EVOLUTION

BEYOND The Origin of life through six kingdoms ending with ANIMALIA

PLANTAE

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POPULATION GENETICS & EVOLUTION

LECTURES XII

Making sense of evolution by classification

Robert Whittaker's 5 kingdom classification

1. **Monera**

- Single-celled prokaryotes (bacteria).
- Display great biochemical diversity but little internal complexity.
- Includes producers and decomposers.

2. **Protista**

- Mostly single-celled eukaryotes.
- Photoautotrophs (algae) and heterotrophs (protozoa).
- More internal complexity than bacteria.

3. **Fungi**

- Multicelled eukaryotes that feed by extracellular digestion and absorption.
- Heterotrophs; includes major decomposers; many are pathogens and parasites.

4. **Plantae**

- Multicelled photosynthetic autotrophs.
- Producers; form embryos.

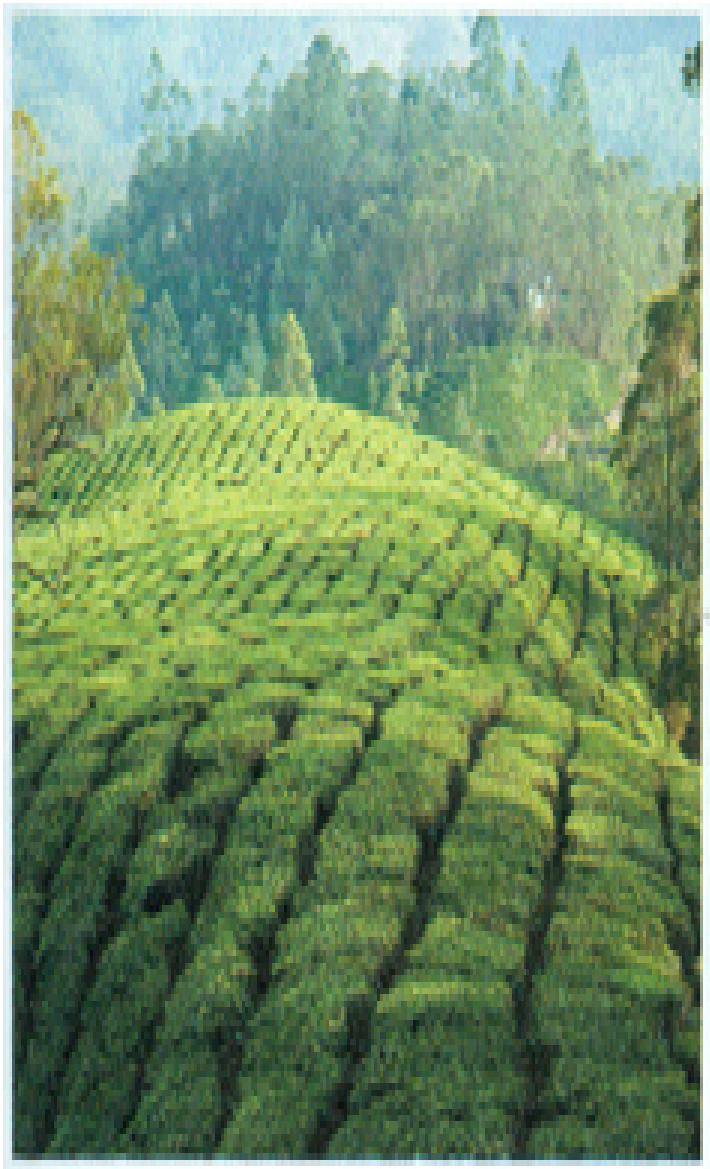
5. **Animalia**

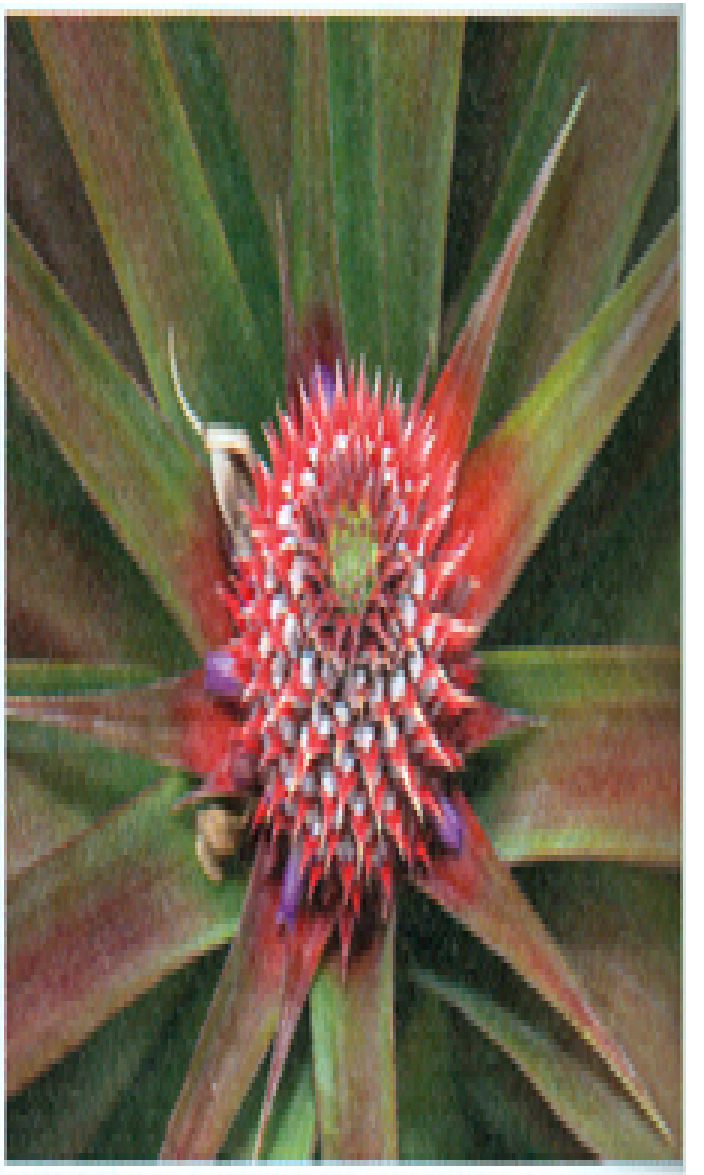
- Diverse multicelled heterotrophs.
- Range from sponges to vertebrates.
- The latest scheme **uses six-kingdoms** in which the **Monera** are divided into the **Eubacteria** and the **Archaebacteria.**

❖ PLANTS

- A plant is a multicellular eukaryote that produces its own food by photosynthesis- that is, it carries out photosynthesis, using energy from sunlight to convert carbon dioxide and water to sugar, has an embryo that develops within the protected environment of the female parent.

- plants are organisms that are fixed in place, they obtain food and water, protect itself from predators, and reproduce-but it can't move.





PLANTS CREATE THEIR OWN FOOD

Almost all plants carry out photosynthesis, using energy from sunlight to convert carbon dioxide and water into sugar

PLANTS ARE SESSILE AND (MOSTLY) TERRESTRIAL

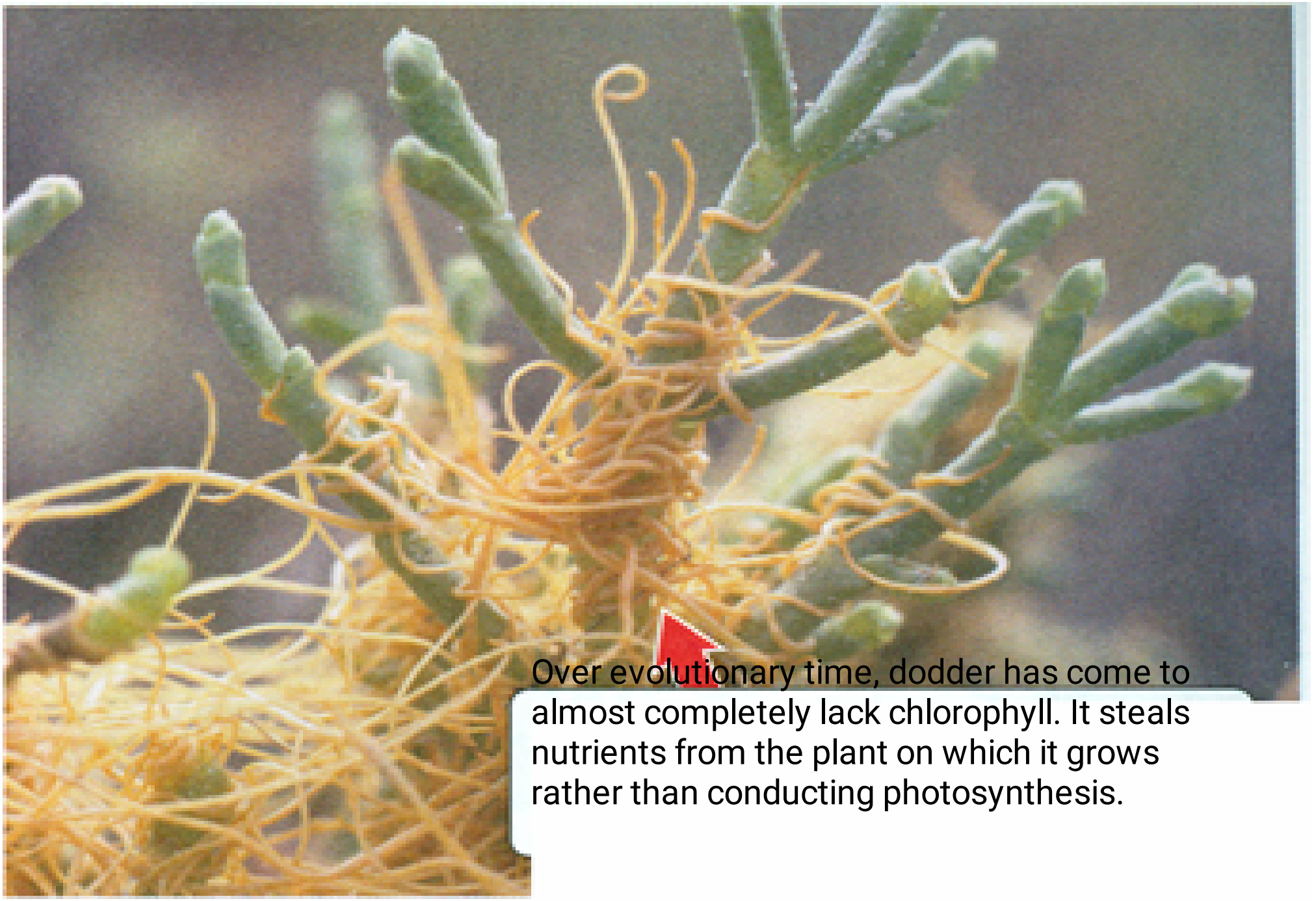
Plants are anchored in place at their bases and occur almost exclusively on land.

PLANTS ARE MULTICELLULAR

Plants consist of multiple cells and have structures that are specialized for different functions.

- Plants occur almost exclusively on land, and vary in size from less than 0.04 inch (1 millimeter) to 380 feet (117 meters) tall.
- There are other multicellular and photosynthetic eukaryotes on earth, including many species of algae, such as seaweed, as well as species that are the closest relatives of land plants.
- a plant can't live on carbohydrate alone, the product of photosynthesis.
- A plant needs nitrogen to build proteins, phosphorus to make ATp, and salts to create concentration gradients between the inside and outside of cells.

- Plants use roots, the part of a plant below ground, to obtain these needed substances from the soil.
- Above ground, plants have a shoot that consists of a stem and leaves.
- Most plants are chlorophyll-containing, but some plants have no chlorophyll-their ancestors had chlorophyll
- they live as parasites that steal nutrients from other plants.
- Dodder is an example of a parasitic plant that almost completely lacks chlorophyll and gets its sugar from the host plant it grows on .



Over evolutionary time, dodder has come to almost completely lack chlorophyll. It steals nutrients from the plant on which it grows rather than conducting photosynthesis.

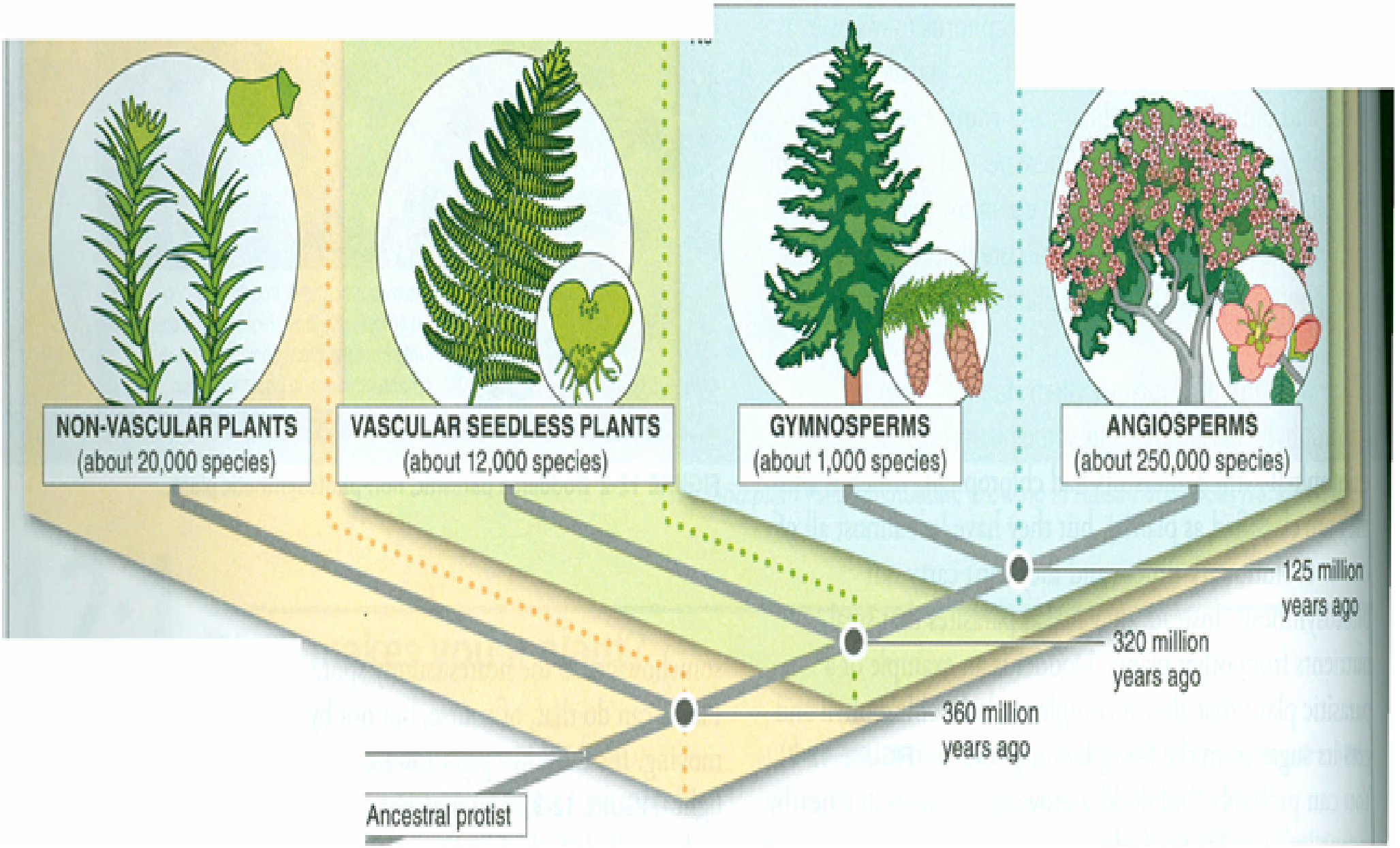
OBTAINING FOOD
Because plants can't move to reach sunlight, they bend in place and grow toward light.

FINDING A MATE
Male and female plants can't meet to reproduce, so they have developed ways of getting the male gamete to the female gamete, including alternating haploid and diploid life stages, and using other organisms to transport the male gametes.

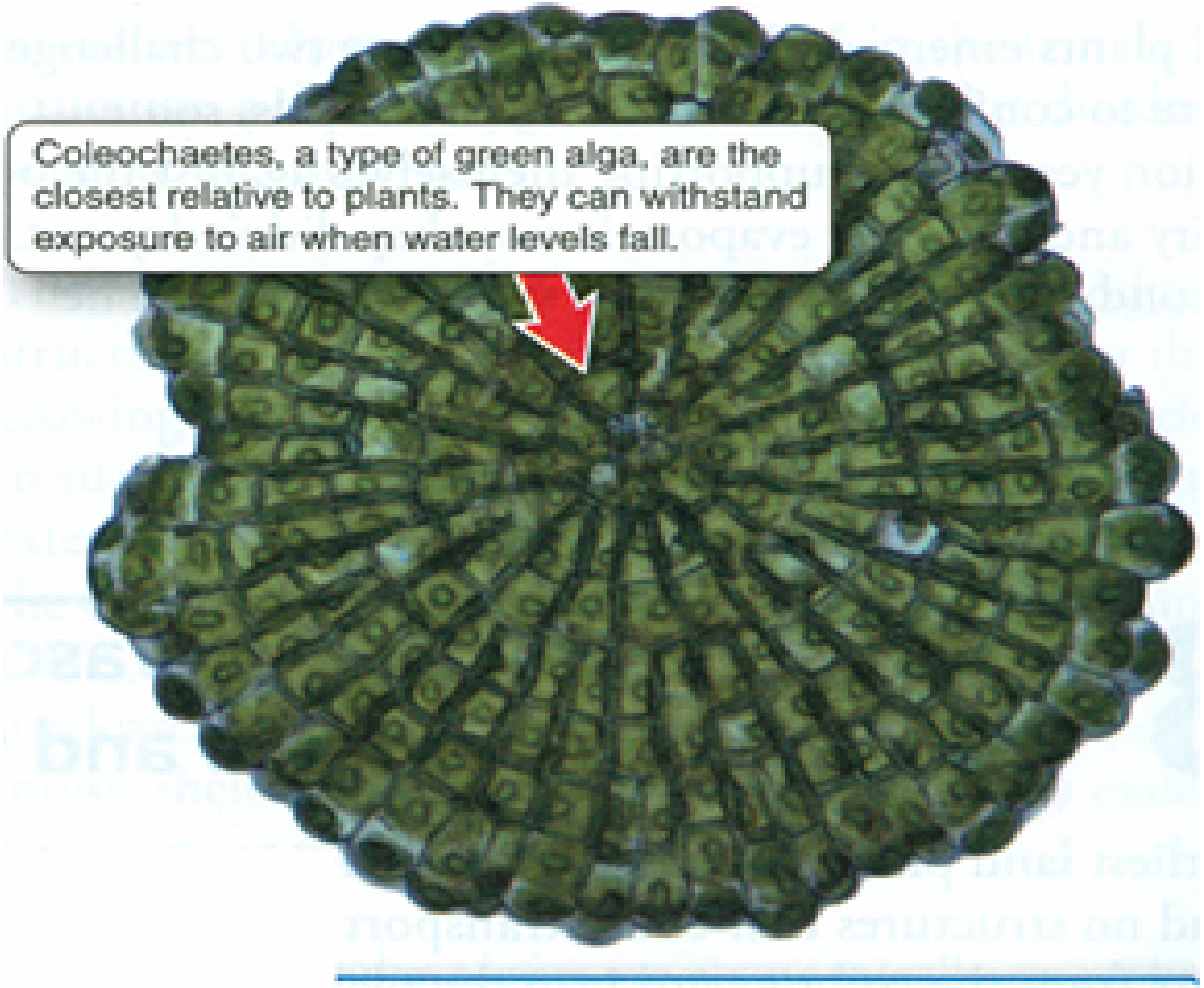
RESISTING PREDATION
Plants can't run from predators, so they have developed adaptations such as thorns to defend themselves.

- The inability of plants to move shapes the way they obtain food, reproduce, and protect themselves from predation.

- Characteristics evolved that made it possible for plants to succeed on land despite this challenge.


NON-VASCULAR PLANTS
(about 20,000 species)
VASCULAR SEEDLESS PLANTS
(about 12,000 species)
GYMNOSPERMS
(about 1,000 species)
ANGIOSPERMS
(about 250,000 species)
125 million years ago
320 million years ago
360 million years ago
Ancestral protist

- The aquatic ancestors of land plants were green algae, which are classified as part of the plant kingdom.
- Like the land plants, green algae are multicellular, photosynthetic eukaryotes, but green algae live only in water or on very moist land surfaces.
- They do not require specialized structures to obtain water and nutrients; water simply enters their cells by osmosis, and the nutrients they require are in solution in the water that surrounds them
- some green algae that look like slime on rocks eg. organisms called coleochaetes to be the closest relatives of plants.



• NON-VASCULAR PLANTS

MOVING ONTO LAND PRESENTS PROBLEM:

PROBLEM: GRAVITY

SOLUTION: The earliest plants grew very close to the ground,
as mosses do today, in order to resist the pull of gravity.

PROBLEM: DESICCATION

SOLUTION: Plants developed an outer waxy layer called a
cuticle that covers their entire surface.

- The first land plants were small, had no leaves, roots, or flowers, and could grow only at the water's edge.

- these inconspicuous little plants set the stage for the enormous diversity of terrestrial plants and animals on earth today.

- Diffusion is a slow process, and plants that rely on diffusion can grow only a few centimeters tall.
- Despite the limitations of diffusion, three groups of plants, all known as **bryophytes**, still use it, rather than having any sort of circulatory system.
- They are the liverworts, hornworts, and mosses.
- Liverworts and hornworts are small (less than an inch in height),
- simple plants that grow in moist and shady places and resemble flattened moss.
- These three types of bryophyte plants are referred to as **non-vascular**

- This is because they do not have vessels to transport water and food.

- Water and nutrients are absorbed into the outermost layer of cells by projections that penetrate a few micrometers into the soil.

- these projections are so short, non-vascular plants must either live in places where the soil is always moist or become dormant when the soil surface dries out.

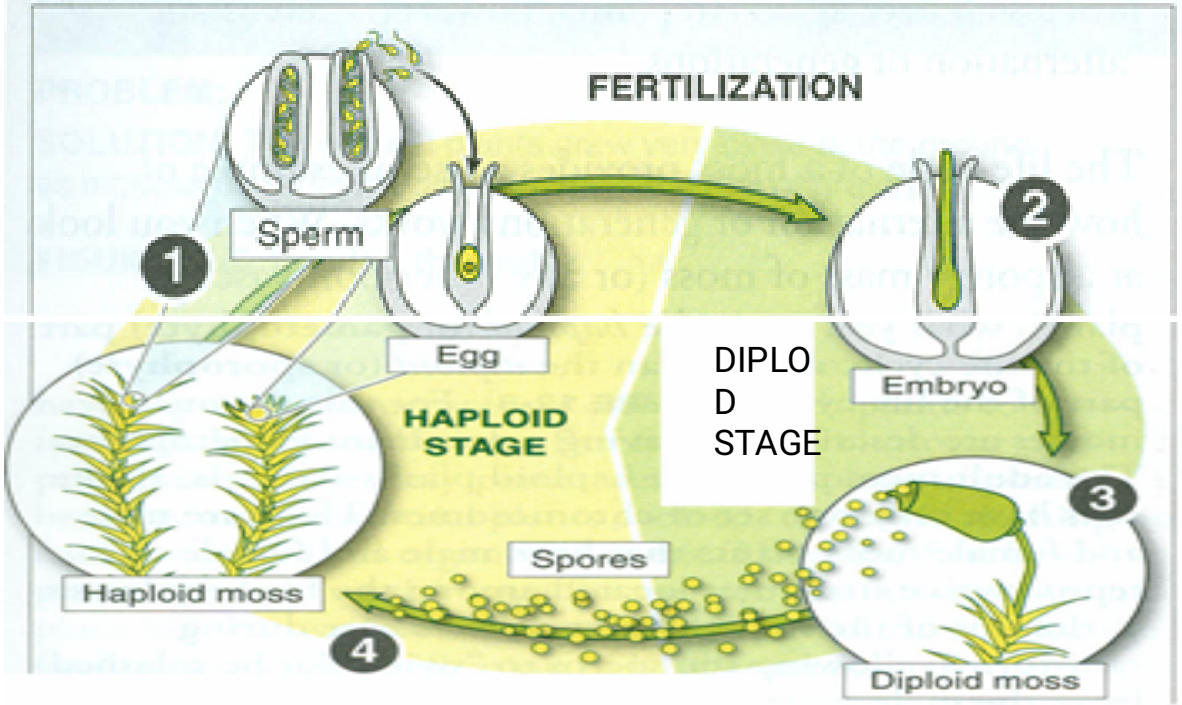
CHARACTERISTICS

•Distribute water and nutrients throughout plant by diffusion
•Release haploid spores, which grow and produce gametes
•Life cycle with multicellular haploid and diploid phases

MEMERS INCLUDE

•Mosses (about 12,000 species) •Liverworts (about 8,000 species) •Hornwort (about 100 species)

- To adapt to land, the non-vascular plants had to develop a method of reproduction that protected the plant embryo from drying out and provided it with a source of nutrients.
- The innovation that made this possible was a life cycle of alternating haploid and diploid generations,
- which is different from the life cycle of humans and most other animals.
- In animals, the haploid gametes, at fertilization, produce a new, diploid cell that becomes a multicellular organism, which, in the adult stage, starts the process allover again.
- In plants, however, there is an alternation of generations.

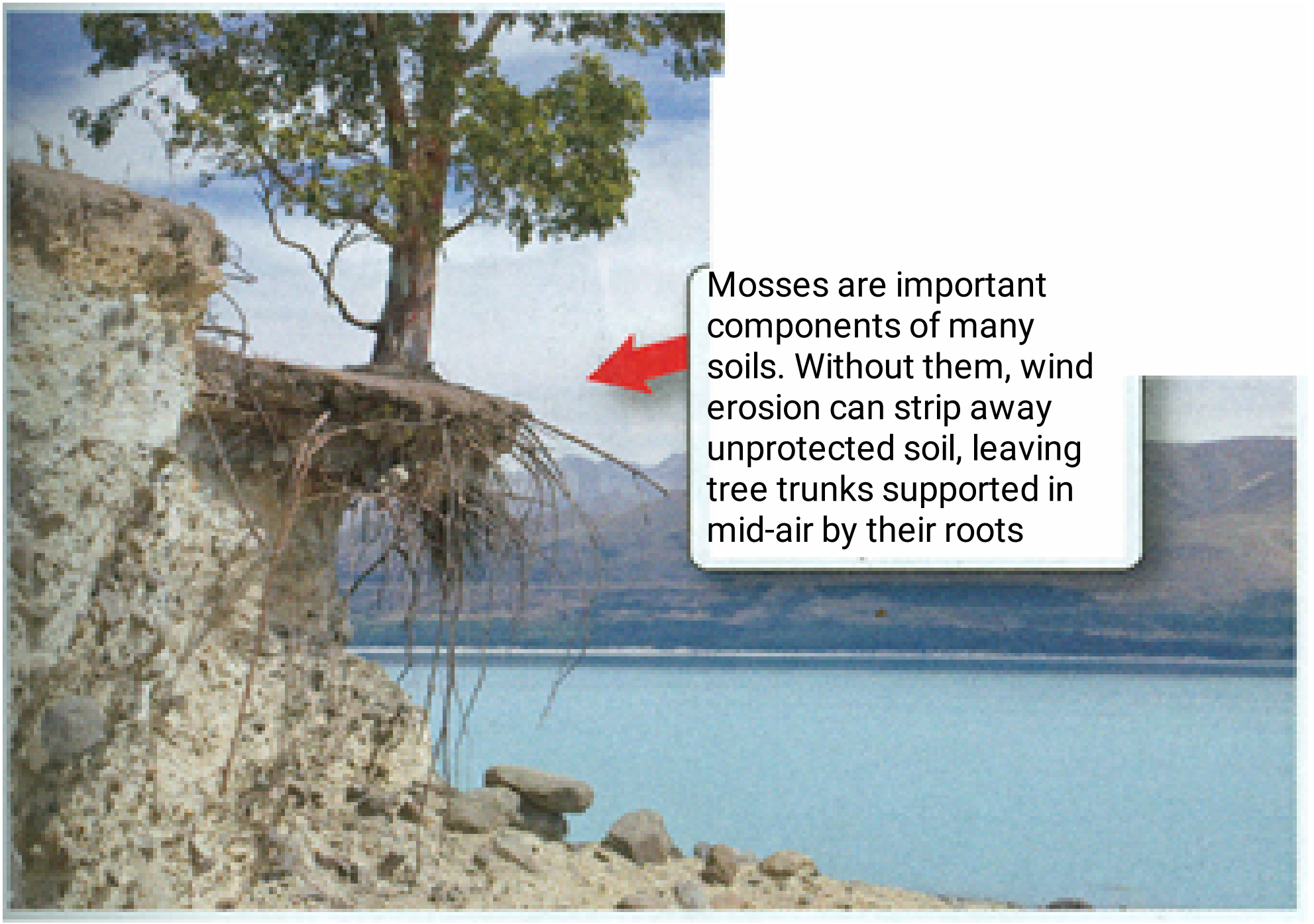

FERTILIZATION
Sperm
1
2
Egg
Embryo
DIPLO
D
STAGE
HAPLOID
STAGE
3
Spores
Haploid moss
4
Diploid moss

- Some non-vascular plants are economically or ecologically important.
- "Peat moss" (Sphagnum moss), found in many parts of the world, is sold as a soil enhancer for gardening.
- In areas where trees are scarce, peat is dried and burned as fuel.
- In places with monsoon seasons, such as Malaysia and of burning peat are used to dry the barley used in producing Scotch whisky. This gives Scotch its distinctive smoky taste .

Non-vascular plants such as peat moss have many important economic and ecological uses, from flood control to gardening to the production of Scotch whisky (shown here).

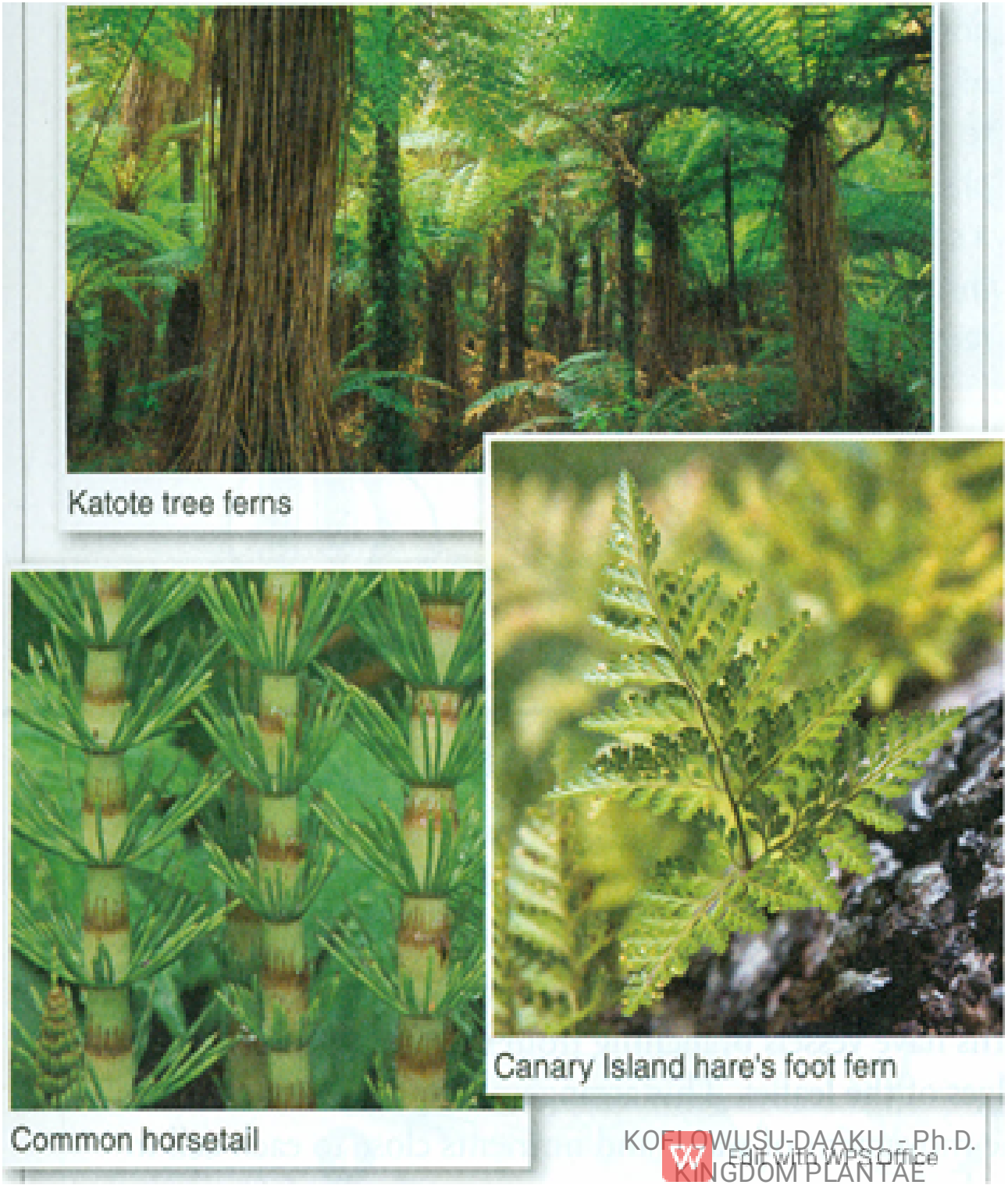
- non-vascular plants can grow in deserts, and mosses along with lichens and cyanobacteria are important components of the biological crust that holds desert soils in place.

- The crust cements the soil particles together and allows the soil to resist wind erosion, but it is extremely fragile and very slow to regenerate.


Mosses are important components of many soils. Without them, wind erosion can strip away unprotected soil, leaving tree trunks supported in mid-air by their roots

• VASCULAR PLANTS

- These have vascular tissue is, a sort of infrastructure of tubes that begins in a plant's roots and extends up its stem and out to the tips of its leaves.
- The evolution of vascular tissue allowed early land plants to transport water and nutrients faster and more effectively than the cell-to-cell diffusion that non- vascular plants
- Vascular plants' roots penetrate far enough into the soil to reach moisture even when the soil surface is dry.
- Roots that reach deep into the soil also provide the support that a plant needs to grow upward without falling over.
- As a result plants can grow taller than non-vascular plants and are more successful in areas where the surface of the ground dries out between rains



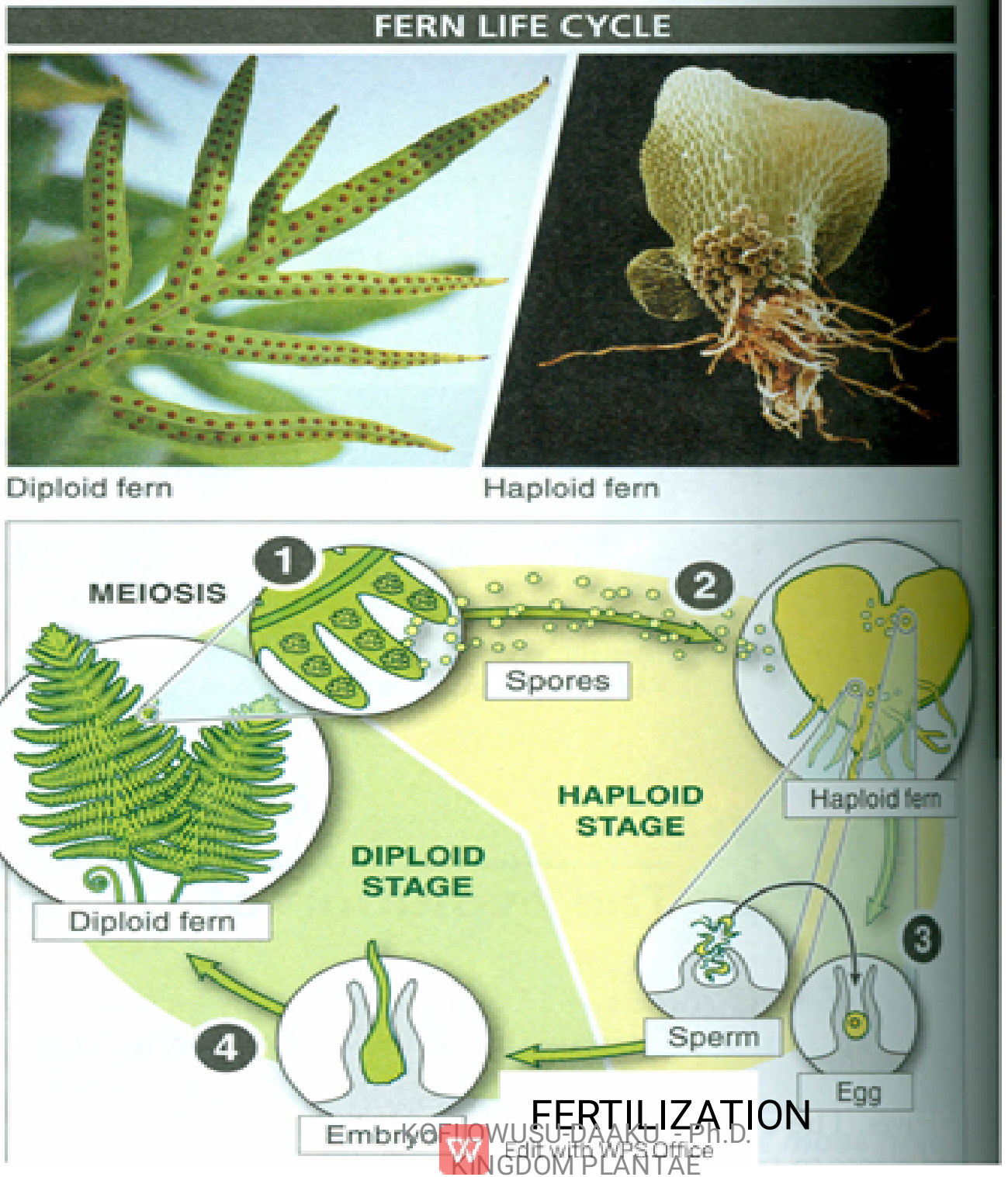
COMMON CHARACTERISTIC

- Distribute water and nutrient throughout the plant with a "circulatory system" of vascular tissue
- Release haploid spores, dispersed by the wind, which grow and produce gametes
- Life cycle (unlike in animals) with multicellular haploid and diploid phases

MEMBERS INCLUDE

- Ferns (about 12,000 species)
- Horsetails (about 15 species

- Ferns are the most familiar of the primitive vascular plants
- the leaves of ferns have vessels branching from the central vessel to the edges of the leaflet.
- This arrangement places a channel for the movement of water and nutrients close to each cell in the leaf
- Like non-vascular plants, most ferns reproduce with spores
- Many ferns have sporangia (sing. sporangium) on the undersides of the leaves where spores are produced
- Because the haploid gametophyte is much smaller and simpler than the diploid sporophyte, ferns are described as having a dominant sporophyte.



KINGDOM PLANTAE

- their spores can be blown by the wind when they are released, and they may settle some distance from the parent plant.
- This increased dispersal ability was an important adaptation
- A spore that lands on moist soil grows into a tiny heart-shaped structure called a pro thallus, which is the free-living haploid life stage of a fern
- The prothallus produces the haploid gametes: some cells produce eggs and others produce sperm.
- Sperm swim through drops of rainwater to fertilize an egg, and the fertilized egg (a diploid zygote with two sets of chromosomes) grows into an adult fern.

- One big innovation in plant evolution was the **seed**, an embryonic plant with its own supply of water and nutrients encased within a protective coating.
- they contain the materials needed to begin a new life.
- Unlike spores, which are single cells that contain only DNA, RNA, and a few proteins, seeds contain both a multicellular embryo and a store of nutrients, mostly starch.

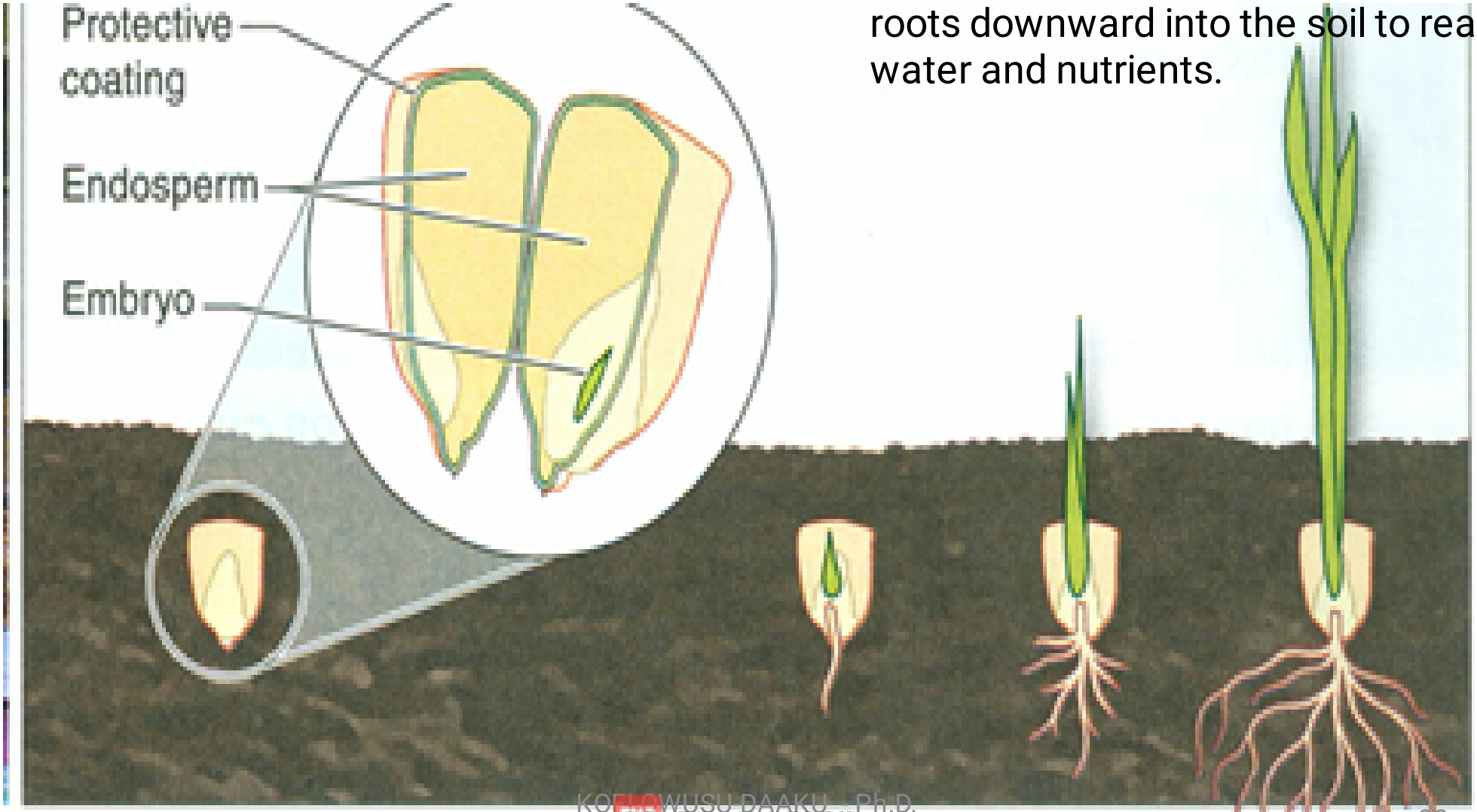
- This nutritive tissue-called endosperm in flowering plants and trees can fuel the seed's initial growth.
- A seedling draws energy from the endosperm while it extends its leaves upward to begin photosynthesis and its roots downward to reach water and nutrients in the soil.
- There are two modern groups of seed-producing plants:
- gymnosperms (including pines, firs, and redwoods)
- angiosperms (all of the flowering plants and trees)

STRUCTURE

Fertilization produces a diploid seed, which contains a multicellular embryo and a store of carbohydrate (endosperm) to fuel its initial growth

GROWTH

A seedling draws energy from the endosperm while it extends its leaves
upward to begin photosynthesis and its
roots downward into the soil to reach water and nutrients.



- Pollen grains and ovules are the male and female gametophytes, respectively, of seed plants
- a haploid female gamete (egg) forms inside the ovule.
- When a pollen grain lands near the ovule, it produces a tube that grows into the ovule. Sperm from the pollen grain move through the pollen tube into the ovule and fertilize the egg.
- The external layer of the ovule then forms the seed coat.
- The seed stage is the only opportunity most plants have to send their offspring away from home.
- These range from the forceful send-off of exploding seed pods, to seeds that hitch a ride in or on passing animals, to those that are so small and light that they can float in water or air as well as those that use fruits in seed dispersal

- **Gymnosperms**
- Gymnosperms include four major groups: the conifers, cycads, gnetophytes, and ginkgo
- All of the 900 or more species of gymnosperms are seed-bearing plants that produce ovules on the edge of a cone-like structure.
- The reproductive structures of gymnosperms-the cones-are male or female.
- The male cones are smaller and release pollen that is blown by the wind, and some of it reaches the ovules, which lie beneath the protruding scales of the female cones.

THE GYMNOSPERMS

COMMON CHARACTERISTICS

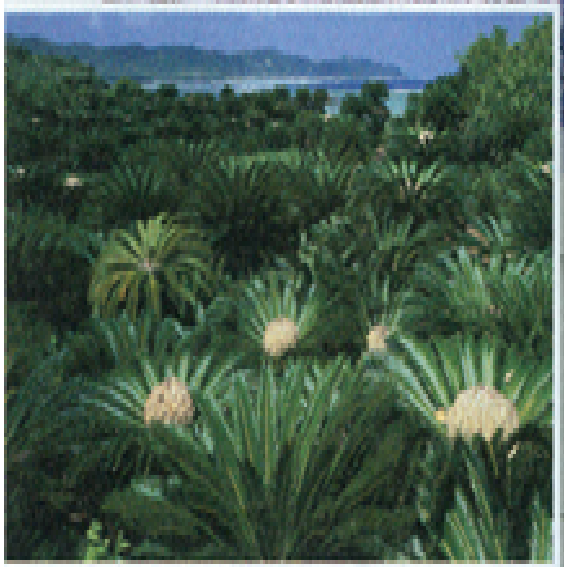
- Distribute water and nutrients throughout the plant with a "circulatory system" of vascular tissue
- Reproductive structures called cones produce the gametes
- Fertilization produces seeds

MEMBERS INCLUDE

- Conifers (about 600 species)
- Cycads (about 300 species)
- Gnetophytes (about 65 species)
- Ginkgo (1 species)

Douglas fir

Ginkgo



Cycad

Welwitschia

GROUPS OF GYMNOSPERMS

CONIFERS
•Most commonly found in colder
temperate and sometimes drier regions of the world
•Commonly have needle -shaped leaves
•Important source of timber
•Include pines, spruces, firs, cedars,
hemlocks, yews, larches,

CYCADS
•Slow-growing gymnosperms of tropical and subtropical regions
•Most resemble palm trees
•Several species are facing extinction in the wild

GNETOPHYTES
•Composed of 3 groups: Gnetum,
Ephedra, and Welwitschia
•Most gnetophyte species are Ephedra, a shrub-like plant sometimes used as a herbal remedy for respiratory ailments

GINKGO
•Ginkgo biloba is the only remaln]
species
•Distinctive fan-shaped leaves
•The outer covering of the seeds
emits a foul odor

KINGDOM PLANTAE

CONES

MALE CONE

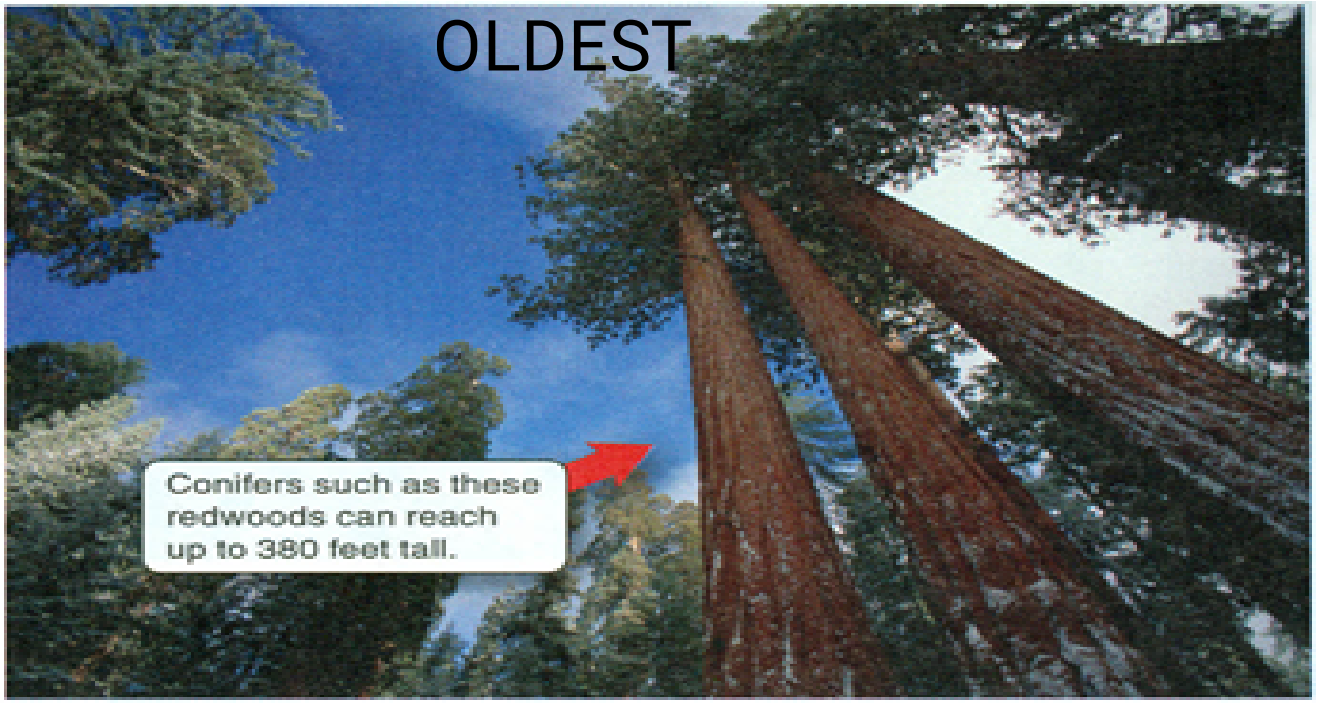
The male cone releases pollen grains that require wind to reach a female cone.

FEMALE CONE

The female cone has ovules on the protruding scales. They produce seeds when fertilized by pollen

- the cone-bearing trees-that is, the conifers-include both the tallest and the oldest living organisms on earth
- The four tallest trees in the world are conifers: a coast redwood that is 380 feet (113 m) tall, a Douglas fir and a Sitka spruce, each 318 feet (97 m), and a Sierra redwood at 311 feet (95 m).
- But not all conifers are big: there are also miniature species of conifers, such as the shore pine, which can be just 20 centimeters tall
- Conifers are the success stories among gymnosperms with more species and a larger geographic range than all of their relatives combined.
- Rigidity an exterior layer of bark and the ability to exude sticky pitch protect conifers allowing them to grow taller and reach older ages than any other plants.

TALLEST AND OLDEST



Conifers have grown taller and reached older ages than any other plants.

- **Angiosperms**
- The appearance of flowering plants (angiosperms) about 135 million years ago set the stage for the botanical world we know today,
- with flowering trees, flowering bushes, and all the grasses and herbaceous (non-woody) plants we see around us.
- The vast majority of plants on earth are flowering plants in the angiosperm group

COMMON CHARACTERISTICS

•Distribute water and nutrients throughout the plant with a "circulatory system" of vascular tissue

•Produce flowers, which produce gametes

•Seeds are enclosed within an ovule

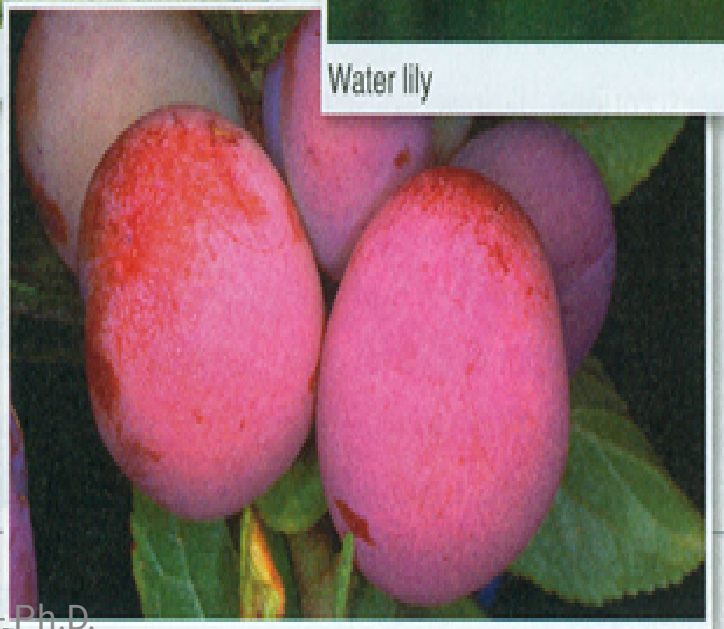
MEMBERS INCLUDE

•Flowering trees, bushes, herbs, and grasses (about 250,000 species)

Apple tree

Water lily

French lavender



Victoria plums

- Flowers come in a bewildering variety of sizes, shapes, and colors, but they all have similar structures:
- a supporting stem with modified leaves-the flashy petals and the sepals, which are green wrapping that encloses the flower while it is in bud.
- Most angiosperms combine the male and female reproductive structures in the same flower.
- The male structure is the stamen and includes the anther, which produces the pollen, and its supporting stalk, the filament.
- The female reproductive structure is the carpel. It has an enclosed ovary at its base, which contains one or more ovules in which eggs develop; a stalk (the style), extending from the ovary; and a sticky tip (the stigma)

STAMEN
Male reproductive structure

CARPEL
Female reproductive structure

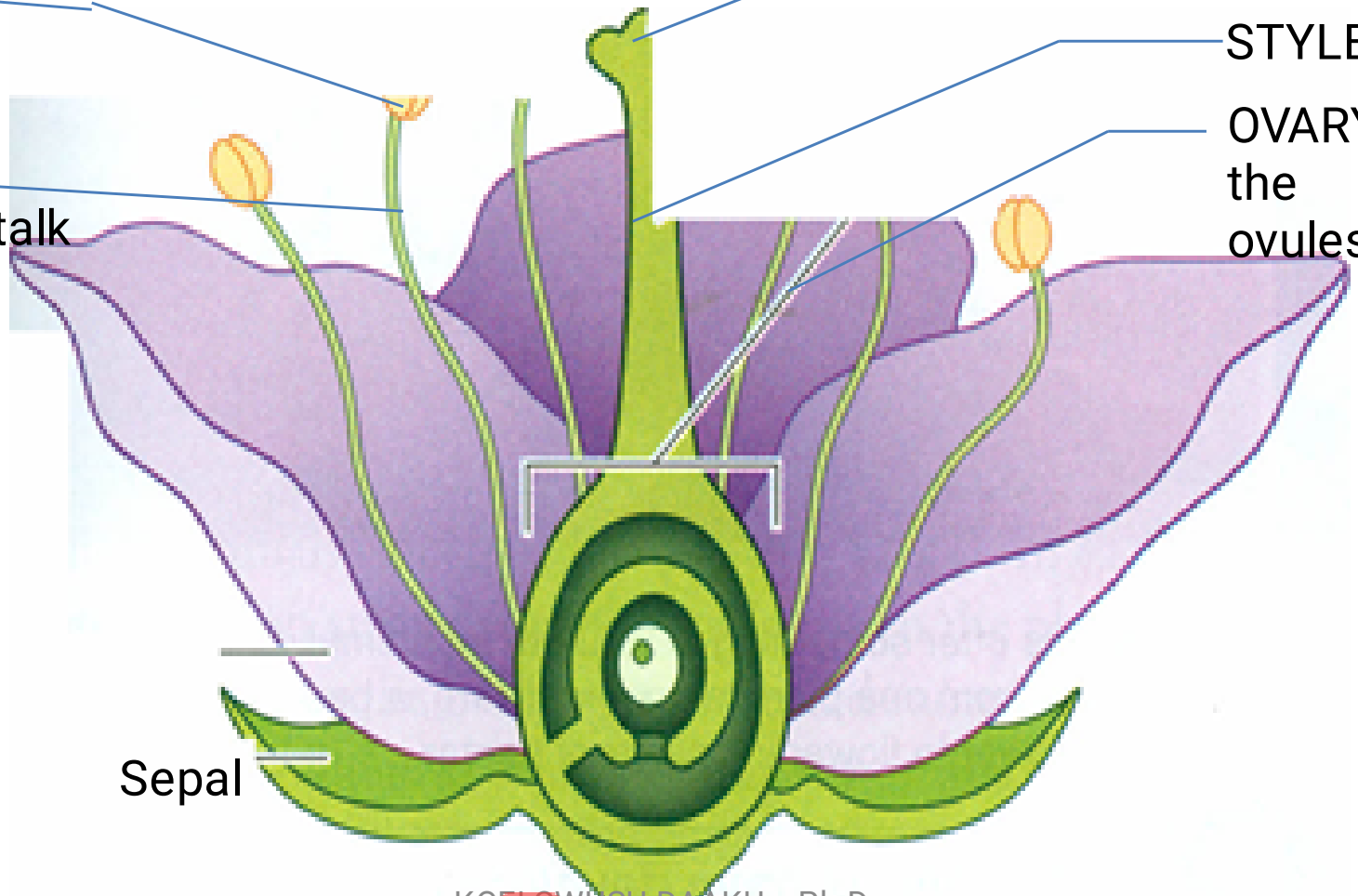
Male reproductive structure
ANTHER

STIGMA Sticky tip

STYLE Elongated st

OVARY Contains the ovules

FILAMENT
Supporting stalk



Sepal

- Fertilization occurs when the male gamete merges with the female gamete.
- The first step toward this is pollination-when a pollen grain makes the journey to the stigma.
- A small number of angiosperms achieve pollination by releasing tremendous amounts of pollen into the wind, as do the gymnosperms, or into water-on the slim chance that some will land on the female reproductive organs of another plant of the same species.
- Most angiosperms have a different way of moving pollen from the anthers of one flower to the stigma of another: they use animals to carry it

STRATEGIES FOR ATTRACTING POLLINATORS

TRICKERY

Some plants deceive animals into carrying pollen from one plant to another. Shown here: This isn't a bee, It's actually an orchid flower. Pollen is picked up and delivered by male bees that attempt to mate with the flower.

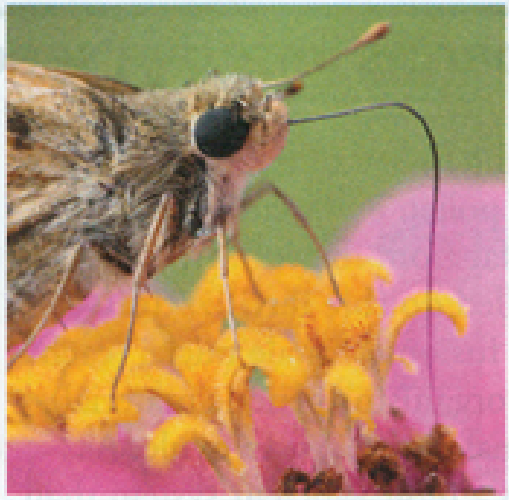
BRIBERY

Some plants offer something of value to an animal, bribing the animal to carry pollen from one plant to another. Here, a bee, covered in pollen, flies from flower to flower in search of nectar.

- Two strategies for achieving pollination have evolved among the flowering plants.
- Trickery.
- The plant deceives some animals into carrying its pollen from one plant to another. Some orchid species, for example, produce flowers that resemble female wasps.
- The mimicry is so good that male wasps mount the flower and attempt to mate with it. The male wasp twirls wildly on the flower, like a cowboy on a bucking bronco, repeatedly whacking his head against the strategically located anthers and getting pollen stuck allover his head and body. That
- is not enough for the plant to achieve pollination-bur
- it's a start. If that male wasp gets fooled again by another
- orchid flower and mounts it in an attempt to mate, he will
- inadvertently deposit some of the pollen from his body
- onto the also strategically placed stigma of that flower. In
- the end, the wasp does not gain from his actions, bur the
- orchids have used an effective system of pollination.

- Bribery.
- The plant bribes some animals to carry its pollen
- from one plant to another. Rather than just using trickery,
- the plant offers something of value to the animal. For this






COLORS AND PATTERNS

WHITE: Nocturnal pollinators, such as moths and bats

BRIGHT COLORS: Visually oriented diurnal pollinators, such as birds, butterflies, and bees

FLOWER STRUCTURE

TUBE: Pollinators with long tongues, such as moths

INTRICATE/CLOSED: Pollinators such as bees

ODORS

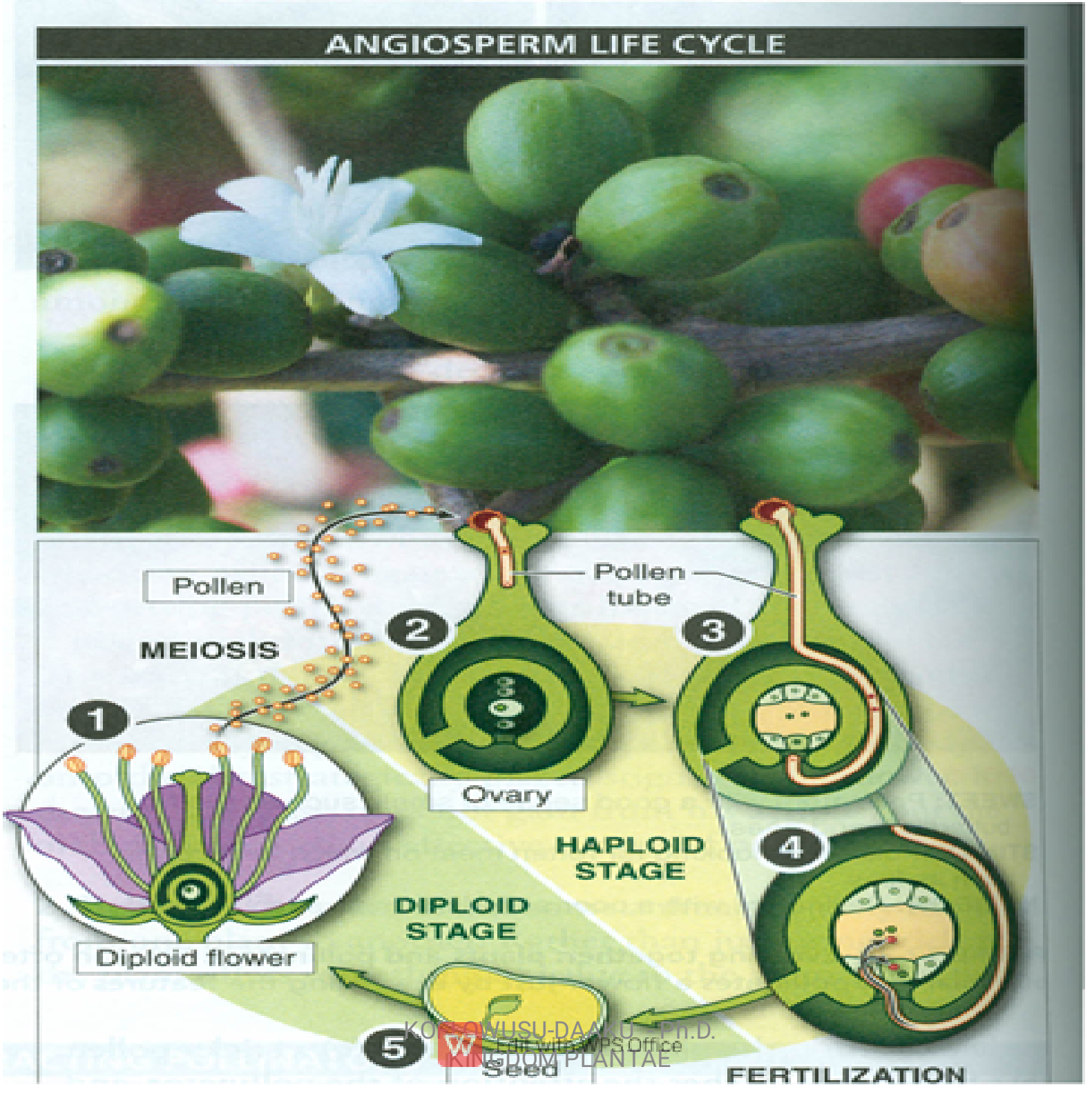
SWEET: Pollinators with a good sense of smell, such as moths,
butterflies, and bees

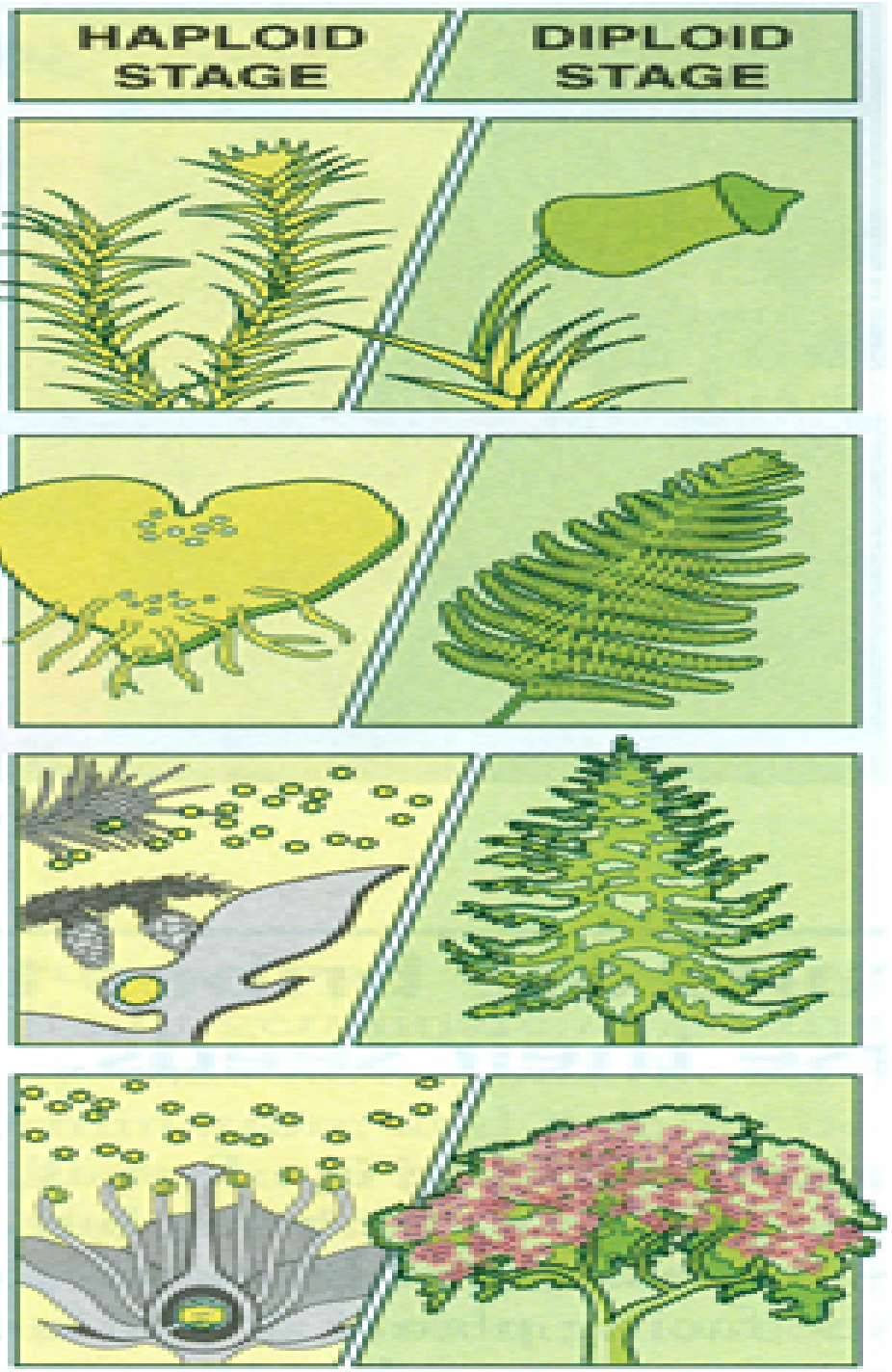
STINKY: Pollinators looking for rotten meat on which to lay eggs,
such as flies

NO ODOR: Pollinators with a poor sense of smell, such as

ABUNDANT: Pollinators with high energy needs, such as bees, birds,
and butterflies

ABSENT: Pollinators, such as flies, looking for a place to l eggs, or
such as beetles, looking for petals, pollen, and other parts to eat





NON-VASCULAR PLANTS

The majority of the life cycle is spent in the haploid stage.

VASCULAR SEEDLESS PLANTS

The haploid and diploid stages are both multicellular and physically independent from one another.

GYMNOSPERMS

The evolution of seeds almost completely eliminates the prominent haploid stage seen in mosses and ferns.

ANGIOSPERMS

Haploid gametes are further reduced in size, enabling more rapid seed production

- On one hand, plants depend on animals to pollinate their flowers and disperse their seeds. On the other hand, many kinds of animals eat plants, and plants are vulnerable because they can't run away.
- plants can't run away from plant-eating animals, however, they are not defenseless.
- A host of defensive devices have evolved in plants that give them some protection against being eaten.
- These defenses fall into two categories:
- anatomical structures, such as thorns, and chemical compounds, including hallucinogens

SEED DISPERSA

HITCHING A RIDE

Some seed pods have spines or projections that attach them to passing animals

FLYING AND FLOATING

The structure of the seed allows it to be carried away from the parent plant by wind or water.

PROVIDING A FOOD SOURCE

Fleshy fruit is a form of bait that lures an animal to eat the seed and carry it far from the parent plant before eliminating it

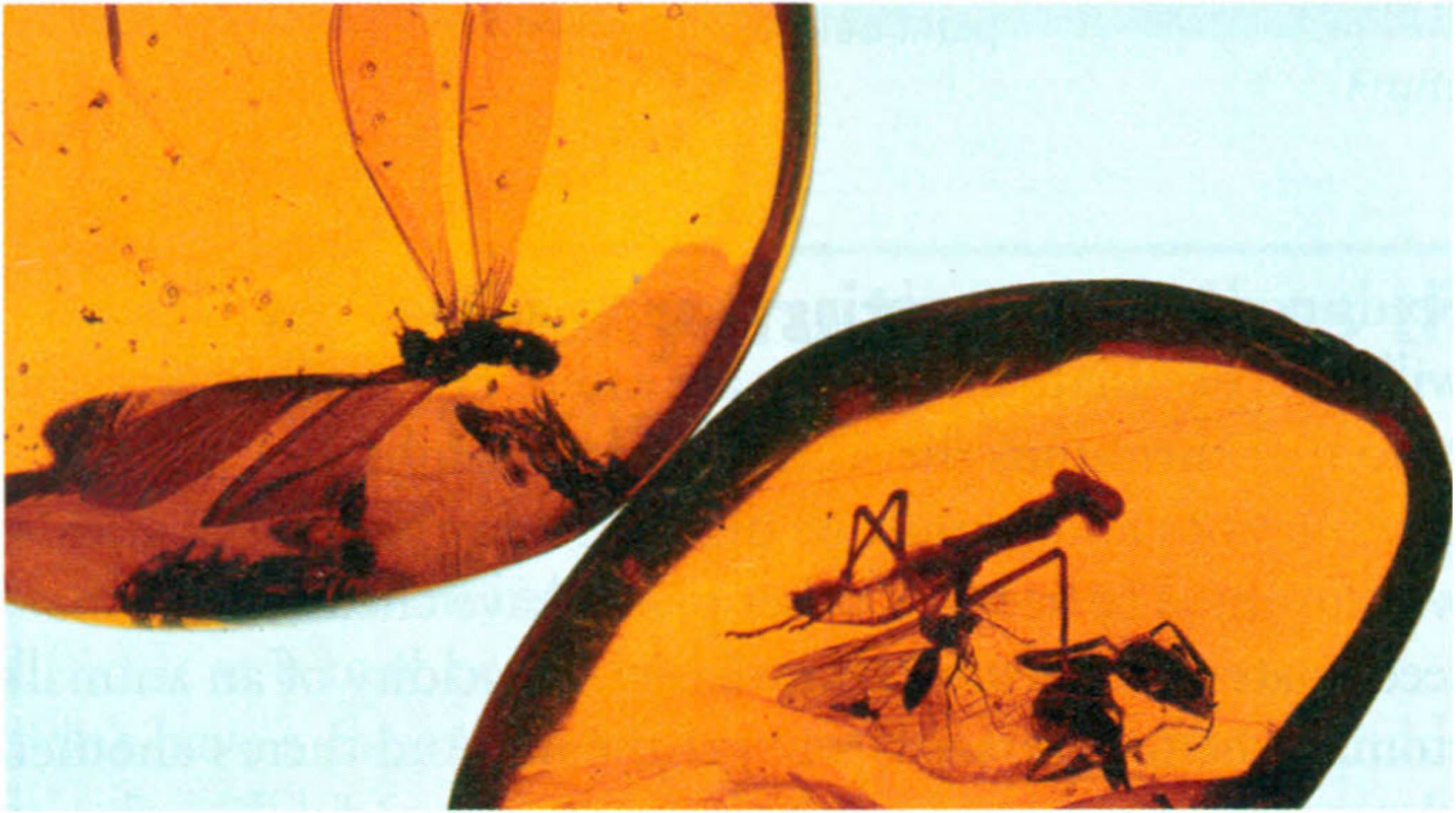
- Spines, prickles, and thorns are a common way to discourage herbivores, and some of these structures are impressively large.
- The acacias, a group of plants that grow as large bushes or small trees, are notoriously spiny.

- In these plants, the deterrent effects of spines are sometimes enhanced by the presence of ants that live in the swollen bases of the spines and fight off other animals-from insects to mammals, including humans.

ANATOMICAL STRUCTURES

Some plants have spines, spikes, and thorns that deter predators.

Some trees have thick layers of bark that are shed in order to get rid of attacking insects.

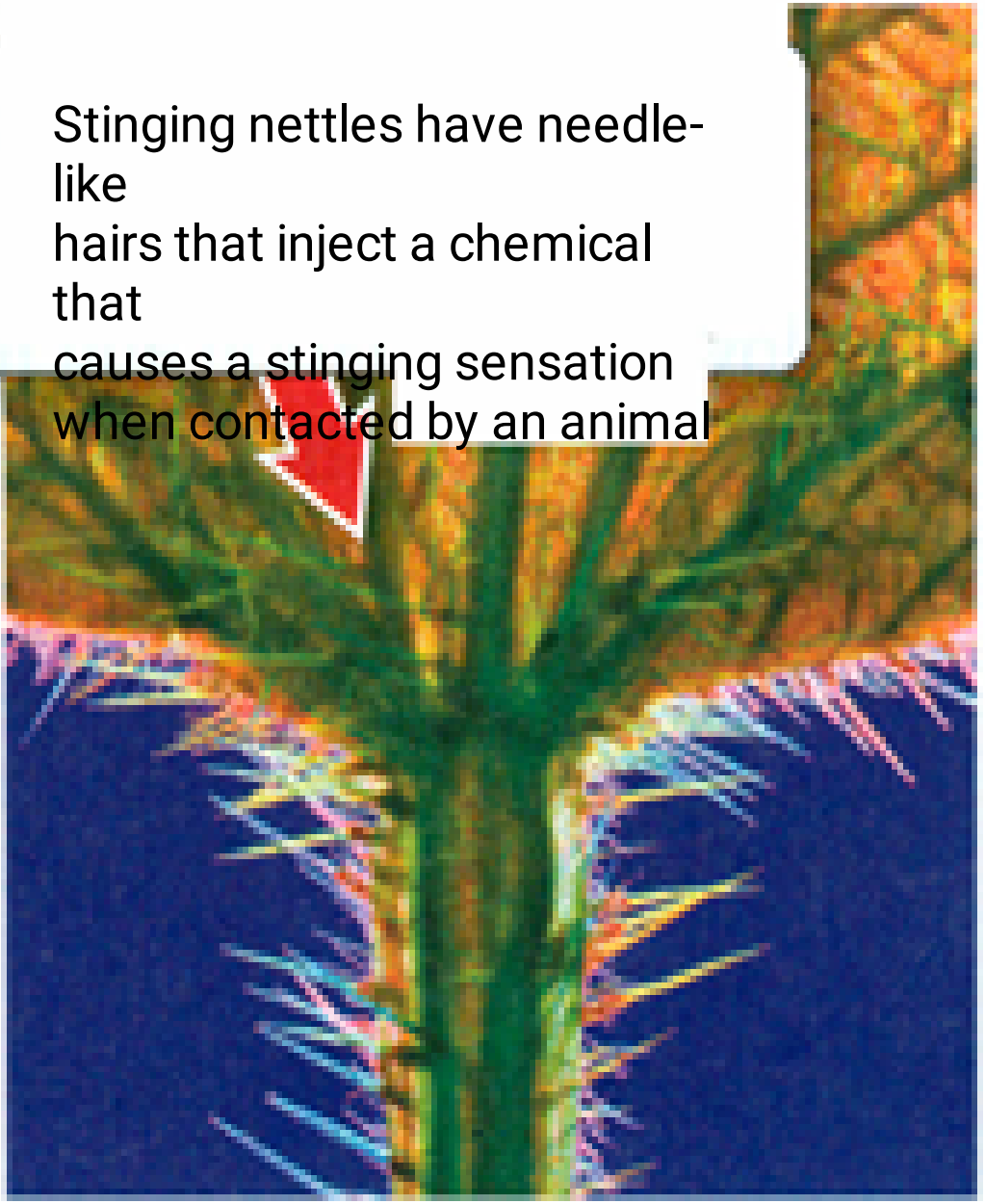


STICKY TRAPS

Conifers exude pitch, a sticky substance that can engulf and smother attacking insects.

Locoweed contains substances that, when eaten, can cause cattle and horses to become lethargic and stop feeding.

Stinging nettles have needle-like
hairs that inject a chemical that
causes a stinging sensation
when contacted by an animal



- Some plants release volatile chemicals when they are attacked by insects, and these airborne chemicals can warn nearby plants of the impending threat or can call protective insects to their aid.
- About 900 species of plants turn the tables- and eat insects.
- They use the protein in their insect meals to supplement the nitrogen compounds they get from the soil. Insectivorous plants are most common in boggy areas, because boggy soil often has low nitrogen concentrations

Some plants living in nitrogen-deficient soil have turned the tables, becoming predators on insects.