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Diversity of Gymnosperms

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ABSTRACT

Gymnosperms consist of four main phyla: the Coniferophyta, Cycadophyta, Gingkophyta and Gnetophyta. Conifers are the dominant plant of the gymnosperms, having needle-like leaves and living in areas where the weather is cold and dry. Cycads live in warm climates, have large, compound leaves, and are unusual in that they are pollinated by beetles rather than wind. *Gingko biloba* is the only remaining species of the Gingkophyta and is usually resistant to pollution. Gnetophytes are the gymnosperms believed to be most closely related to the angiosperms because of the presence of vessel elements within their stems.

KEYWORDS: *gymnosperms, phyla, diversity, species, cycads, vessel, conifers, leaves, needle*

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INTRODUCTION

Modern gymnosperms are classified into four phyla. The first three (the Coniferophyta, Cycadophyta, and Gingkophyta) are similar in their production of secondary cambium (cells that generate the vascular system of the trunk or stem and are partially specialized for water transportation) and their pattern of seed development. However, these three phyla are not closely related phylogenetic ally to each other. The fourth phylum (the Gnetophyta) are considered the closest group to angiosperms because they produce true xylem tissue.[1,2]

Coniferophytes

Conifers are the dominant phylum of gymnosperms, with the most variety of species. They are typically tall trees that usually bear scale-like or needle-like leaves. Water evaporation from leaves is reduced by their thin shape and the thick cuticle. Snow slides easily off needle-shaped leaves, keeping the load light and decreasing breaking of branches. Adaptations to cold and dry weather explain the predominance of conifers at high altitudes and in cold climates. Conifers include familiar evergreen trees such as pines, spruces, firs, cedars, sequoias, and yews. A few species are deciduous, losing their leaves in fall. The European larch and the tamarack are examples of deciduous conifers. Many coniferous trees are harvested for paper pulp and timber. The wood of conifers is more primitive than the wood of angiosperms; it contains tracheids, but no vessel elements, and is, therefore, referred to as "soft wood."

Cycads

Cycads thrive in mild climates. They are often mistaken for palms because of the shape of their large, compound leaves. Cycads bear large cones and may be pollinated by beetles rather than wind, which is unusual for a gymnosperm[3,4]. They dominated the landscape during the age of dinosaurs in the Mesozoic, but only a hundred or so species persisted to modern times. Cycads face possible extinction; several species are protected through international conventions. Because of their attractive shape, they are often used as ornamental plants in gardens in the tropics and subtropics.

Gingkophytes

The single surviving species of the gingkophytes group is the *Gingko biloba*. Its fan-shaped leaves, unique among seed plants because they feature a

dichotomous venation pattern, turn yellow in autumn and fall from the tree. For centuries, *G. biloba* was cultivated by Chinese Buddhist monks in monasteries, which ensured its preservation. It is planted in public spaces because it is unusually resistant to pollution. Male and female organs are produced on separate plants. Typically, gardeners plant only male trees because the seeds produced by the female plant have an off-putting smell of rancid butter.[5,6]

Gingko biloba

Gingko biloba is the only surviving species of the phylum Gingkophyta. This plate from the 1870 book Flora Japonica, Sectio Prima (Tafelband) depicts the leaves and fruit of Gingko biloba, as drawn by Philipp Franz von Siebold and Joseph Gerhard Zuccarini.

Gnetophytes

Gnetophytes are the closest relative to modern angiosperms and include three dissimilar genera of plants: *Ephedra*, *Gnetum*, and *Welwitschia*. Like angiosperms, they have broad leaves. In tropical and subtropical zones, gnetophytes are vines or small shrubs. *Ephedra* occurs in dry areas of the West Coast of the United States and Mexico. *Ephedra's* small, scale-like leaves are the source of the compound ephedrine, which is used in medicine as a potent decongestant. Because ephedrine is similar to amphetamines, both in chemical structure and neurological effects, its use is restricted to prescription drugs. Like angiosperms, but unlike other gymnosperms, all gnetophytes possess vessel elements in their xylem.[7,8]

Discussion

Gymnosperms, meaning "naked seeds," are a diverse group of seed plants and are paraphyletic. Paraphyletic groups are those in which not all members are descendants of a single common ancestor. Their characteristics include naked seeds, separate female and male gametes, pollination by wind, and tracheids (which transport water and solutes in the vascular system).Gymnosperm seeds are not enclosed in an ovary; rather, they are exposed on cones or modified leaves. Sporophylls are specialized leaves that produce sporangia. The term strobilus (plural = strobili) describes a tight arrangement of sporophylls around a central stalk, as seen in cones. Some seeds are enveloped by sporophyte tissues upon maturation. The layer of sporophyte tissue that surrounds the mega sporangium, and later, the embryo, is called the integument. Gymnosperms were the dominant phylum in Mesozoic era. [9,10]They are adapted to live where fresh water is scarce during part of the year, or in the nitrogen-poor soil of a bog. Therefore, they are still the prominent phylum in the coniferous biome or taiga, where the evergreen conifers have a selective advantage in cold and dry weather. Evergreen conifers continue low levels of photosynthesis during the cold months, and are ready to take advantage of the first sunny days of spring. One disadvantage is that conifers are more susceptible than deciduous trees to infestations because conifers do not lose their leaves all at once. They cannot, therefore, shed parasites and restart with a fresh supply of leaves in spring. The life cycle of a gymnosperm involves alternation of generations, with a dominant sporophyte in which the female gametophyte resides, and reduced gametophytes. All gymnosperms are heterosporous. The male and female reproductive organs can form in cones or strobili. Male and female sporangia are produced either on the same plant, described as monoecious ("one home" or bisexual), or on separate plants, referred to as dioecious ("two homes" or unisexual) plants. The life cycle of a conifer will serve as our example of reproduction in gymnosperms.[11]

Pine trees are conifers (cone bearing) and carry both male and female sporophylls on the same mature sporophyte. Therefore, they are monoecious plants. Like all gymnosperms, pines are heterosporous and generate two different types of spores: male microspores and female megaspores. In the male cones, or staminate cones, the microsporocytes give rise to pollen grains by meiosis. In the spring, large amounts of yellow pollen are released and carried by the wind. Some gametophytes will land on a female cone. Pollination is defined as the initiation of pollen tube growth. The pollen tube develops slowly, and the generative cell in the pollen grain divides into two haploid sperm cells by mitosis. At fertilization, one of the sperm cells will finally unite its haploid nucleus with the haploid nucleus of a haploid egg cell. Female cones, or ovulate cones, contain two ovules per scale. One megaspore mother cell, or megasporocyte, undergoes meiosis in each ovule. Three of the four cells break down; only a single surviving cell will develop into a female multicellular gametophyte, which encloses archegonia (an archegonium is a reproductive organ that contains a single large egg). Upon fertilization, the diploid egg will give rise to the embryo, which is enclosed in a seed coat of tissue from the parent plant. Fertilization and seed development is a long process in pine trees: it may take up to two years after pollination. The seed that is formed contains three generations of tissues: the seed coat that originates from the sporophyte tissue, the gametophyte that will provide nutrients, and the embryo itself.[12,13]

The sporophyte (2n) phase is the longest phase in the life of a gymnosperm. The gametophytes (1n)—microspores and megaspores—are reduced in size. It may take more than year between pollination and fertilization while the pollen tube grows towards the megasporocyte (2n), which undergoes meiosis into megaspores. The megaspores will mature into eggs (1n).

Results

The gymnosperms are cone-bearing, vascular seed plants that do not bear flowers. Their seeds develop either on the surface of scales or leaves, often modified to form cones, or at the end of short stalks as in Ginkgo. There are now only just over 1000 living species of gymnosperm, although there are many more extinct species in the fossil record. They evolved about 365 million years ago and were dominant from 245 to 65 million years ago when the angiosperms took over.

Gymnosperms were thought to be a natural evolutionary group with one common ancestor (a clade), but with new discoveries in genetics, there is evidence to show that this is not the case. Scientists have yet to work out the evolutionary relationships, but it seems that angiosperms evolved from an extinct group of gymnosperms, although it is not clear which one is their closest relative.[14,15]

By far the largest group of living gymnosperms are the conifers (pines, cypresses and relatives), followed by cycads, gnetophytes (*Gnetum*, *Ephedra* and *Welwitschia*) and a single living species of ginkgo. In southern Africa we have a few indigenous representatives from the conifers, cycads and gnetophytes although several others are naturalised exotics, garden plants and alien invaders.

Conifers (sometimes called *Pinophyta*) include pines, cedars, cypressus, yellowwods, firs and redwoods which are mostly evergreen shrubs and trees with needle-like leaves. In southern Africa we have species in the family *Podocarpaceae* (our yellowwoods – one species of *Afrocarpus* and three of *Podocarpus*) and the family *Cupressaceae* (three species of cedar – *Widdringtonia* and the African Juniper (*Juniperus procera*).

There are a hundred known species of **cycad** worldwide. They appeared about 320 million years ago and reached their peak in the Mesozoic Era where they existed side by side with the dinosaurs. In southern Africa we have several species of *Encephalartos* and one *Stangeria*. Having survived for so long, our cycads are seriously in danger of extinction due to human activity.[16,17]

Finally, the group of **gnetophytes** consists of 70 know species in the three genera *Gnetum* and *Ephedra* and *Welwitschia mirabilis*. This group of plants has no close living relatives. *Welwitschia mirabilis* occurs in the Namib Desert and has evolved to cope with hyper-arid conditions. Two leathery leaves grow continuously from a cone shaped corky stem – becoming rather tattered as it ages. The leaves are grooved which collect and channel condensing fog down to the tap roots which are adapted to store moisture. Male and female plants produce cones that are pollinated by *Welwitschia* Beetles that only occur on the plants. A truly fascinating living fossil!

There is only one surviving member of the ginkgos, the Maidenhair Tree (*Ginkgo biloba*) that occurs naturally in China, but they are easy to cultivate and grace many gardens, including Kirstenbosch. It remains virtually unchanged from 80 million years ago.

Conclusions

Almost all land plants reproduce by means of two distinct, alternating life forms: a sexual phase that produces and releases gametes or sex cells and allows fertilisation, and a dispersal phase. The sexual phase is known as the GAMETOPHYTE or haploid (n) generation and the dispersal phase is the SPOROPHYTE or diploid (2n) generation. In gymnosperms, as in all vascular plants, the sporophyte phase is the dominant generation.[18,19]

The gametophyte phase is reduced to a few cells – the embryo sac (female) and the pollen grain (male). Haploid (n) microspores and megaspores (i.e. each spore has a single set of chromosomes) which are produced in male and female cones. A female megaspore develops into the embryo sac (megasporophyte) that grow inside the ovule, which is retained within the female cone on the tree. Male microspores develop into pollen grains (microsporophtes) and are transferred from the male cones onto the female cones – preferably on different plants – by wind or insects. Pollen grains enter the ovules through a microscopic gap in the ovule coat called the micropyle. Once inside, they mature further and produce sperm cells.

The gametophytes are not free living and are totally dependent on the sporophyte for water, nutrients and protection. However, no external water is needed for fertilisation to take place. Two modes of fertilization are found in gymnosperms. Cycads and ginkgos have motile sperm that "swim" to the egg inside the ovule, whereas the sperm of conifers and **gnetophytes** are conveyed to the embryo sac along a pollen tube that is formed inside the ovule.[20,21]

Once fusion of the egg and sperm – or fertilisation – takes place, a diploid (2n) zygote forms with two sets of chromosomes. The zygote grows by cell division (mitosis) into an embryo and eventually forms the seed. The mature seed comprises the embryo and the remains of the female gametophyte, which serves as a food supply, and the seed coat. The seed then germinates and grows into the familiar form of the tree or plant (the mature sporophyte). The diploid (2n) sporophyte gymnosperm plants produce cones in which the haploid (n) megaspores and microspores are produced.[22] These have undergone a process of cell division called meiosis that results in four daughter cells each with half the number of chromosomes of the parent cell. The haploid gametophyte generation takes place within the female cones which will eventually release the diploid sporophyte seeds – and so the cycle continues.[23,24]

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