# conifer

plant



*Also known as: Coniferophyta*

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Article History

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**Conifer**, any member of the division Pinophyta, class Pinopsida, order Pinales, made up of living and fossil gymnospermous plants that usually have needle-shaped evergreen leaves and seeds attached to the scales of a woody bracted cone. Among living gymnosperm divisions, the conifers show little similarity to the Cycadophyta and Gnetophyta but share several vegetative and reproductive traits with the Ginkgophyta. Conifers are most abundant in cool temperate and boreal regions, where they are important timber trees and ornamentals, but they are most diverse in warmer areas, including tropical mountains.

# General features

## Diversity of size and structure

The conifers are the most varied gymnosperms. The world's oldest trees are the 5,000-year-old bristlecone pines (*Pinus longaeva*) of desert mountains in California and Nevada. The largest trees are the giant sequoias (*Sequoiadendron giganteum*) of the Sierra Nevada of California, reaching

(*Sequoiadendron giganteum*) of the Sierra Nevada of California, reaching heights of more than 95 metres (312 feet) and weights of at least 2 million kilograms (4.4 million pounds; compared with 190,000 kilograms for the largest recorded blue whale). Wherever conifers grow, especially in temperate climates, one of these species is usually the tallest tree. In fact, the very tallest trees are the coast redwoods (*Sequoia sempervirens*) of coastal California, some of which are more than 110 metres (361 feet) tall.

The world's smallest trees probably are also conifers: the natural bonsai cypresses (*Cupressus goveniana*) and lodgepole pines (*Pinus contorta*) of the pygmy forests (adjacent to the towering redwood forests) of the northern California coasts. On the sterile hardpan soils of those astounding forests, the trees may reach full maturity at under 0.2 metre (0.7 foot) in height, while individuals of the same species on richer, deeper soils can grow to more than 30 metres (98 feet). Other conifers, such as the pygmy pine (*Lepidothamnus laxifolius*) of New Zealand, the smallest conifer, are always shrubby and may mature as shorter plants (less than 8 centimetres [3.15 inches] in height) than the pygmy cypress, but with greater spread.

## Distribution and abundance

Conifers almost cover the globe, from within the Arctic Circle to the limits of tree growth in the Southern Hemisphere. At those extremes, they often form pure stands of one or a few species. The immense boreal forests (or taiga) of northern Eurasia and North America are dominated by just a dozen species of conifers, with even fewer adjunct kinds of hardwoods. The richest north temperate conifer forests are those of mid-latitude mountain systems, where conifers also dominate in numbers. At lower latitudes and moderate elevations are found warm temperate woodlands and forests of pine (*Pinus*), oak (*Quercus*, a hardwood), and juniper (*Juniperus*), which vary in composition and density across Eurasia and North America.

Most tropical conifers are confined to cooler mountain areas where they form solid stands or grow with tropical hardwoods, while a few species inhabit lower elevations. The dammars (*Agathis*), for instance, dominate lowland tropical

rain forests in Malaysia, Indonesia, and the Philippines, where they support an important forest industry. Conifers are widespread in southern temperate regions as well, generally with less dominance than in the north. Their greatest diversity is found in the humid portions of the three southern continents, but the largest areas are occupied by semiarid open woodlands of cypress pine (*Callitris*) in Australia and sederboom (*Widdringtonia*) in southern Africa.

Conifer species are unevenly distributed. The Eurasian continent is richest in conifers, but every region has its own endemic genera and species. The most widely distributed genera are junipers (*Juniperus*) and pines (*Pinus*), both of which cover the northern continents and extend well into the tropics. Spruces (*Picea*) and firs (*Abies*) are only slightly more restricted. Yellowwood (*Podocarpus*) is the most widely distributed genus on the southern continents, followed by *Retrophyllum*.

At the other extreme, the most narrowly restricted endemic genera are *Austrotaxus*, *Neocallitropsis*, and *Parasitaxus* of New Caledonia, an island with the richest conifer flora in the world for its size (14 genera and 44 species). Other highly local genera include *Athrotaxis*, cheshunt pine (*Diselma*), and creeping pine (*Microcachrys*) in Tasmania, Patagonian cypress (*Fitzroya*) and Prince Albert yew (*Saxegothaea*) in Chile and Argentina, giant sequoia (*Sequoiadendron*) in California, and dawn redwood (*Metasequoia*) and white-berry yew (*Pseudotaxus*) in China. Most conifer genera fall between those extremes, with scattered distributions on one or more continents.

## Economic importance

Conifers provide all the world's softwood timber, the major construction wood of temperate regions, and about 45 percent of the world's annual lumber production. Softwoods have always had many general and specialty applications. The original great cedar (*Cedrus libani*) forests of the Middle East were felled to float the warring imperial navies of the ancient world. The same fate later befell the tall North American white pines (*Pinus strobus*) that masted the dominating British navies of the 18th and 19th centuries. Medieval archers drew longbows of the elastic yew wood (*Taxus baccata*). Victims of war and other dead in East Asia have been buried from earliest recorded times in coffins of sugi (*Cryptomeria japonica*) and sanmu (*Cunninghamia lanceolata*), relatives of the equally decay- and termite-resistant redwood (*Sequoia sempervirens*) and bald cypress (*Taxodium distichum*). In the family Cupressaceae are the fragrant cedars. Some are still used to line the chests that protect fine fabrics and furs against insects, but the wonderful fragrance of sharpened lead pencils has disappeared as eastern red cedar or pencil cedar (*Juniperus virginiana*) has been superseded by tropical hardwoods.

The domination of softwoods in lumber construction in northern temperate regions has been further extended by composite products such as plywood, particleboard, and chipboard. Other processed softwood products include

paper and plastics derived from chemically treated wood pulp of spruces (*Picea*), tannins from the bark of hemlock (*Tsuga canadensis*), and naval stores (including turpentine) from many pines. Foods and beverages from conifers include pine nuts and gin, which is flavoured with juniper berries. Canadian balsam, from resin blisters on the bark of the balsam fir (*Abies balsamea*) of northeastern North America, is used as a mounting medium for microscopic preparations.

Conifers are popular ornamentals in parks, cemeteries, and other public places, as well as around private homes and gardens. Although few species are grown indoors as houseplants, the traditional Christmas tree of western Europe and North America brings the fragrance and freshness of the forest into homes during the depth of the northern winter.

## Natural history

All conifers share a typical seed-plant life cycle with a long-lived, dominant, photosynthetic, diploid sporophyte and a reduced, transient, dependent, haploid gametophyte. All phases of this general life cycle vary among conifers.



### Sporophyte phase

The sporophytes of all conifers are trees or shrubs. They have a life span that ranges from a few decades to more than 5,000 years. The ecological role and way of life of this sole photosynthetic phase of the conifer life cycle varies with the size, form, and habitat of each species. Where conifers are ecologically dominant, as in the boreal and montane forests of the Northern Hemisphere, including the Douglas fir forests of western North America, they may make up 90 percent or more of all the living matter and they contribute greatly to the biosphere through photosynthesis. One unusual genus, *Parasitaxus* (of New Caledonia) is the only gymnosperm that is parasitic, deriving water and

nutrients from the roots of *Falcatifolium*, another conifer genus.

Fires play an important role in many conifer forests. Most conifers contain highly flammable resins. The flammability of such trees increases during hot, dry fire weather, when the water content of the living needles is drastically reduced. Few adult conifers can withstand a conflagration. The giant sequoia (*Sequoiadendron giganteum*) is an outstanding exception because it has insulating bark more than 50 centimetres (20 inches) thick.

Despite their susceptibility to fires, many conifers actually depend on such ecological disturbance for regeneration. In such fire-dependent forests (including giant sequoia groves, Douglas fir forests, boreal forests, low latitude pine forests, and Australian cypress pine woodlands), the dominant conifers are unable to regenerate among the more shade-tolerant species that grow up around them with time. Fires clear the understory to bare soil, stimulating the germination and establishment of seeds. Most of those species have cones that

germination and establishment of seeds. Most of those species have cones that protect the seeds from the worst of the fire and then open to scatter them on the ash-fertilized seed bed.

At the other extreme are flooded swamp forests of bald cypress (*Taxodium*) in the southeastern United States and *shuaisuong* (*Glyptostrobus*) in southeastern China. Reproduction of such trees is as attuned to flooding as that of fire species is to scorched earth. Their seeds have air and resin pockets that allow them to float away to slightly raised areas revealed by receding floodwaters.

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Without extremes of fire and flood, mesophytic species living in temperate and tropical mixed forests may dominate or grow scattered among other trees. The conifers with broad, flat blades rather than needle leaves almost all live in moist forests, as do most species whose seeds have fleshy structures that attract birds or small mammals.

## Gametophyte phase

The gametophytes of conifers, like those of other seed plants, live out their brief, nonphotosynthetic lives almost entirely within the spore wall. All of their nutrition is derived from the parent sporophyte. The female gametophyte is never released from the tree until the seed matures. The male gametophyte is briefly separated from the sporophyte when pollen is released into the wind. Those pollen grains contain an immature male gametophyte enclosed and dispersed in the microspore wall. In the Pinaceae, three successive divisions of the microspore produce a four-celled pollen grain within the microsporangium. It has two tiny prothallial cells (the last body remnants of the old free-living gametophyte), a tube cell, and a generative cell. After pollination, the tube cell develops the pollen tube and the generative cell divides to form a sterile cell and a spermatogenous cell. Prior to fertilization, the spermatogenous cell

divides again to produce two male gametes. Other conifers share the later phases of male gametophyte development with the Pinaceae, but vary in the number of prothallial cells, from none in *Cephalotaxus*, *Sciadopitys*, Cupressaceae, and Taxaceae to as many as 40 in *Agathis* of the Araucariaceae, which has the most complex male gametophytes among the seed plants. Unlike the ovule (megasporangium), which houses a solitary female gametophyte, each microsporangium produces hundreds or thousands of pollen grains.

The female gametophytes of conifers are more massive and complex than their male counterparts and basically resemble gametophytes of *Ginkgo* and the cycads. The life history of the female gametophyte begins with a protracted series of free nuclear divisions in the megaspore. At the end of those divisions, there may be up to 2,000 nuclei in a thin layer of cytoplasm pressed against the megaspore wall by a giant central vacuole. Cell walls then form between adjacent nuclei and gradually extend into the central vacuole until the entire gametophyte is filled with radially elongated alveolar cells that are equivalent to the prothallial cells of the pollen grain. That stage is followed by the appearance of archegonia at the micropylar end of the ovule. One to eight archegonia are usual in the female gametophyte of conifers, but there may be up to 200 in some species, each of which can produce an embryo if fertilized. Each archegonium has a single huge egg cell capped by a ventral canal cell and separated from the micropylar surface of the gametophyte by a short neck made up of one or two layers of neck cells. The archegonial end of the female gametophyte usually protrudes from the megaspore wall, which might otherwise prevent pollen tube penetration and fertilization.

## Pollination

All conifers are pollinated by wind. Pollen may be produced in enormous quantities, particularly by species of true pine (*Pinus*), which can blanket the surface of nearby lakes and ponds with a yellow scum of pollen (the pollen can cause allergies in humans). The pollen grains of many Pinaceae and Podocarpaceae have air bladders, which orient them in a pollination droplet exuded by the ovules so that, when the droplet is withdrawn back into the ovule, the pollen tube will penetrate the nucellus to the archegonium. The pollen grains of families that lack prothallial cells are more or less spherical, lack air sacs, and can extend a pollen tube anywhere on their surface so that precise orientation is unnecessary. Some conifers lack a pollination droplet mechanism. Douglas fir pollen grains land on an enlarged, stigmalike growth of the micropyle, from which the pollen tubes grow into the nucellus and archegonium. The pollen grains of the Araucariaceae land on the scales of the female cone, and the pollen tubes reach the micropyle by burrowing into the cone scales.

## Fertilization and embryogeny

The processes of gametophyte growth and maturation in conifers is slow. The time from pollination to fertilization can exceed a year. After passing through the nucellus, the pollen tube presses between the neck cells of the archegonium and ruptures to release the tube nucleus, sterile cell, and the two male gametes

(sperm). The ventral canal cell seems to help the male gametes enter the egg. One of the sperm fertilizes the egg nucleus to form the zygote, the first cell of the new sporophyte generation.

The conifer zygote has fewer free nuclear divisions than do *Ginkgo* or the cycads. While many divide twice to form four free nuclei in the centre of the egg cytoplasm, there may be from zero to six free nuclear divisions. The nuclei usually move away from the micropyle, and cell-wall formation accompanies further cell divisions. The embryo develops and is fed by the nutritive tissue of the female gametophyte. The embryo rapidly enlarges at the expense of the maternal tissue and initiates typical sporophytic organization, consisting at maturity of a single axis with a root apex at one end and a shoot apex at the other, surrounded by two to eight cotyledons.