Life Sciences IEB

CLASS TEXT & STUDY GUIDE

Liesl Sterrenberg, Helena Fouché & Grace Elliott

GRADE

11

IEB

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Grade 11 Life Sciences 3-in-1 IEB

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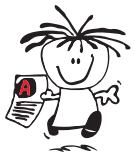

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THIS CLASS TEXT & STUDY GUIDE INCLUDES

1 Notes

- Life Processes in Plants and Animals
- Life at the Molecular, Cellular and Tissue Level
- Diversity, Change and Continuity
- Environmental Studies

2 Questions and Rapid Fire Questions

3 Detailed Memos

(in separate booklet)

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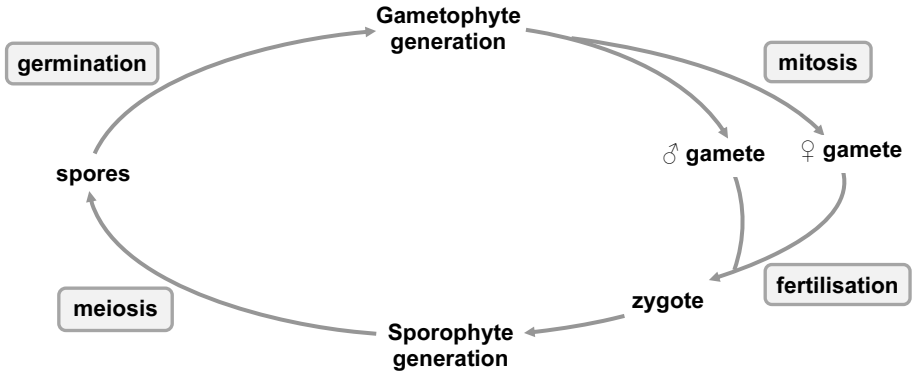
CONTENTS

Alteration of generations

During the life cycles of each of the four plant groups two definitive generations occur, i.e.:

- **Gametophyte generation**, which is sexual, and produces **gametes**
- **Sporophyte generation**, which is asexual, and produces **spores**

These two generations alternate in that the one generation gives rise to the other. This phenomenon is known as **alternation of generations**.

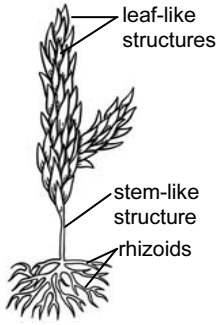


BRYOPHYTES (MOSSES)

- Bryophytes include three groups, namely:
  - mosses
  - liverworts
  - hornworts

Mosses are the first plants that are thought to have lived on land 400 million years ago.

- Mosses grow in cool, moist, shady environments.
- The **gametophyte generation** is the **dominant** generation and is represented by the adult moss plant.
- The plant body is known as a **thallus**, because it does not have true roots, stems and leaves.
- Instead it has **leaf-like structures, stem-like structures** and **rhizoids**.
- The rhizoids anchor the moss plant firmly in the soil and absorb water and mineral salts.
- **Vascular tissue** (xylem and phloem) are **absent**.

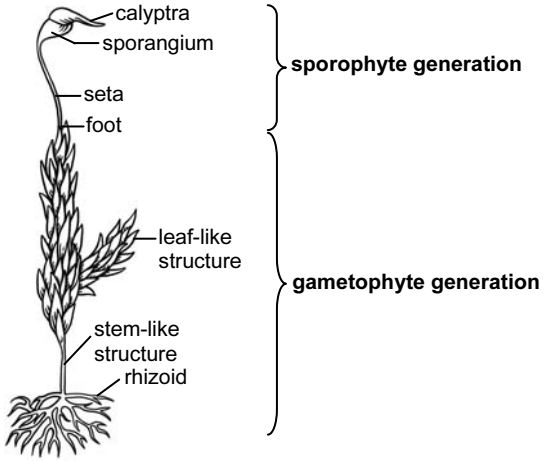


Adult moss plant - gametophyte

- Gametes (ova and sperm) are produced in male and female sex organs of the gametophyte.

Remember: *The gametophyte generation produces gametes for sexual reproduction.*

- In sexual reproduction, the sperm **requires water** to move to the ovum for fertilisation to occur.
- After fertilisation has occurred a zygote is formed which is the beginning of the **sporophyte generation**.



- The sporophyte develops on the gametophyte and it is dependent on it.
- The sporophyte consists of a **foot** part which is anchored in the gametophyte, and a **seta** which bears a capsule known as the **sporangium**.

A sporangium is a structure that produces and stores spores.

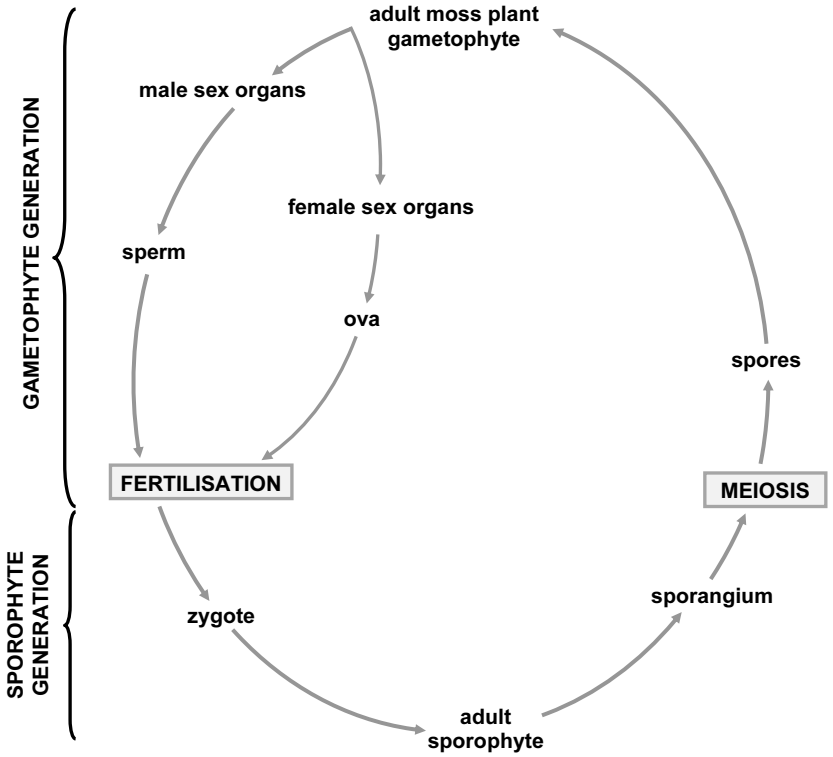
- The sporangium is covered with a cap, the **calyptra**.
- The **spores** form in the sporangium.
- The sporangium eventually dries out and releases the spores.

Remember: *The sporophyte generation produces spores for asexual reproduction.*

- The spores are dispersed by the wind and germinate in damp soil.
- A new plant, representing the **gametophyte generation**, develops.

Note that moss plants do not produce seeds and fruit.

The life cycle of Bryophytes is represented below. You do not have to learn it, it is simply given to illustrate the concepts in context and make them more understandable.



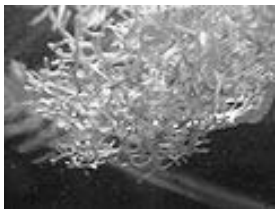
Overview

BRYOPHYTES	Structure of dominant generation (gametophyte)	Vascular tissue	Spores/ seeds	Fruits	Dependency on water for reproduction
mosses, liverworts, hornworts	thallus - no true roots, stems or leaves	absent	spores	none	water needed for fertilisation

South African examples of Bryophytes

Funaria **(moss)**

Leucobryum **(moss)**

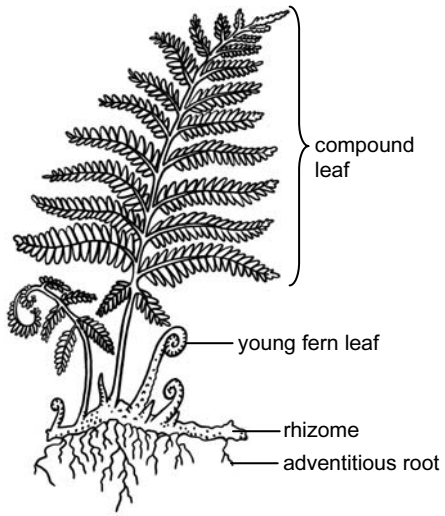


Riccia fluitans **(aquatic liverwort)**

Wardia hygrometrica **(a moss plant that is endemic to the Western Cape)**

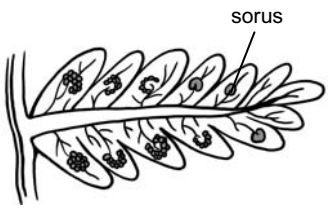
PTERIDOPHYTES (FERNS)

- Pteridophytes are a group of plants that are adapted to life on land.
- Ferns mostly occur in moist, shady environments.
- Unlike the Bryophytes, the **sporophyte generation** is the dominant generation in ferns.
- The adult fern plant represents the sporophyte generation.
- The fern has **true roots**, **stems** and **leaves** i.e. it is not a thallus.
- In most ferns (excluding tree ferns) the stem is a horizontal, underground **rhizome**.

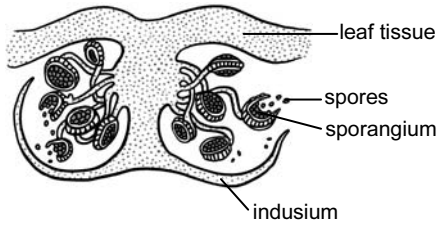


Adult fern plant - sporophyte generation

- **Adventitious roots** develop from the rhizome, anchor the plant in the soil and absorb water and mineral salts.
- The green compound **leaves** (fronds) with long leaf stalks develop from buds on the rhizome.
- Well-developed **vascular tissue** (xylem and phloem) is **present**.
- The sporophyte is perennial and therefore produces spores over many generations.
- Clusters of sporangia are found on the underside of the leaves.
- These clusters of sporangia are called **sori** (singluar: sorus).

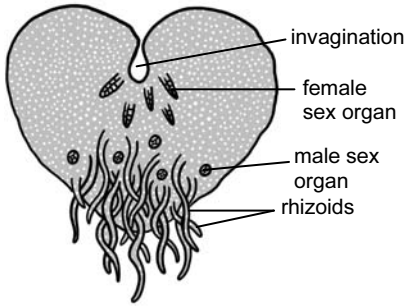


Underside of fern leaf



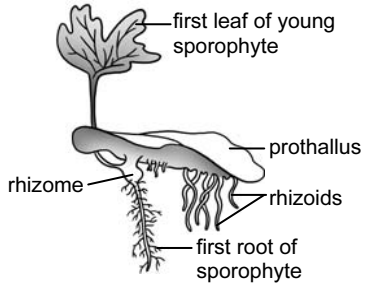
Structure of a sorus

- Spores are released from the sporangia and dispersed by the wind.
- When a spore germinates it gives rise to a green, **heart-shaped prothallus**, that represents the gametophyte generation.



Prothallus - gametophyte generation

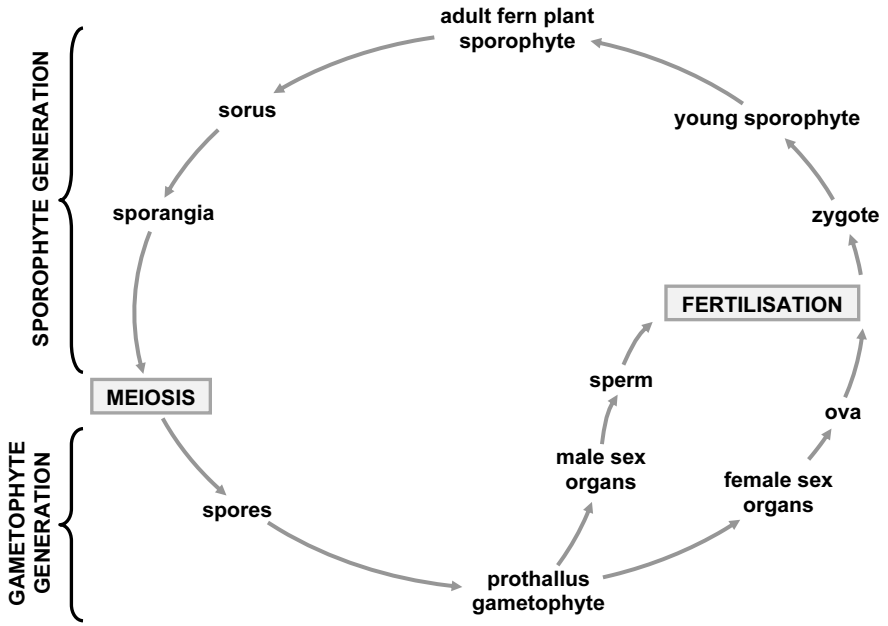
- The **gametophyte generation** is **less prominent**, has a shorter lifespan and disappears after one cycle of gamete formation and fertilisation.
- Rhizoids on the ventral (lower) surface of the prothallus anchor it in the soil.
- **Male and female sex organs**, which produce sperm and ova respectively, are also found on the ventral surface of the prothallus.
- Released sperm **need water** to move to the ovum in the female sex organ.
- Therefore, fertilisation is dependent on water.
- After fertilisation occurs a zygote is formed and this gives rise to the new fern plant (sporophyte).



- Initially, the young sporophyte lives parasitically on the gametophyte. When the young sporophyte is independent (absorbs its own water and mineral salts and can photosynthesise), the prothallus disappears.

Take note that ferns, just like mosses, produce no seeds and no fruit.

The life cycle of Pteridophytes is represented below. You do not have to learn it, it is simply given to illustrate the concepts in context and make it more understandable.



Overview

PTERIDO-PHYTES	Structure of dominant generation (sporophyte)	Vascular tissue	Spores/ seeds	Fruit	Dependency on water for reproduction
ferns	true roots, underground stem, large compound leaves	xylem and phloem present	spores	none	water needed for fertilisation

South African examples of Pteridophytes

Polystichum maclae

Asplenium boltonii

Psilotum nudum

Marattia fraxinea

*The following two plant groups, Gymnosperms and Angiosperms, are both **seed-forming** plant groups and are collectively known as the **Spermatophytes**.*

GYMNOSPERMS (NAKED SEEDS)

The term 'gymnosperm' is derived from the Greek word '*gymnospermos*', which means 'naked seeds' and refers to the fact that the seed is not enclosed in a fruit, but is naked (uncovered).

- The Gymnosperms are a group of terrestrial plants that are thought to have appeared on earth approximately 300 million years ago.
- There are four groups of Gymnosperms:
  - **Conifers** - the most abundant group with approximately 600 different species of shrubs and trees including the coniferous trees and other cone-bearing trees

- **Cycads** - the group that includes cone-bearing, palm-like plants
- **Gnetales** - the group that consists of three genera only with the *Welwitschia mirabilis* (from Namibia) as the best known example
- **Ginkgo** - the group that is limited to one genus only with the single well known species, *Ginkgo biloba,* considered a living fossil

Conifers

Cycads

Welwitschia

Ginkgo biloba

The cone-bearing pine tree (Pinus sp.) is used below to illustrate the life cycle of a Gymnosperm.

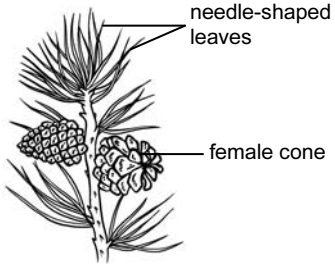
Pine - *Pinus sp*

Pine tree

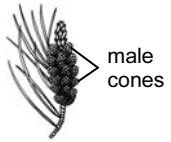
- The **sporophyte generation** is the **dominant** generation and is represented by the vegetative plant (adult pine tree).
- The plant has true roots, stems and leaves i.e. it is not a thallus.
- The **roots** consist of a well-developed taproot system with lateral roots.
- The **stem** is woody and covered with bark.
- Two types of **leaves** can be distinguished in the pine: needle-shaped green leaves and brown scales.
- Well-developed **vascular tissue** (xylem and phloem) occur.
- Pine trees bear clearly distinguishable male and female cones.

*Pine trees carry both male and female cones on the same plant, therefore the pine is **monoecious**. If they are carried on separate plants, the plant is **dioecious**.*

- Male cones are small and are borne in clusters.
- Female cones are larger and occur singly on the ends of branches.



Branch with female cones



Branch with male cones

- The male cones bear the pollen sacs containing pollen grains (male spores).

The pollen sacs are male sporangia which produce male spores (pollen grains).

- The female cones bear the ovules containing female spores on the upper surface of each seed scale.

The ovules contain female sporangia that produce female spores. There are only 4 female spores in each ovule.

- Unlike mosses and ferns, pines have separate male and female spores.

The male and female spores give rise to male and female gametophytes respectively.

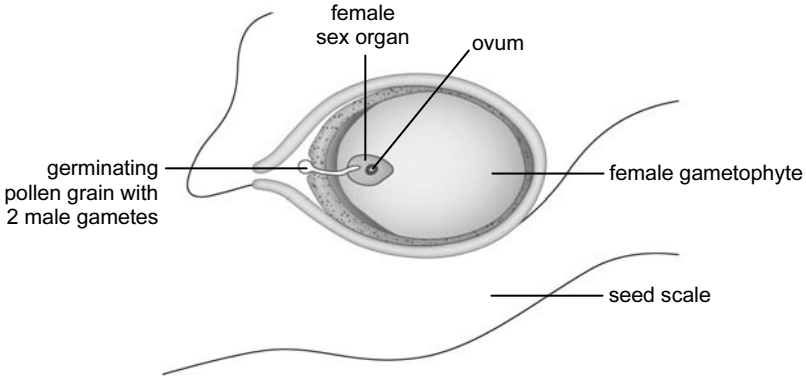
- Pollen grains (male spores) are released during spring and are dispersed by the wind.

- Some of the pollen lands on the female cones. The seed scales of the cones will be open if they are ready for pollination, so that the pollen grain can be deposited on the ovule.
- The pollen grain (male spore) germinates in favourable conditions and develops a pollen tube that contains two male gametes.
- The germinating pollen grain represents the **male gametophyte** (it contains male gametes).
- One of four female spores within the ovule develops into the **female gametophyte** (embryo sac).
- The female gametophyte (inside the ovule) contains two or three female sex organs, each containing an ovum.

We can conclude that:
- the male gametophyte (germinating pollen grain) produces male gametes (sperm).
- the female gametophyte (tissue in the ovule/ embryo sac) produces female gametes (ova).

- The pollen tube of the germinating pollen grain grows into the ovule and enters one of the female sex organs.
- The two male gametes are released and one gamete fuses with the ovum to form a zygote.
- Water is not required for fertilisation.

Gymnosperms are the first plants where the male sperm do not need water to reach the ovum. This indicates an organism well adapted to life on land.



Ovule (on seed scale in female cone)

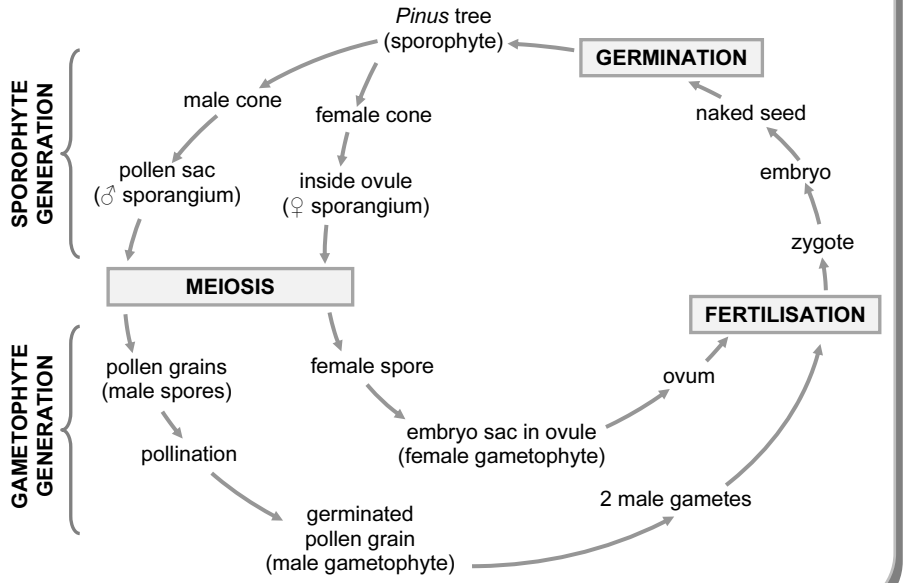
- The zygote is the beginning of the **sporophyte generation**.
- The zygote develops into the embryo.
- The fertilised ovule (containing the embryo) develops into a **seed**.
- The seed is not enclosed in a fruit and is described as a **naked** seed.

Gymnosperms do produce seeds, but not fruit. Seeds are thus exposed or 'naked'.

- The seed scales open in dry conditions, the seed is released and dispersed by the wind.
- When conditions are favourable, the seed germinates to give rise to a new pine tree (sporophyte generation).

Compared to Bryophytes and Pteridophytes, the gametophyte generation of Gymnosperms (male germinating pollen grain and female embryo sac) are poorly adapted for a terrestrial life. They are very small and are surrounded and protected by the sporophyte generation (cones).

The life cycle of Gymnosperms is represented below. You do not have to learn it, it is simply given to illustrate the concepts in context and make it more understandable.



Overview

GYMNO-SPERMS (Pine)	Structure of dominant generation (sporophyte)	Vascular tissue	Spores/seeds	Fruits	Dependency on water for reproduction
conifers, cycads, gnetales and ginkgo	taproot system, with lateral roots, small leaves, woody stem.	xylem and phloem present	◦ spores give rise to separate male and female gametophytes ◦ seeds are produced	none	water not needed for fertilisation

South African examples of Gymnosperms

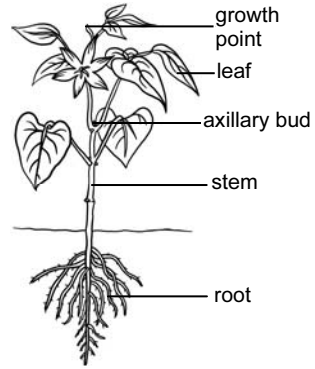
Podocarpus falcatus **(Yellowwood)**

Widdringtonia cedarbergensis
(Clanwilliam Cedar)

ANGIOSPERMS (FLOWERING PLANTS)

Just like Gymnosperms, Angiosperms are also seed-bearing plants and are therefore also part of the **Spermatophytes**. However, the difference between them is that the seeds of the Angiosperms are surrounded by a fruit, while those of the Gymnosperms are naked. Angiosperms are flowering plants and they all bear flowers. The fruit, which surrounds the seeds, develops from the ovary of a flower.

- Angiosperms are considered the most advanced plants and are also the most successful terrestrial plants in the plant kingdom.
- There is a large variety including herbaceous and woody shrubs, succulents, creepers and trees.
- Angiosperms are subdivided into **monocotyledonous** (monocots) and **dicotyledonous** plants (dicots).
- As with the Gymnosperms, the **sporophyte generation** of the Angiosperms is the dominant generation and is represented by the adult flowering plant.



Adult flowering plant

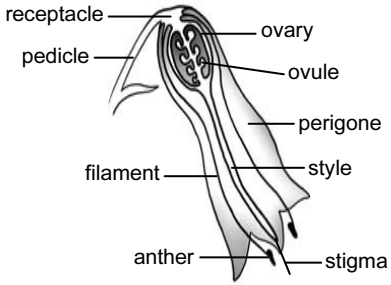
- Flowering plants have **true roots**, **stems**, **leaves** and **flowers**.
- The root systems of monocotyledonous and dicotyledonous plants differ.
  - Monocots have an adventitious root system.
  - Dicots have a taproot system, which consists of a main root with lateral roots.

Adventitious root system

Taproot system

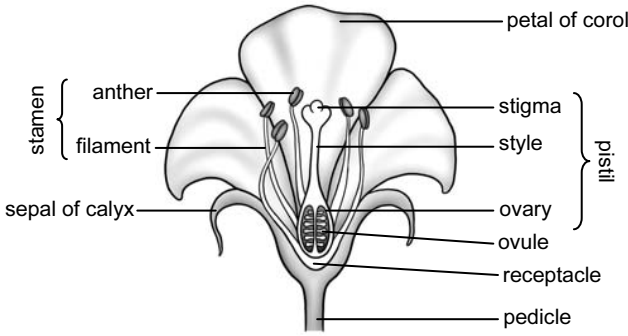
Adventitious roots *develop from any plant organ, except another root.*
Lateral roots *develop out of other roots.*

- The **stem** grows upright and consists of nodes and internodes.
- The stem has **strengthening tissue** that ensures that the plant grows upright.
- The **stem** bears its leaves in a favourable position to absorb sufficient sunlight and carbon dioxide for photosynthesis.
- It also positions its flowers in such a way that they can be easily pollinated, and the fruits in such a way that seeds can be dispersed.
- Well-developed **vascular tissue** (xylem and phloem) is **present**.
- The xylem and phloem occur in vascular bundles in flowering plants.
- The **leaves** are the main organs for photosynthesis.
- The leaves of monocotyledonous plants have **parallel** veins while dicotyledonous plants have a **net venation** with one or more main veins.
- The **flowers** are the sexual reproductive organs.
- A flower consists of three main parts:
  - perianth (corolla and/or calyx)
  - androecium (stamen)
  - gynoecium (pistil)
- In monocotyledonous flowers, the perianth consists of a single whorl (floral ring) i.e. the corolla and calyx are fused to form a single tube called the **perigone**.



Structure of monocotyledonous flower

- In dicotyledonous flowers, the perianth is differentiated into two whorls: the **corolla** (consisting of petals) and the **calyx** (consisting of sepals).

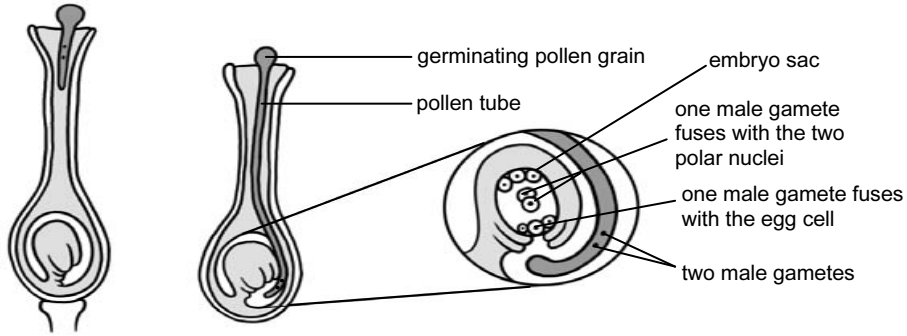


Structure of a dicotyledonous flower

- The stamens are the male sex organs in which pollen grains (male spores) are produced in pollen sacs (male sporangium).
- The pistil, consisting of a sticky stigma, a long thin style and an ovary, composes the female sex organ.
- The ovule (containing the female sporangium with female spores) is located inside the ovary.

In flowering plants the gametophyte generation is less prominent and enclosed by the sporophyte. Separate male and female gametophytes occur.

- During pollination, a ripe pollen grain (male spore) lands on a receptive stigma.
- After pollination the pollen grain germinates (in a sugar solution on the stigma) and develops a pollen tube with two male gametes.



Fertilisation in Angiosperms

- The germinating pollen grain, containing the two male gametes, represents the male gametophyte.
- One of the female spores (in the female sporangium located in the ovule of the ovary) forms the embryo sac (female gametophyte).
- The embryo sac inside the ovule contains an ovum and two polar nuclei.
- The pollen tube grows down the style into the ovary and penetrates the ovule and eventually the embryo sac to release the two male gametes.
- During fertilisation, one of the male gametes fuses with the ovum to form a zygote, which is the beginning of the next sporophyte generation.
- No water is thus needed for fertilisation.

The other male gamete fuses with the two polar nuclei in the embryo sac to form the endosperm, which serves as food for the developing embryo. Double fertilisation has taken place, as both male gametes participated in the fertilisation process.

- The zygote develops into an embryo, which enters a dormant phase.
- The fertilised ovule develops into a seed that contains the embryo, endosperm and testa (hard seed coat).
- Seeds are dispersed by the wind, water, insects or animals.
- The testa ruptures when water is present and the seed germinates.
- The radicle of the germinating seed gives rise to the root and the plumule to the stem of the new vegetative plant which represents the sporophyte generation.

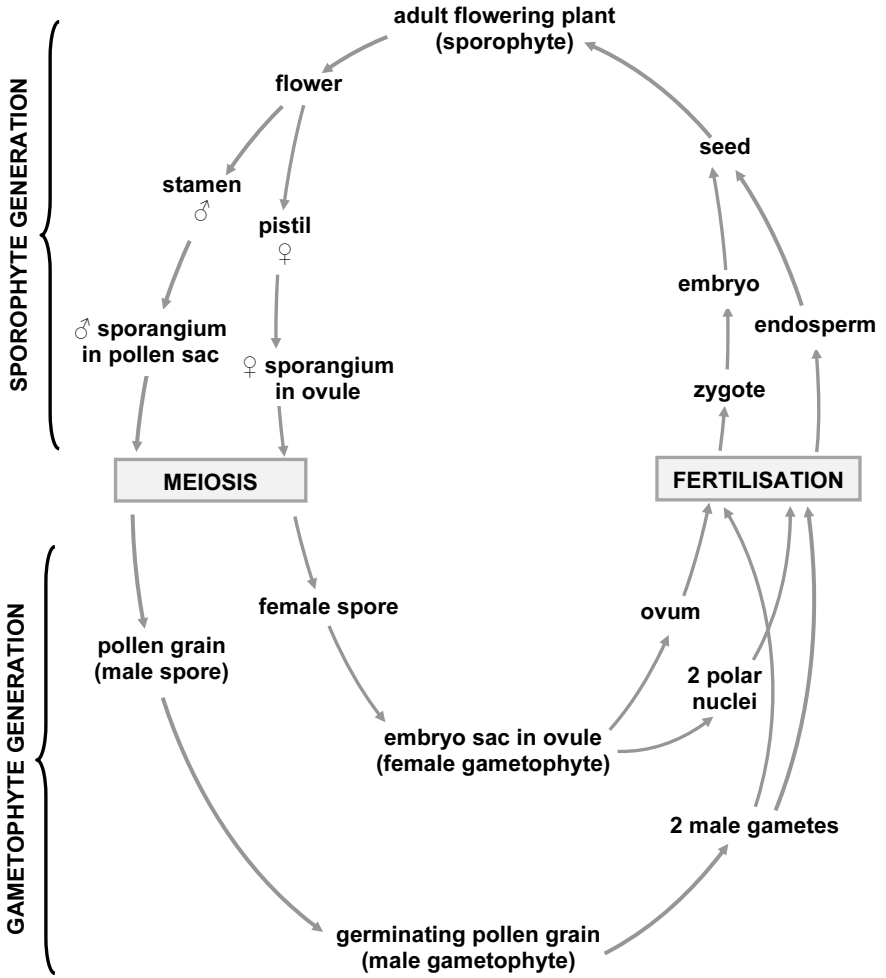
Morphological differences between monocotyledonous and dicotyledonous plants

MONOCOTYLEDONOUS PLANT (monocotyledon) - *Aloe*	DICOTYLEDONOUS PLANT (dicotyledon) - *Petunia*
Adventitious root system	Taproot system
Leaves have parallel venation	Leaves have net venation
Calyx and corolla cannot be distinguished - perigone	Separate calyx and corolla can be distinguished
Floral parts are in multiples of 3	Floral parts are in multiples of 4 or 5
Ovary has 3 locules	Ovary has 2 locules
One cotyledon in the seed	Two cotyledons in the seed
Has no cambium, therefore no secondary thickening	Has cambium, therefore secondary thickening does occur
Vascular bundles lie scattered in ground tissue of the stem	Vascular bundles are arranged in a circle in the stem

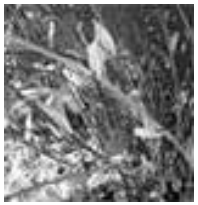
Overview

ANGIO-SPERMS	Structure of dominant generation (sporophyte)	Vascular tissue	Spores/seeds	Fruits	Dependency on water for reproduction
flowering plants, e.g. mono- and dicotyledonous, *Aloe* and *Petunia*	roots, stems, leaves and flowers	xylem and phloem present	spores give rise to separate male and female gametophytes seeds are produced	fruit surrounds the seed	no water needed for fertilisation

Just as in Gymnosperms, the life cycle of Angiosperms is represented below. You do not have to learn it, it is simply given to illustrate the concepts in context and make it more understandable.



South African examples of Angiosperms

Monocotyledons *Familie Restionaceae*	Dicotyledons
 *Calopsis*	 *Gerbera jamesonii* (Baberton Daisy)
 *Ceratocaryum*	 *Protea aristata* (Ladismith Sugarbush)
 *Restio*	 *Carpobrotus edulis* (Sour Fig)
 *Ischyrolepis*	 *Zantedeschia aethiopica* (Arum Lily)
	 *Protea nitida* (Waboom)
	 *Acacia galpinii* (Apiesdoring)

Adaptations for a successful life on land

Now that we have discussed all four plant groups, we can see the clear progression from Bryophytes (mosses), which are the least adapted for life on land, to Pteridophytes (ferns), to Gymnosperms (naked seeds) and eventually to Angiosperms (covered seeds), which are the most successful terrestrial plants.

The greatest challenges that faced plants for a successful life on land were preventing desiccation (water loss), ensuring efficient gaseous exchange and effective reproduction.

Adaptations include:

- a **cuticle** to prevent moisture loss
- **stomata** for gaseous exchange
- a plant body differentiated into **true roots**, **stems** and **leaves** for specialised functions such as absorption of water and mineral salts, transport and photosynthesis
- **vascular tissue** (xylem and phloem) for efficient transport in the plant
- **supporting/strengthening tissue** to keep the plant upright
- formation of **seeds**, which ensure that unfavourable conditions can be overcome and the embryo can still have a chance of survival

These above-mentioned adaptations are absent in the gametophyte generation of the Bryophytes and Pteridophytes. The gametophytes are poorly adapted to life on land.

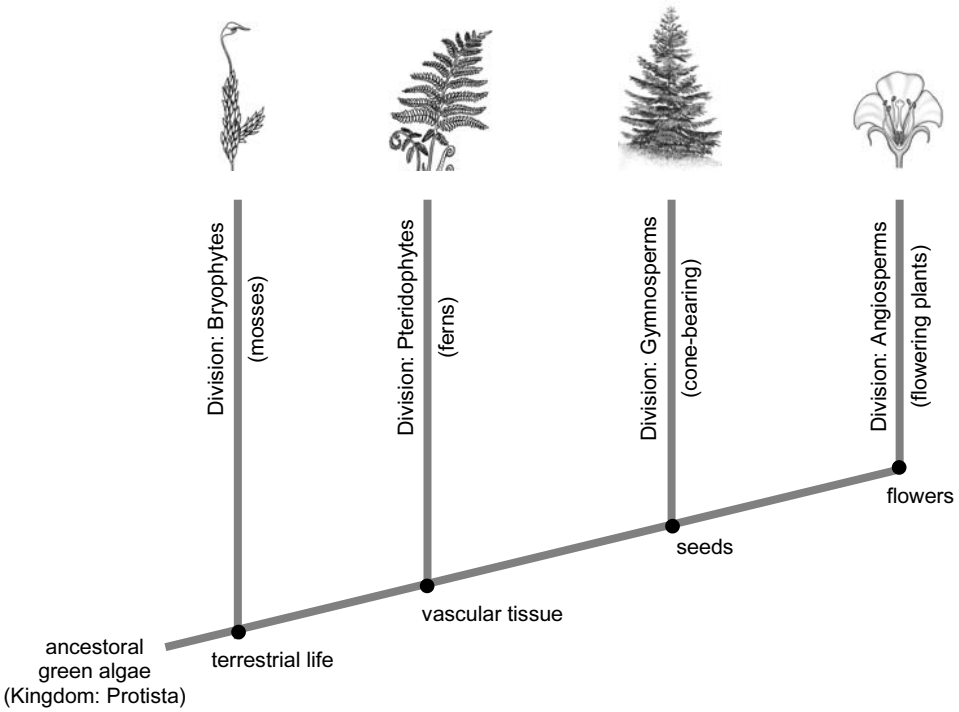
The sporophyte generations of the two groups are better adapted, with the sporophyte of the Pteridophytes better suited to a terrestrial environment than that of the Bryophytes.

The sporophytes of the Pteridophytes have true roots, stems and leaves, vascular tissue, a cuticle, stomata, and sporangia that require dry conditions for spore dispersal.

Bryophytes and Pteridophytes are both dependent on water for fertilisation.

The gametophytes of Gymnosperms and Angiosperms are reduced and are enclosed and protected by the well-adapted sporophytes. These two plant groups are now a step above the Pteridophytes in that they are not dependent on water for fertilisation and they also form seeds.

The Angiosperms are the best adapted of all the groups. This group bears flowers, and the seeds are enclosed in fruits.



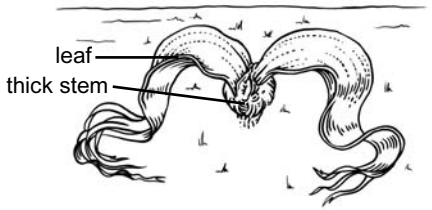
Phylogenetic tree for the Plant kingdom

The phylogenetic tree (a branched diagram showing evolutionary relationships) above suggests that the plant divisions may have developed from an ancestoral green algae of Kingdom Protista. A new branch formed with the development of each new characteristic and subsequent branches would have the new characteristic.

ANCIENT AND UNIQE PLANTS IN SOUTHERN AFRICA

Welwitschia mirabilis

- This unique plant falls under the group Gnetales of the Gymnosperms.
- It is found in the deserts of Southern Africa, especially in the Namib Desert.
- It has a short, thick, woody stem, with only two leaves that continually grow from the base, as well as a long, thick taproot.



Welwitschia mirabilis

- The leaves can grow up to 6 m long.
- The plant obtains moisture from dew overnight. The dew is absorbed by structures on the leaves.
- The *Welwitschia* can live for 1 000 years.

Cycads (bread trees)

- Cycads are also Gymnosperms.
- These plants are the oldest living seed-bearing plants and are considered living fossils that date back to about 300 million years ago.

The content of the cycad's stems was once used to make bread. This is where the name 'bread tree' comes from.

Cycad

- The habitat of cycads ranges from dry semi-deserts to subtropical forest regions.
- There are only a limited number of plants that occur naturally in the environment and a large number of South African cycads are in danger of dying out.
- There are 38 species in South Africa, of which 3 species *(Encephalartos woodii*, *Encephalartos brevifoliolatus* and *Encephalartos numbimontanus)* are classified as 'extinct in the wild', 12 species are 'critically endangered' and 13 are 'endangered'.
- South Africa has an extraordinarily high number of 'critically endangered' cycads. These plants are very popular in gardens and are considered a 'status plant'. The scarcer a species, the more sought after it is for collectors.
- Illegal trade in plants is lucrative in South Africa and worldwide.
- A rare 1 m tall cycad can fetch up to R100 000 on the black market.
- The plants are removed from their natural habitat or stolen from gardens to be sold to overseas collectors.
- Habitat destruction is the biggest threat for the survival of cycads worldwide. In South Africa the habitats are relatively intact, but theft by crime syndicates is the biggest threat.
- In South Africa it is illegal to remove cycads from the wild or to damage them. Legislature demands:
  - a permit for owning a cycad
  - a permit for the trade in cycads

The Convention on International Trade in Endangered Species (CITES) is an international agreement between governments, with the main aim being to ensure that international trade in endangered wild animals and plants is controlled or banned. This agreement has already been signed by 175 countries, including South Africa. The trade in an endangered species, such as one of the endangered species of cycads, requires CITES documentation so that the trade can be controlled.

- Another method that is used to address theft and poaching is to implant microchips into the stems of cycads. Cycads implanted with these microchips can be tracked using a GPS (Global Positioning System).

Agriculturally important plants

- Most cultivated food is derived from angiosperm crops.
- Angiosperm plants provide the staple food of people worldwide, e.g. corn, wheat, oats, rice, potatoes, barley and sweet potato.
- Other types of food derived from angiosperms include: sugar cane, beans, tomatoes, onions, pumpkin and cabbage.
- Angiosperms also produce fruits, e.g. apples, pears, cherries, plums and apricots.
- Olive trees are cultivated to produce olive oil from the fruit.
- Alcoholic drinks are produced from grapes (wine), barley (beer), sorghum (beer) and corn (mahewu).
- Spices, such as cinnamon, turmeric and nutmeg, come from Angiosperms.
- Cotton, tobacco and Rooibos tea are also products of Angiosperms.

FORESTRY

Natural forests of indigenous trees, such as yellowwood and stinkwood, are very scarce in South Africa. Most of the wood for commercial purposes is cultivated in industrial forest plantations.

Economic importance of forestry

- Indigenous forests provide resources for:
  - furniture
  - medicinal plants
  - flower industry
  - recreation
  - fuel
  - food
  - building materials
  - tourism
- Commercial forest plantations in South Africa provide wood for:
  - pulp and paper
  - mining
  - construction material for houses, factories and other large buildings
  - telephone poles
  - furniture
  - timber

*Commercial forest plantations are of great **economic importance** and a significant source of income in South Africa. It must be remembered, however, that they also cost the economy billions of Rands in terms of: the loss of food resources and traditional medicines for rural communities, the decrease in land value and the medical costs of allergies etc.*

Impact on ecosystems

- Indigenous forests provide:
  - habitats for organisms
  - stabilisation of soil and protection against soil erosion
  - protection of water resources
  - recycling of carbon dioxide
  - climate stabilisation
- Commercial forest plantations of alien species are responsible for:
  - destroying habitats of indigenous plants and animals including pollinators
  - restricting growth of indigenous plants
  - absorbing huge volumes of water to the detriment of indigenous trees
  - increasing risk of destructive fires
  - leaching nutrients from the soil