100
oil 259
ointment 32
Olbaum 209
Olea europaea **209**
Olea europaea subsp. *cuspidata* 209
Oleaceae 73, 167, 209
oleacein 209
Oleae folium 209
Oleander 206
oleander 26, 62, **206**
Oleandri folium 206
oleandrin 26, ***62***, ***206***
oleandro 206
oleandro giallo 259
oleanic acid 241
oleanoglycotoxin A ***60***
oleanolic acid ***58***
oleic acid 209
oleoresin 56, 143, 165, 205, 220, 235
oleoside ***167***
oleum 29
Oleum angelicae 107
oleuropein ***52***, ***209***
Olibanum spp. 29, 122
oligosaccharides 75
Olivae oleum 209
olive oil 58
olive tree 209
olivello spinoso 179
olivier 209
olivo 209
olmaria 165
ololiuqui 23, 80, 185
omega-3-fatty acids 18, 171
Onagraceae 209
onagre bisannuelle 209
onion 12, 17, 28, 89, **100**
α-onocerin ***210***
onocol 210
ononide 210
Ononidis radix 210
ononine 210
Ononis spinosa **210**
opiates 23
opioids 23
opium 12, 13, 22, 28, 34, 55, 212
Opium 212
opium alkaloids 28
opium lettuce 23, ***55***
opium poppy 23, 28, **212**
orange amère 141
orange lily ***79***
orange mullein 267
orbicuside A ***62***
Orchidaceae 266
orcinol ***64***
ordeal bean 218
ordeal poisons 9, 81, 133, 218
ordeal tree 9, 26
oregano 210
Oregon grape 15, **197**
organic acids 44, 65, 75, 76–77, 112, 134, 139, 146, 149, 162, 178, 186, 211, 224, 237, 243, 251, 256, 264, 265, 269
orge 180
origan 210
Origani vulgaris aetheroleum 210
Origani vulgaris herba 210
origano 210
Origanum dictamnus 210
Origanum majorana 210
Origanum syriacum 210
Origanum vulgare **210**
orthosiphol A–C 211
Orthosiphon aristatus **211**
Orthosiphon stamineus 211
Orthosiphonis folium 211
ortica bianca 190
ortica maschio 264
ortie blanche 190
ortie brûlante 264
ortiga blanca 190
ortiga mayor 264
orzo 180
Osage orange 26
Osterglocke 205
osthenole 107
osthole 107
otic application 34
ou jie 206
*ou zhou xiang wan do*u 190
ouabain 21, 25, ***252***
oval leaf buchu 98
ovenia dolce 180
oxalic acid 74, ***76***, ***114***, 154, 234
oxalyldiaminopropionic acid **190**
ox-eye daisy 125
Oxytropis 82
P57 ***179***
pachycarpine 21
Pacific yew 257
paclitaxel 20, 21, ***56***, ***80***, ***257***
Paeonia albiflora 211
Paeonia lactiflora 12, ***51***, **211**
Paeonia officinalis 211
Paeonia radix 211
Paeoniaceae 211
Paeoniae flos 211
Paeoniae radix rubra 211
paeoniflorin ***51***, ***211***
pale purple coneflower 17, **157**
palmatine 21
palmetta di Florida 248
palmier de l'Amérique du Nord 248
palmitic acid 179
palmitoleic acid ***179***
palosanto 173
Panax ginseng 12, ***13***, 17, **212**
Panax quinquefolius 212
Paonie 211
papaia 128
papain 21, 91, 128
Papaver bracteatum 83
Papaver somniferum 12, 13, 20, 21, 23, 28, 83, **212**
Papaver spp. 83
Papaveraceae 82, 110, 135, 167, 212, 242
papaverine 21, 23, ***83***
papavero domestico 212
Papaya 128
papaya tree 128
papayer 128
papayotin 128
paper chromatography 37
Papilionoideae 68
pará cress 251
Paracelsus 10, 24
Paradieskorner 97
[6]-paradol ***97***
Parakresse 251
Pareira 136
pareira brava 136
pareira root 14
parenteral application 34
Parmeliaceae 134
parsley 216
partenio 256
Parthenium 54
parthenolide ***55***, ***256***
pas d'âne 263
pasque flower ***71***
passicol 213
passiflora 213
Passiflora incarnata **213**
Passifloraceae 90, 213, 262
Passiflorae herba 213
passiflore 213
passion flower 213
paste 32
pastille 31
patchouli 223
Patchouli aetheroleum 223
Patchouli folium 223
patchouli oil 53
patchoulol ***53***, ***223***
patchouly 223
Paternostererbse 93
Patschulipflanze 223
Paullinia cupana 14, 19, 20, 23, 84, **213**
Pausinystalia johimbe 21, **214**
pavero messicano 110
pavot epineux 110
pavot officinal 212
pavot somnifere 212
paw paw 128
pectins 74, 75, 95, 178, 256
Pedaliaceae 175, 249
Peddiea africana 27
Peddiea factor A1 27
pédiveau vénéneux 154
pedunculagin 166
peelu 240
peganine 21, 23, ***85***, 188
peganum 214
Peganum harmala 12, 23, 81, **214**
pekoe 125
pelargonidin 18, ***69***
Pelargonium antidysentericum **9**
Pelargonium reniforme 66
Pelargonium sidoides 17, 66, **215**
pelletierine ***84***, ***231***
penduletin 270
pensée sauvage 269
pentadecylcatechols 235
pentagalloylglucose ***70***
peonia 211
peonidin ***69***, ***264***
peony 51
peperoncino arbustivo 128
pépon 147
pepperbark tree 28, **271**
peppermint 17, 29, 51, **202**
peptides 16, 26, 64, 80, 88, 91, 127, 171, 261, 269, 273
perce-neige 168
perejil 216
Periploca 62
periplocymarin 27
periwinkle 268
permethrin 21
Persian powder 137
persil 216
Peruanischer Pfefferbaum 245
Peruvian balsam 205
Peruvian bark tree 14, **139**
Peruvian rhatany 189
peruvoside 259
pervenche de Madagascar 130
pervinca minore 268
petasin 16, 77, ***215***
petasite vulgaire 215
Petasites hybridus 16, 77, **215**
Petasites spp. 85
Petasitidis folium 215
Petasitidis rhizoma 215
Petersilie 216
petit houx 238
petite centaurée 132
petite pervenche 268
Petroselini fructus 216
Petroselini herba 216
Petroselini radix 216
Petroselinum crispum **216**
petty spurge 163
petunidin ***69***, 265, 271
Peumus boldus 14, 83, **216**
peuplier fauxtremble 225
peyote 14, 23, **195**
Peyotekaktus 195

peyoti 195
peyotl 195
Pfefferminze 202
Pfefferrindenbaum 271
Phalaris 78
phalloidin 26
pharmacognosy 40
pharmacological effects 44
pharmacological studies 42
Phaseoli pericarpium 217
Phaseolus vulgaris 58, 91, **217**
phasin 91, 217
phellandrene 122, ***245***, 273
Phellodendron amurense **217**
phenol ***64***
phenolic acids 18, 50, 64, 65, 76, 125, 150, 166, 167, 173, 191, 192, 197, 201, 210, 220, 222, 225, 239, 255, 260, 264
phenylalanine ***88***, ***124***
phenylethanols 235
phenylethylamines 23
phenylpropanoids 29, 50, 64
phenylpropylamines 84
Philodendron spp. 65
phlein 75
phlorizin ***68***
phloroglucinol ***64***
phlorotannins 115
Phoenix dactylifera 58
phorbol esters 26, 27, 57, ***100***, 147, 151, 163, 186
Phormium tenax 14
phosphatidylcholine ***171***
phospholipids 171
Phyllanthaceae 218
phyllanthin 218
Phyllanthus acidus 76
Phyllanthus emblica **218**
phyllantine ***218***
phyllodulcin 21
Physalis 87
physcione 164
physic nut 186
physiomedicalism 14
Physoclaina spp. 87
Physostigma venenosum 9, 21, 25, 81, **218**
physostigmine 21, 25, ***81***, ***218***
physovenine 25
phytic acid 74
phytoecdysones 58
phytoestrogen 149, 171, 194, 230, 261
Phytolacca dodecandra 9, 60, ***61***
Phytolaccaceae 60
phytomedicine 16, 50
phytosterol glycosides 183
phytosterols 17, 58, 59, 61, 147, 175, 183, 185, 188, 208, 227, 248
pichi 164
pichi romero 164
pichi-pichi 164
picrocrocin 146
picrotoxinin 21, ***54***
pie de leon 99
pied-de-loup 197
Pieris spp. 57, 68
pig's ear 62, ***63***
pigeon pea 124
pigeonpea 124
pigna rossa 157
pignon d'Inde 186
pill 32
pilocarpine 21, ***219***
Pilocarpus jaborandi 21, **219**
Pilocarpus microphyllus 219
Pilocarpus pennatifolius 219
Pilocarpus racemosus 219
piment 128
pimenta rosa 245
pimpinella 220
Pimpinella anisum 29, 65, **219**
Pimpinella major **220**
Pimpinella saxifraga 220
Pimpinellae fructus 219
pin sauvage 220
pina 105
Pinaceae 52, 220
pineapple 19, **105**
pinene 126, 204
α-pinene ***50***, 51, 94, 122, 187, ***220***, 237, 245, 262
β-pinene ***50***, 187, 220, 245, 262
Pini aetheroleum 220
Pini turiones 220
pinitol 21, 149, 193
pink pepper 245
pino silvestre 220
pinocarvone 51
pinoresinol ***67***, 162
Pinus spp. 56, 187
Pinus sylvestris 58, **220**
pioppo 225
Piper betle 22, 110
Piper methysticum 14, 17, 21, 23, 28, **221**
Piper nigrum 84
Piper wichmannii 221
Piperaceae 73, 221
piperidine alkaloids 26, 84, 144, 156, 194, 207, 231
piperine ***84***
Piperis methystici rhizoma 221
piperitone ***50***, 51
pipiltzintzintl 240
Piptadenia peregrina 105
pissenlit 257
Pistacia lentiscus 29
pitchi 164
pituri 14, 23
pivoine 211
placebo effect 42
plakkie 62
plant parts 28
plant poisons 24
plant stanols 18
plant sterols 18
plantaggine 222
Plantaginaceae 52, 60, 62, 118, 154, 221, 222
Plantaginis lanceolatae folium 222
Plantaginis lanceolatae herba 222
Plantaginis ovatae semen 221
Plantaginis ovatae testa 221
Plantago afra **221**
Plantago arenaria 221
Plantago asiatica 221
Plantago lanceolata 75, **222**
Plantago ovata 75, 221
Plantago psyllium 221
Plantago spp. 52, 74, 75
plantain 75
plantain lanceole 222
Plasmodium falciparum 54, 139
Platycodi radix 222
platycodigenin ***222***
platycodon 222
platycodon a grandes fleurs 222
Platycodon grandiflorus **222**
Plectranthus barbatus 56
pleurisy root ***59***
plumbagin ***72***, 156
Poaceae 50, 52, 60, 66, 75, 78, 90, 117, 149, 159, 180
Podocarpus spp. 58
podofillo 223
podophylle pelte 223
Podophylli peltati rhizoma 223
Podophylli resina 223
podophyllin 223
podophyllotoxin 21, ***67***, ***223***
Podophyllum hexandrum 223
Podophyllum peltatum 20, 21, **223**
Podophyllum spp. 67
Pogostemon cablin 53, **223**
Pogostemon patchouli 223
pohutukawa 14
pois cajun 124
pois rouge 93
poison hemlock 10, 11, 26, **144**
poison ivy 15, 65, **235**
poison leaf 27, **153**
poison oak 235
poison olive 27
poison rope ***48***
poison sumac ***15***
poisoning, symptoms 24
poisons 9, 10, 11, 13, 14, 15, 24–27, 54, 60, 62, 68, 79, 80, 81, 83, 85, 90, 91
poivre de Guinee 97
poivre rose 245
poivrette 208
poligala 224
pollinae 28
polyacetylenes 16, 17, 73, 109, 113, 131, 134, 138, 144, 152, 157, 158, 173, 176, 185, 199, 212, 213
polyenes 73
Polygala senega **224**
polygala senega 224
Polygalaceae 224, 247
Polygalae radix 224
polygodial ***53***, 271
Polygonaceae 72, 164, 224
Polygoni avicularis herba 224
Polygonum aviculare **224**
Polygonum hydropiper 53
Polygonum spp. 72
polyphenols 17, 64, 77, 112, 218, 232, 236, 264
polypodine B ***58***
Polypodium vulgare 58
polysaccharides 16, 17, 29, 36, 45, 74, 75, 93, 102, 104, 115, 116, 117, 122, 123, 129, 133, 134, 136, 143, 148, 157, 158, 159, 178, 195, 199, 251, 259, 264, 269
polyterpenes 50, 63
polyunsaturated fatty acids 18
pomegranate 12, 70, **231**
pomegranate juice 19
Pomeranze 141
pomme de mai 223
pomodoro 196
ponticaepoxide 157
Populi cortex 225
Populi folium 225
Populi gemmae 225
populin ***225***
Populus balsamifera 225
Populus candicans 225
Populus nigra 225
Populus spp. 64
Populus tremula 225
Populus tremuloides **225**
pot marigold 124
potato ***15***, 250
potentilla 225
Potentilla 70
Potentilla anserina **225**
Potentilla erecta **226**
Potentilla fragaroides 20
Potentilla tormentilla 226
potentising 10
Prachtwinde 185
prana 13
prebiotics 18
pregnane glycoside 179
pregnenolone 61
Preiselbeere 265
prêle de champs 160
presenegin ***224***, 247
prezzemolo 216
prickly lettuce 23
prickly poppy 110
prickly poppy 23
primavera 226
primevere officinale 226
primin ***72***
Primula officinalis 226
Primula spp. 72
Primula veris 61, 64, **226**
Primulaceae 60, 226
Primulae flos cum calycibus 226
Primulae radix 226
primverogenin A ***226***
primverogenin B 226
principal components analysis 39
proanthocyanidins 18, 69, 112, 166, 170, 174, 175, 187, 213, 215, 225, 226, 232, 239, 242, 260, 265, 271
probiotics 18
procumbide 175
procyanidin B-2 ***69***
procyanidins 17, 18, 69, 140, 146, 264
prodrug 34, 90, 102, 233
progesterone 61
progoitrin ***90***
proline ***88***
propanethial *S*-oxide ***89***
S-propenylcysteine-*S*-oxide ***89***
propionic acid ***76***
Proteaceae 65
protoaescigenin ***97***
protoanemonin ***70***
protoberberine 82, 145
protocatechuic acid ***76***
protopine 110, ***167***
protoveratrine 21, 26, ***79***, ***267***
protoyamogenin 250
prugnolo 228
prunasin ***90***, ***228***, 230
prunellier 228
Pruni spinosae flos 228
Pruni spinosae fructus 228
Prunus africana 9, 17, ***59***, **227**
Prunus dulcis 12, **227**
Prunus laurocerasus **228**
Prunus spinosa **228**
pseudoephedrine 21, 22
Psidii pyriferi folium 229
Psidium guajava 14, **229**
psilio 221
psillio 221
psilocin 23, ***78***
Psilocybe mexicana 23, 78
psilocybin 23, ***78***
Psoralea bituminosa 66
psoralen ***66***, 104
psychedelics 22
psychoactive plants 22
psychomimetics 22
psychotics 22
Psychotria ipecacuanha 20, 83, **229**
Psychotria viridis 22, 119
Psyllii semen 221
psyllium 221
psyllium husk 75
ptaquiloside ***55***, ***230***
Pteridium aquilinum 55, 58, **230**
Pteridophyta 196
Pueraria lobata **230**
Pueraria montana var. *lobata* 230
Puerariae flos 230
Puerariae radix 230
puerarin ***230***
pulegone 98
Pulmonaria officinalis ***71***
Pulsatilla vulgaris ***71***
pumpkin 147
pungitopo 238
Punica granatum 12, 19, 29, 58, 69, 70, 84, **231**
Punicaceae 231
punicalagin 231
punicalin ***70***, 231
Purgiernuss 186
purging croton 14, 27, **147**
purine alkaloids 22, 23, 27, 84, 142, 147
purity 40
purple coneflower 158
purple foxglove 62
purpurea glycoside 26
Purpur-Sonnenhut 158
pycnogenols 271

Pygei africani cortex 227
pygeum 227
Pygeum africanum 227
pyrèthre 137
pyrethrin I ***137***
pyrethrin II 137
Pyrethrum 137
pyrethrum 21, **137**
pyridine alkaloids 22, 23, 25, 207, 236
pyrogallol ***64***
γ-pyrones 213
pyrrolidine alkaloids 85, 94
pyrrolizidine alkaloids 24, 41, 85, 122, 177, 215, 247, 254, 263
pyrrolysine 88
qat 130
qin cai 108
qing hao 12, 114
quality control 40
quassia *15*, 28, **231**
quassia 231
Quassia amara 15, 28, **231**
Quassiae lignum 28, 231
Quassiaholzbaum 231
quassin ***231***
quassinoids 231
queen-of-the-meadow 165
quercetin 18, ***68***, 160, 164, 166, 225, 229, 251, 253, 260
quercetin-3-rutinoside 164, 253
quercetrin 120
quercia commune 232
quercitrin 241
Quercus cortex 28, 232
Quercus petraea 232
***Quercus robur* 232**
Quercus spp. 28, 70
quillaic acid ***244***
Quillaja saponaria ***48***
quina 139
quinic acid ***65***
quinidine 21, ***85***, 139
quinine 21, 28, ***85***, ***139***
quinoline alkaloids 23, 85, 126, 139, 164
quinolizidine alkaloids 23, 84, 85, 87, 150, 189, 196
quinones 72
quinovic acid ***263***
quinquina 139
quisqualic acid 21
Quisqualis indica 21
rabano picante 111
rabarbaro 234
racines de colique 155
radix 28
ragweed 91
raisin d'ours 109
raisin de chine 180
raisin de mer 160
raisin tree 19
ramentaceone 156
ramsons 19, **101**
rankkopieva 123
Ranunculaceae 60, 62, 70, 82, 90, 94, 96, 139, 145, 177, 181, 208
ranunculin ***70***, 71, 177
ranunculoside 26
rapeseed ***59***
raphides 26
rasas 13
raspberry ***48***
ratanhia 189
Ratanhia 189
Ratanhiae radix 189
ratanhiaphenol II ***189***
ratania 189
Rauschpfeffer 221
Rauvolfia canescens 20
Rauvolfia serpentina 13, 20, 21, 81, 82, **232**
Rauvolfia spp. 20
Rauvolfia vomitaria 232
Rauwolfia 232
rauwolfia 232
Rauwolfiae radix 232
rebaudioside A 21, ***57***, 252
rebiana 57
rectal application 34
red bryony 59
red cinchona 139
red clover 19, 68, **261**
red soapwort 244
red stinkwood 9, 17, ***59***, **227**
red-sorrel 19, **178**
regalicia 172
regina dei prati 165
réglisse officinale 172
regulation 46
reine des prés 165
relative toxicity 24
ren shen 12, 212
renouee des oiseaux 224
rescinnamine 21
Resedaceae 89, 90
reserpine 20, 21, ***82***, ***232***
resina 29
Resina mastix 29
resins 29
resorcinol ***64***
resveratrol ***68***, 163, 267, ***271***
reticuline 216
retinal ***63***
retinoic acid ***63***
retinol ***63***
Rhamnaceae 72, 180, 233, 233, 234, 273
Rhamni cathartici fructus 233
Rhamni purshiani cortex 234
rhamnose 93, 104
Rhamnus 72
***Rhamnus catharticus* 233**
Rhamnus frangula 72, **233**
***Rhamnus purshianus* 234**
Rhaponticum spp. 58
rhatany 189
Rhei radix 234
rhein ***72***, ***234***, 248
Rheum officinale 234
Rheum palmatum 12, **234**
Rheum rhaponticum 234
Rheum spp. 72
rhizoma 28
rhizome 28
***Rhodiola rosea* 235**
rhodiole rose 235
rhodiolin 235
Rhododendron molle 21
Rhododendron spp. 57, 68
rhodotoxin 57
rhomitoxin 21
rhubarb 234
rhubarbe 234
Rhus toxicodendron 15, 65, **235**
Rhus vernix ***15***
ribes nero 236
Ribes nigrum 19, **236**
Ribis nigri folium 236
ribwort plantain 222
ricin 236
ricin 24, 25, 91, 236
Ricini oleum 236
Ricini semen 29
ricinine 25, 236
ricino 236
ricinoleic acid 25, 186, ***236***
Ricinus communis 9, 25, 29, ***91***, **236**
Ringelblume 124
rinsing 34
Rispiges Gipskraut 174
Rivea corymbosa 80
Rizinus 236
robin 91
Robinia pseudoacacia 91
roburin ***232***
rockrose 56
rodiola rosea 235
Roman chamomile 28, 77, **134**, 199
romarin 237
Römische Kamille 134
ronce noire 238
Rongoa Maori 14
Rooibos 115
rooibos tea 9, 19, 33, 68, **115**
rooperol 183
root 28
rorella 156
rorifone 21
Rorippa indica 21
***Rosa canina* 237**
rosa canina 237
Rosa centifolia 237
Rosa ×*damascena* 12, 237
Rosa roxburghii 19, 237
Rosaceae 67, 90, 98, 99, 112, 146, 166, 225, 226, 227, 228, 237, 238, 242
Rosae flos 237
Rosae pericarpium 29
Rosae pseudofructus 237
rosarin 235
rosary bean 27
rosavin ***235***
rose 237
rose du desert 96
rose hips 29, 77, 237
rose laurel 206
roselle 9, 19, 76, **178**
rosemary 237
rosenrot 235
Rosenwurz 235
roseroot 235
rosin 235
Rosmarin 237
Rosmarini aetherolium 237
Rosmarini folium 237
rosmarinic acid ***65***, 197, 201, 211, ***237***, 241, 243, 260
rosmarino 237
***Rosmarinus officinalis* 237**
rosolida 156
Rosskastanie 97
rossolis à feuilles rondes 156
Rotbusch 115
rotenone 21, ***68***, ***152***
Roter Chinarindenbaum 139
Rotklee 261
rotundifoline 56
rotundifurane 270
rotundine 21
round leaf buchu 98
routes of administration 34
rovo 238
rubber 63
Rubi fruticosi folium 238
Rubiaceae 52, 66, 72, 81, 82, 85, 139, 142, 203, 214, 263
rubixanthin 237
***Rubus fruticosus* 238**
Rubus idaeus ***48***, 238
ruda común 239
rudbeckia 157
rudbeckia rossa 158
rudbeckie poupre 158
rue 239
Ruhmeskrone 171
Rundblättriger Sonnentau 156
Rusci aculeati rhizoma 238
ruscin 238
ruscogenin ***238***
ruscoside 238
***Ruscus aculeatus* 238**
ruta 239
Ruta chalepensis 9, ***48***, 239
Ruta graveolens 86, **239**
Rutaceae 50, 52, 66, 67, 73, 81, 82, 85, 86, 98, 141, 153, 217, 219, 239
rutacridone ***86***
Rutae folium 239
Rutae herba 239
rutin 21, ***164***, 165, 166, 167, ***239***, 241, 243, ***253***, 267
Saatplatterbse 190
sabadine 26
sabal 248
Sabal fructus 29, 248
Sabdariffa-Eibisch 178
sabila 102
sabina 187
sabine 187
sabinene 23, 27, 51, 187, ***187,*** 204
sabinol ***50***, 51
sabiylacetate 27
Saccharomyces cerevisiae 71
Saccharum officinarum 71
sacred basil 208
sacred lotus 206
sacree 234
Sadebaum 187
safety 40
safflower 12, **129**
safflower seed oil 19
saffron 28, 63, **146**
saffron crocus 146
saffron thistle 129
Saflor 129
safran 146
Safran 146
safranal 146
safrol 204
safrole 23, ***64***, 65, ***174***
sage 241
Sägepalme 248
sai kan choi 108
Salicaceae 225, 239
salice bianco 239
salicic acid 224
salicin 17, 21, ***64***, 239
salicin-5-benzoate 225
Salicis cortex 28
salicortin 225, 239
salicylaldehyde 165
salicylates 165, 239
salicylic acid 20, ***64***, 166, 225, ***239***, 261, 269
salidroside 235
saligenin 64, 239
Salix alba 17, 20, 21, **239**
Salix cortex 239
Salix fragilis 239
Salix purpurea 64, 239
Salix spp. 28, 58
Salpichroa 87
Salvadora persica 12, **240**
salvadora persica 240
Salvadoraceae 240
salvia 241
salvia dei veggenti 240
Salvia divinorum 23, **240**
Salvia fruticosa 241
Salvia hispanica 18, 19
salvia officinal 241
***Salvia officinalis* 241**
Salvia sclarea 55
Salviae folium 241
Salviae trilobae folium 241
salvin 241
salvinorin 23, ***240***
Sambuci flos 241
Sambuci fructus 241
sambuco 241
***Sambucus nigra* 241**
samidin 270
sandalo 243
sandalwood 13, 28, **243**
Sanddorn 179
Sand-Strohblume 176
sandy everlasting 176
sanguiin H-6 242
sanguinaire du Canada 242
sanguinaria 242
Sanguinaria canadensis 16, 21, 82, **242**
Sanguinariae canadensis rhizoma 242
sanguinarine 16, 21, ***82***, ***110***, 135, ***242***
Sanguisorba minor 242
***Sanguisorba officinalis* 242**
Sanguisorbae herba 242
Sanguisorbae rhizoma et radix 242
sanguisorbe 242
sanguisorbic acid ***242***
sanguisorbin 242
sanicle 243
sanicola 243
***Sanicula europaea* 243**
Saniculae herba 243
saniculoside A ***243***

saniculu 243
Sanikel 243
sanjoinine A 273
Sanqua 10
santal blanc 243
Santalaceae 73, 243, 269
Santali album lignum 28
Santali lignum albi 243
santalol ***243***
Santalum album 13, 28, **243**
santonica 55
santonin 21, ***55***
Sapindaceae 89, 90, 97, 121, 213
sapogenins 60
saponaire 244
saponaria 244
Saponaria officinalis 60, **244**
Saponariae albae radix 174
Saponariae rubrae radix 244
saponarosides 244
saponaside 174, 244
saponins 17, 23, 26, 28, 44, 60, 99, 118, 159, 172, 173, 174, 176, 178, 200, 226, 242, 243, 250, 251, 267, 269
Sapotaceae 60, 63, 254
Sarothamnus scoparius 150
sarpagandha 232
sarrasin 164
sarrasine 111
sarsaparilla 14
sarsasaponin 116
sasarone ***64***
sassafras ***65***
Sassafras albidum ***65***
sauco 241
Sauerdorn 120
sauge commune 241
sauge des devins 240
sauge officinale 241
saule blanc 239
sausage tree 188
Saussurea costus 54
savin 187
savin 27
saw palmetto 15, 17, 29, 227, **248**
scaly grindelia 173
sceletium 23, **244**
Sceletium 244
Sceletium tortuosum 9, 23, 82, **244**
Schafgarbe 94
Schinus molle **245**
Schinus terebinthifolia 245
Schisandra chinensis 16, **245**
schisandra de Chine 245
Schisandraceae 184, 245
Schisandrae folia 245
Schisandrae fructus 245
schistosomiasis 60
schizandrin A 16, ***245***
Schizanthus spp. 87
Schlafbeere 272
Schlafmohn 212
Schlangenholz 173, 232
Schlehdorn 228
Schlehe 228
Schleierkraut 174
Schoenocaulon drummondii 26
Schöllkraut 135
Schwarze Apfelbeere 112
Schwarze Johannisbeere 236
Schwarzer Andorn 119
Schwarzer Holunder 241
Schwarzer Nachtschatten 250
Schwarzkummel 208
Schwarznessel 119
Scillae bulbus 28, 155
scillaren A 21, ***62***, 155
scillarenin ***155***
scille maritime 155
sclareolide ***55***
Sclerochiton illicifolius 21
scopolamine 21, 22, 23, 25, 26, 27, ***87***, ***123***, 151, ***156***, 182, ***198***, 246
scopoletin 202
scopolia 23, **246**
Scopolia carniolica 23, **246**
Scopolia spp. 87
Scopoliae rhizoma 246
Scotch broom 150
Scots pine 220
Scrophularia nodosa 52, ***53***
Scrophulariaceae 52, 60, 62, 72, 154, 267
scutellaire du lac Baïkal 246
scutellarein 211
Scutellaria baicalensis **246**
Scutellaria galericulata 246
Scutellaria virginiana 246
Scutellariae radix 246
sea onion 155
sea squill 155
sea wormwood 55
Secale cereale ***25***
secoiridoids ***52***
secoisolariciresinol 194
secondary metabolites 49–91
securidaca 247
Securidaca 247
Securidaca longepedunculata **247**
Securidaca longipedunculata 247
securinine 247
sedano 108
sedanolide ***108***, 193
sedative tea 32
Sedum acre 11
Sedum rhodiola 235
Sedum rosea 235
seed 29
See-Mango 133
selenocystathionine 89
selenocysteine ***88***
β-selinene ***53***
Sellerie 108
semen 29
Semen Amygdalae 227
Se-methylselenocysteine ***89***
sempervirine 27
semprevivo 176
sen 248
senecic acid ***77***
Senecio jacobaea **247**
Senecio ovatus 247
Senecio serratuloides 247
Senecio spp. 85
senecione di San Giacomo 247
Senecioninae 85
senecionine ***85***, ***247***
seneciphylline 247
senega 224
Senega Klapperschlangen-wurzel 224
senegasaponins 224
Senfbaum 240
senkirkine 215, 263
senna 12, ***13***, **248**
Senna 248
Senna alexandrina 12, ***13***, 73, **248**
Senna spp. 20, 21, 72
Sennae folium 248
Sennae fructus 248
sennosides 21, ***72***, ***248***
Serenoa repens 15, 17, 29, 59, 227, **248**
serine ***88***
serotonin ***78***
serpentella 224
serpentina indiana 232
serum 180
Sesam 249
sesame 12, 19, **249**
sésame 249
sesamin 159, ***249***
sesaminol glucosides 249
sesamo 249
sésamo 249
sesamol 249
sesamolin 249
Sesamum indicum 12, 19, **249**
seso vegetal 121
sesquiterpene lactones 16, 22, 54, 55, 113, 114, 131, 134, 138, 150, 185, 217, 256, 257
sesquiterpenes 16, 50, 52, 112, 126, 138, 161, 164, 165, 199, 215, 220, 223, 243, 259, 273
sesquiterpenoids 29, 50, 53, 95, 112, 113, 126, 131, 134, 199, 209, 211, 215, 266, 271
Seville orange 141
Shan Hai Jing 12
shan shu yu ***48***
shazenshi 221
shen mi guo 254
Shen Nong 12
Shen Nong Ben Cao Jing 12
sheng luo le 208
shepherd's purse 127
shikimi 184
Shikimibaum 184
shikimic acid ***184***
shogaols 66, 97
Siam benzoin 29
Siamese ginger 103
Siberian ginseng ***48***, **159**
Siberian motherwort 192
Sibirischer Ginseng 159
sigillo d'oro 181
silandrin 67
Silberweide 239
Silene spp. 58
silica 117, 159
silicic acid ***160***, 168, 217, 264
silicin 239
silver birch 120
silverweed 225
silybin ***249***
silybinin ***67***
Silybum marianum 10, 17, 21, 29, 67, 249
silychristin 67
silymarin 17, 21, 249
Simarouba glauca 20
Simaroubaceae 231
sinapic acid 167
sinensetin ***211***
sinhapuri 188
sinicuiche 23
sinigrin ***90***, 111
sirupus 32
Sirupus Althaeae 104
β-sitosterol ***59***, ***147***, 183, 200, ***227***, 248
sitosterols 17, 59, 210, 220, 227, 264
siwak 240
skimmianine ***86***
sloe 228
small cranberry 264
Smilax aristolochiaefolia 14
smoking 34
smooth rupturewort 178
snakeroot senega 224
snorting 35
snowdrop 168
snuff 32
snuffing 35
soapbark tree ***48***
soapwort 60, **244**
sofora 253
soia 171
Sojabohne 171
Sojae oleum 171
Sojae semen 171
α-solacidine 250
soladulcidine ***86***, ***250***
Solanaceae 60, 86, 87, 117, 123, 128, 151, 156, 164, 182, 195, 196, 198, 207, 246, 250, 272
solanidine ***86***
solanine 86, ***250***
solano nero 250
Solanum alkaloids 86
Solanum dulcamara 28, 86, **250**
Solanum lycopersicum 19, 63, **196**
Solanum melanocerasum 250
Solanum nigrum **250**
Solanum pseudocapsicum ***87***
Solanum retroflexum 250
Solanum tuberosum ***15***, 250
Solidaginis virgaureae herba 251
solidago 251
Solidago canadensis 251
Solidago gigantea 251
Solidago virgaurea **251**
soluble fibre 18
solvent extraction 36
sontol 149
Sophora japonica 253
sophora japonica 253
Sophora pachycarpa 21
Sophora tetraphylla 14
Sophorae gemmae 253
Sophoreae flos 253
sorbastrella 242
D-sorbitol 74, ***75***
Sorbus aucuparia 74
souci des jardins 124
sour figs 77
Southeast Asian traditional medicine 14
soy bean 68
soy lecithin 19
soyasapogenols 200
soyasaponins 171
soybean 61, **171**
Spanish thyme 260
Spargel 116
sparteine 21, ***85***, ***150***
spearmint oil 51
special extract 32
species 32
Sperrige Grindelie 173
spilanthe des potagers 251
spilanthes 28, **251**
Spilanthes acmella 14, 21, 73, **251**
Spilanthis oleraceae herba 28, 251
spilanthol 21, ***73***, ***251***
spina cervina 233
spindle tree 162
spiny restharrow 210
Spiraea ulmaria 20, 165
Spiraeae flos 165
Spiraeae herba 165
spiraein ***165***
spiraeoside 165
Spirostachys africana 27
spirostan-26-one 250
Spitzwegerich 222
spotted dumb cane 154
spring adonis 96
sprintillamine 26
Spritzgurke 157
squalene ***58***
squill 10
squilla 155
squirting cucumber 157
St John's wort 17, 28, **182**
St Mary's thistle 249
Stachelmohn 110
Stachelpanax 159
stachenol 27
stachenone 27
stachydrine 94, 192
standardisation 40
staphisine 26
star anise 184
star flower 183
starch 74
starflower oil 122
steam distillation 29, 50
steaming 35
Stechapfel 151
Stechender Mausedorn 238
Steiner, Rudolf 11
stem tips 28
stems 28
steovioside 57
Stephania sinica 21
Stephania spp. 83
Stephania tetrandra 21
Steppenraute 214
Sterculia spp. 75
Sterculiaceae 142, 258
steroid lactones 22

steroidal aglycones 16
steroidal alkaloids 26, 60, 86, 87, 196, 250
steroidal glycoalkaloids 250
steroidal hormones 155
steroidal saponins 16, 26, 60, 61, 116, 155, 238, 250, 261
steroids 44, 50, 200
Δ7-sterols 147
stevia 19, **252**
Stevia 252
Stevia rebaudiana 19, 21, 57, **252**
steviol ***57***
stevioside 21, ***252***
Stictocardia tiliafolia 80
Stieleiche 232
stigmasterol ***58***, 59
stimulants 9, 12, 13, 14, 15, 22, 84
stinging nettle 17, **264**
Stinkasant 165
stipes 28
stipites 28
storax balsams 29
stramoine 151
stramoine odorante 123
Stramonii folium 151
Stramonii semen 151
stramonio 151
Straucherbse 124
strofanto 252
Strophanthi grati semen 252
k-strophanthidin 96
strophanthin 27, 252
Strophanthus 252
strophanthus 27, **252**
Strophanthus gratus 21, 27, **252**
Strophanthus kombe 252
Strophanthus speciosus **48**
Strophanthus spp. 62
strophantidol 27
k-strophantoside 27
Strophariaceae 78
Strychni semen 253
strychnine 14, 21, 25, 26, ***82***, ***253***
Strychnos nux-vomica 14, 21, ***25***, 26, 82, **253**
Strychnos spp. 81
Strychnos toxifera 26
Styphnolobium japonicum 21, **253**
Styrax benzoin 14, **15**, 29
Styrax tonkinensis 29
styrylpyrones 17
succinic acid ***76***
succus 30
sucrose ***75***
sugar 74
sugar beet 71
sugar cane 71
sugar-leaf 19, **252**
suicide tree 13, 26, 27, **133**
sumac grimpant 235
Sumatra benzoin 29
summitates 28
sundew 156
superbe de Malabar 171
superbiine 26
supercritical fluid extraction
suppository 32
Surinam quassia 231
Süßholz 172
sutherlandia 193
Sutherlandia 193
Sutherlandia frutescens 193
Swainsonia 82
swainsonine ***82***
sweet balm 201
sweet clover 66, **201**
sweet flag 95
sweet pepper 56
sweet woodruff ***65***
sweet wormwood 114
swertiamarin ***132***
Symphyti herba 254
Symphyti radix 254
symphytine 254
Symphytum officinale 20, 85, **254**
Symphytum spp. 69
Symphytum ×uplandicum 85
symptoms of poisoning 24
Synadenium cupulare 26
synergism 44
Synsepalum dulciferum 19, 21, **254**
Syrian rue 12
syringic acid ***77***
syringin 240
syringol ***64***
syrup 32
Syzygium aromaticum 14, 20, 28, **255**
tabac de Virginie 207
tabac en arbre 207
tabacco glauco 207
tabacco orecchiuto 207
tabacco Virginia 207
tabaco de Virginia 207
Tabak 207
Tabasco 128
Tabasco pepper 128
Tabebuia impetiginosa 14, 72
Tabernanthe iboga 81
tabersonine 268
tablet 32
tagète 255
***Tagetes minuta* 255**
Tagetes spp. 73
tagetone 255
tagette 255
talasi 208
tamarind 19, **256**
Tamarinde 256
tamarindo 256
Tamarindorum pulpa 256
Tamarindus indica 19, **256**
tamarinier 256
tamboti 27
Tamiflu 184
Tanaceti parthenii herba 256
***Tanacetum cinerariifolium* 137**
Tanacetum parthenium 16, 55, **256**
Tanacetum vulgare 51
tanghin 27
tannins 17, 22, 28, 44, 69, 110, 125, 166, 167, 168, 169, 173, 174, 175, 186, 189, 191, 215, 225, 228, 229, 231, 234, 241, 243, 264, 265
Tao Hung Jing 12
Taraxaci radix cum herba 257
taraxaco 257
taraxacolide β-*D*-glucoside ***257***
Taraxacum officinale 75, **257**
Taraxacum officinale herba tota 28
taraxasterol 257
tartaric acid ***76***, ***95***, 211, ***256***
tasso 257
Taverniera abyssinica 9
Taxaceae 257
taxadiene 56
taxicarioside 26
taxicin 26
taxifolin-3-*O*-acetate **68**
taxin 26
Taxol® 20, 21, ***56***, 80, 257
Taxotere® 80, 257
Taxus baccata 21, 26, ***27***, 80, **257**
Taxus brevifolia 21, 80, 257
Taxus spp. 20, 56
te 125
te de Giava 211
tea 12, 19, 23, 69, **125**
tea 32
tea mixture 32
tea tree 14, 17, **200**
Teebaum 200
Teestrauch 125
tejo 257
teniposide 21
teonanacatl 23, 78
terebino 245
Terminalia bellirica 218
Terminalia chebula 218, **258**
Terminalia spp. 13
terpene alkaloids 23, 26
terpenes 50
terpenoid alkaloids 26
terpinen-4-ol 17, ***50***, 98, 152, ***187***, ***200***
terpinene 17, 200, 210
terpineol 141, 245
α-tertienyl ***73***
testosterone ***58***
12-*O*-tetradecanoyl-phorbol-13-acetate ***57***, 147
tetrahydrocanna-binol 21, 22, ***127***
tetrahydropalmatine 21
tetrahydroridentin B 257
tetrandrine 21
tetraphyllin B ***262***
tetraterpenes 50, 63
teucrin A ***56***
Teucrium chamaedrys ***55***, 56
Teufelsdreck 165
thaumatin 21
Thaumatococcus daniellii 21
thé des bois 169
The English Physician 10
The Great Native Herbal 12
Theaceae 125
Theae folium 125
thebaine 23
theier 125
Theobroma cacao 14, 19, 21, 22, 84, **258**
theobromine 21, 22, 23, ***84***, ***142***, ***258***
theophylline 21, 23, ***84***
***Thevetia peruviana* 259**
Thevetia spp. 62
Thevetiae semen 259
thevetin ***259***
thiaminase 230
thin-layer chromatography 38
thiophenes 255
Thompson, Samuel 14
thorn apple 34, 14, 23, 27, ***87***, **151**
threonine ***88***
thuja 259
***Thuja occidentalis* 259**
Thuja orientalis 259
Thuja spp. 51
Thujae aetheroleum 259
Thujae summitates 259
thujone 23, 27, ***50***, 51, ***113***, 241, ***259***
thuya américain 259
thuya d'occident 259
thym 260
thyme 260
Thymelaeaceae 57, 151
Thymi aetheroleum 260
Thymi herba 260
thymol 21, ***50***, 51, 159, 211, ***260***
thymoquinone ***208***
Thymus vulgaris 21, **260**
Thymus zygis 260
tiglic acid ***77***
tiglio 260
tigloidine 22, 25
12-*O*-tigloyl-4-deoxyphorbol-13-isobutyrate 26
3-tigloyloxytropane-6β-ol 25
Tilia cordata 75, **260**
Tilia platyphyllos 260
Tiliaceae 260
Tiliae flos 260
tiliroside ***260***
tilleul à petites feuilles 260
timo 260
tinctura 33
Tinctura botryos mexicanae 135
tincture 33
tobacco 14, 23, **207**
tobacco tree 207
tocopherol 129, 147
Tollkirsche 117
Tolu balsam 29, 52, 205
Tolu balsam tree 14, **205**
Tolubalsambaum 205
tomate 196
Tomate 196
tomatidine 86
tomato 19, **196**
tomillo 260
tongkat ali 14
tonic root 203
tonka bean 66
toothache plant 251
toothbrush tree 12, **240**
topical application 35
topotecan 21, 126
tormentil 226
tormentilla 226
Tormentillae rhizoma 226
tormentille 226
tormentoside ***226***
toxic effects 44
toxicariosides 26, 27
toxicodendrin 235
Toxicodendron pubescens 235
toxiferine 26, ***81***
toxin classes 24
TPA 27, 147
trachelogenin 131
Trachyspermum ammi 12
Traditional Chinese Medicine 12, 32, 44
tragacanth 12
tragacanth gum 75
trébol acuático 202
tree tobacco 207
trèfle commun 261
trèfle d'eau 202
Trichocaulon piliferum 179
Trichosanthes kirilowii 21
trichosanthin 21
trifoglio 261
trifoglio cavallino 201
trifoglio d'acqua 202
Trifolii pratensis flos 261
Trifolium pratense 19, 68, **261**
Trigonella foenum-graecum 12, 16, 19, 29, 75, **261**
trigonelline 217
trilobed sage 241
triphala 218, 258
triterpene saponins 17
triterpenes 50, 58
triterpenoid saponins 17, 108, 116, 118, 173, 193, 201, 212, 243, 247, 273
triterpenoids 16, 185
triticin ***159***
Tropaeolaceae 90, 262
Tropaeoli herba 262
Tropaeolum majus 19, **262**
tropane alkaloids 22, 23, 25, 26, 27, 48, 78, 86–87, 117, 123, 151, 156, 161, 182, 198, 246
truxilline 22
tryptamines 23, 78, 105
tryptophan ***88***
tuba root 152
Tubawurzel 152
tuber 28
tuber 28
tubocurarine 21, 26, ***83***, ***136***
tulasii 208
Tulipa 71
tulipalin A ***71***
tulipanin ***236***
tuliposide A ***50***, ***71***
tulsi 208
tung oil tree 100
Tungolbaum 100
Tüpfel-Johanniskraut 182
Turbina corymbosa 23
Turbinia spp. 185
turmeric 13, 66, **148**
turmérico 148

Turnera diffusa 14, 15, **262**
Turneraceae 262
tussilage 263
tussilagine 263
Tussilago farfara **263**
tussilagone ***263***
tuur 124
tuya 259
twitch 159
tyramine ***78***
tyrosine ***78***, ***88***, 217
ulivo 209
Umbelliferae 66
umbelliferone ***66***, 107, 151
umckalin 17, ***66***, ***215***
umckaloabo 17, **215**
Umckaloabo 215
umgaba 34
umhlonyane 113
umondi 203
uña de gato 263
Unani-Tibb 12
Uncaria rhynchophylla 263
Uncaria tomentosa 14, **263**
Uncariae tomentosae cortex 263
Uncariae tomentosae radix 263
2-undecanone 239
United States Pharmacopoeia 14
unsaturated fatty acids 18
upas tree 27
Urginea maritima 155
Urginea spp. 62
ursolic acid ***58***
Urtica dioica 10, 17, 28, 59, 227, 248, **264**
Urtica urens 264
Urticaceae 264
Urticae herba 264
Urticae radix 28, 264
urushiol I ***65***, ***235***
uva di monte 169
uva marina 160
uva ursina 109
Uvae ursi folium 109
uva-ursi 109
Uzara 272
uzara 62, ***63***, **272**
Uzarae radix 272
uzarigenin 272
uzarin ***62***, 63, ***272***
Vaccinium corymbosum 265
Vaccinium macrocarpon 17, 19, **264**
Vaccinium myrtillus 19, **265**
Vaccinium oxycoccus 11, 264
Vaccinium spp. 69
Vaccinium vitis-idaea 19, **265**
vaginal application 34
vainilla 266
valepotriates 21, 23, 266
valerenic acid 17, ***52***, ***266***
valerian 10, 17, 23, ***53***, **266**
valeriana 266
Valeriana officinalis 10, 17, 21, 23, 52, ***53***, **266**
Valerianaceae 52, 266
Valerianae radix 266
valériane officinale 266
valine ***88***
valtrate 17, 21, 266
vaniglia 266
vanilla 266
Vanilla planifolia 21, **266**
vanille 266
Vanilleblume 177
vanillin 21, ***76***, ***266***
vanilloside 266
Vanillosmopsis erythropappa 20
vasaka 188
vasicine 21, 23, 85, ***188***
vasicinone ***85***
Veda 13
vedegambre 267
veleño negro 182
vérâtre blanc 267
veratridine 26
veratro bianco 267
Veratrum album 10, 21, **267**
Veratrum spp. 79
Verbasci flos 267
verbascosaponin ***267***
verbascoside 268
Verbascum densiflorum 267
Verbascum phlomoides **267**
Verbascum spp. 74
Verbascum thapsus 267
verbena commune 268
Verbena officinalis **268**
Verbenaceae 50, 52, 103, 268, 270
Verbenae herba 268
verbenalin ***268***
Verek-Akazie 93
verga d'oro 251
verge d'or 251
Vernicia fordii 100
vervain 19, **103**, **268**
verveine des Indes 149
verveine odorante 103
verveine officinelle 268
Vicia spp. 89
vigne 271
vigne sauvage 136
vinblastine 21, ***81***, 130
vinca 130
Vinca 81
Vinca minor 21, **268**
Vinca rosea 130
Vincae minoris folium 268
vincamine 21, ***268***
vincristine 21, 42, 81, ***130***
vindesine 21
vindoline 130
vinorelbin 21
5-vinyl-2-oxazolidinethione 90
viola del pensiero 269
Viola tricolor 64, **269**
Violaceae 269
Violae tricoloris herba 269
violet tree 247
violutoside 269
virgaureasaponins 251
Virginischer Tabak 207
virola 23
Virola calophylloidea 23
Virola peruviana 78
Viscaceae 269
vischio 269
Visci folium 269
Visci herba 269
viscotoxins 17, 269
Viscum album 17, 91, **269**
visnadin ***66***, ***270***
visnaga 270
visnaga 270
Visnaga daucoides 21, 66, **270**
visnaga maggiore 104
visnagin 270
Vitaceae 271
vitamin A 18, 63, 152, 196
vitamin B 180, 203, 230
vitamin B17 90
vitamin C 77, 105, 112, 179, 192, 203, 229, 236, ***237***, 265
vitamin E 179
vite 271
Vitex agnus-castus 16, 56, 76, **270**
Vitex spp. 58
vitexilactone ***56***, ***270***
vitexin 213
vitexin rhamnoside ***146***
Vitis spp. 69
Vitis vinifera 12, 19, 22, 71, **271**
Voacanga africana 268
Vogelknoterich 224
volatile oils 29, 44, 45, 50
Wahrsagesalbei 240
Walderdbeere 166
Waldkiefer 220
wall pepper 11
Walnuss 186
walnut 186
warburganal ***53***, ***271***
warburgia 271
Warburgia 271
Warburgia salutaris 28, 52, 53, **271**
Wasser-Ysop 118
water hemlock 138
water hyssop 118
Wegwarte 138
Weihrauchbaum 122
Weinraute 239
Weinrebe 271
Weiser Zimtrindenbaum 126
Weiße Taubnessel 190
Weißer Germer 267
Weißer Sandelbaum 243
Welensali tea 57
welensalifactor F1 57
Wermut 113
white cedar 259
white cinnamon 126
white dead nettle 190
white hellebore 10, **267**
white henbane 23
white horehound 56, 119, **199**
white mallow 104
white peony *51*, 211
white sandalwood 243
white soapwort root 174
white willow 17, **239**
White's ginger 203
whole grains 18
Wiesenklee 261
Wiesen-Schlusselblume 226
wild carrot 152
wild cinnamon 126
wild daffodil 205
wild garlic 19, **101**
wild germander 56
wild marigold 255
wild pansy 269
wild passion flower 27
wild strawberry 70, **166**
wild watermelon 141
wild yam 155
Wilde Malve 198
Wilde Möhre 152
wildeals 113
willow 64
willow bark 28, 225
winter bark *15*, 126
winter cherry 23, **272**
wintergreen 15, **169**
Wintergrün 169
Winterlinde 260
witania 272
witch hazel 15, 17, **174**
witches tree 27
withaferin A 22, ***272***
withania 272
Withania 272
Withania somnifera 13, 16, 22, **272**
withanolides 16, 22, 272
withasomnine 272
wogonoside 246
wolfsbane 94
Wolliger Fingerhut 154
wood 28
wood avens ***71***
wood sanicle 243
woody nightshade 250
woolly burdock 109
woolly foxglove 154
wormseed goosefoot 14, ***15***, **135**
wormwood 23, 53, **113**
woundwort 94
Wu Shi Er Bing Fang 12
wu wei zi 245
Wunderbeere 254
Wurmtreibender Gänsefuß 135
Wustenrose 96
wuxing 12
xanthophyll 63
Xanthorrhoeaceae 102, 123
xanthotoxin 21, ***66***, 104, 107
xeronine 203
xi shu 126
xiao ru xiang 245
meso-xylitol 74, ***75***
D-xylose 74
Xysmalobium undulatum 62, ***63***, **272**
yagé 119
yamogenin 261
yangonin 23
yarrow 94
yellow gentian 17, **170**
yellow heads 27
yellow jasmine 15, 27, **169**
yellow oleander 259
yellow pheasant's eye 96
yerba mate 183
yerba mora 250
yew 80, **257**
yin and *yang* 12
yohimbe 214
Yohimbe cortex 214
yohimbe tree 214
Yohimbebaum 214
yohimbine 21, ***214***
Yopo 105
yopo 14, 23, **105**
yu gan zi 218
yuanhuacine 21
yuanhuadine 21
zabila 102
Zacherlin 137
zafferano 146
Zahnbürstenbaum 240
zatar 210
Zaubernuss 174
Zaubersalbei 240
Zea mays 28
zeaxanthin 18, ***63***, ***195***
zenzero 273
Zerberusbaum 133
zhi shi 141
Zigadenus brevibracteatus 26
zingerone ***66***
Zingiber officinale 16, 19, 28, 66, **273**
Zingiberaceae 66, 97, 103, 148, 158, 273
zingiberene ***53***, 273
Zingiberis rhizoma 28, 273
Zitronengras 149
Zitronenmelisse 201
Zitronenstrauch 103
ziziphin 21
Ziziphus jujuba 12, 19, 21, **273**
Ziziphus vulgaris 273
Zottige Yamswurzel 155
zucca 147
Zwergpalme 248
zygacine 26
zygadenine 26
Zygophyllaceae 81, 173, 214
Zygophyllum spp. 81