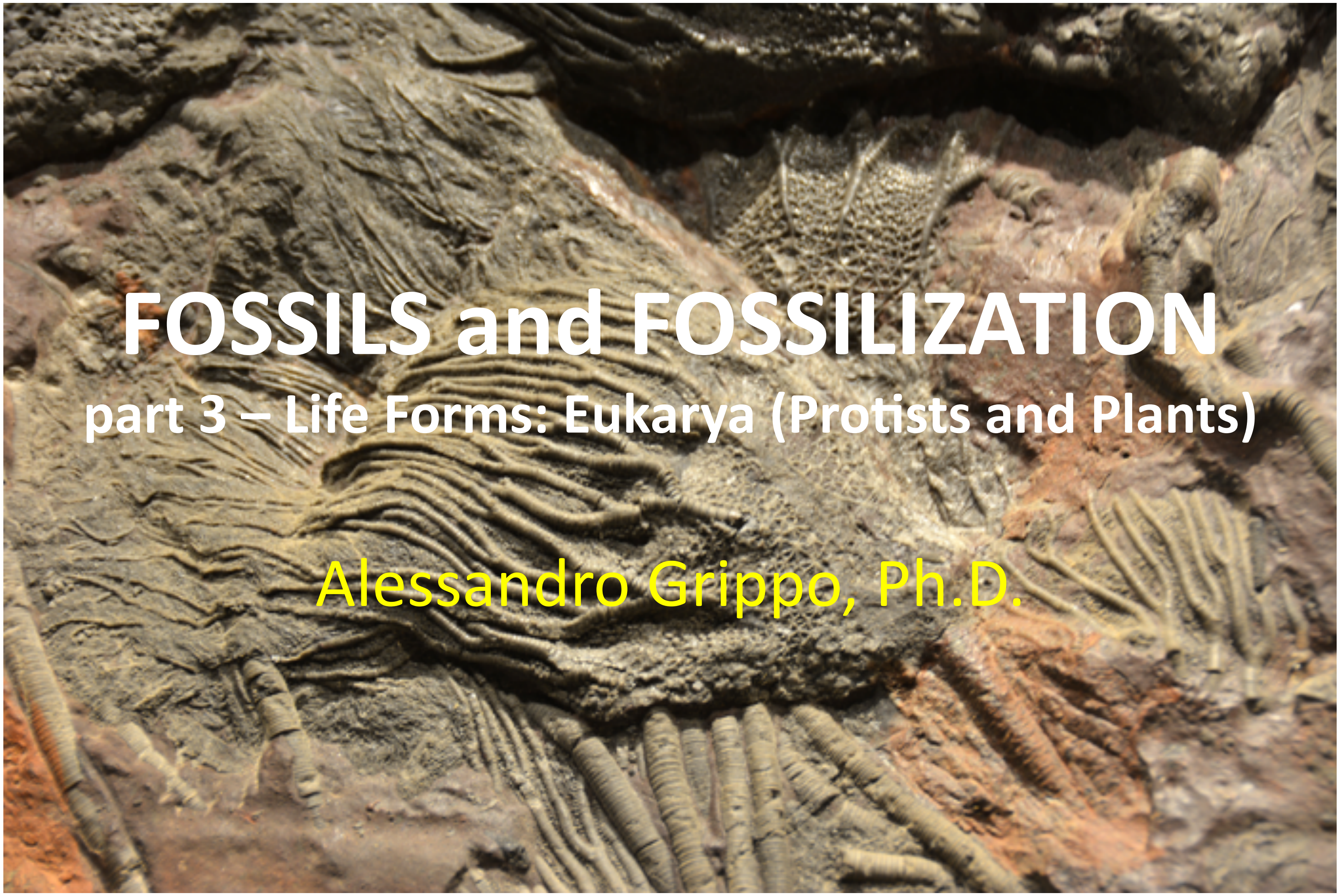


Paleozoic Crinoids, photographed (with permission) in a fossils and rocks store, Las Vegas, Nevada

Life Forms: a Summary

Life on Earth is divided in three Domains

- **Archaea**
  - Prokaryotes
- **Bacteria**
  - Prokaryotes
- **Eukarya**
  - Eukaryotes

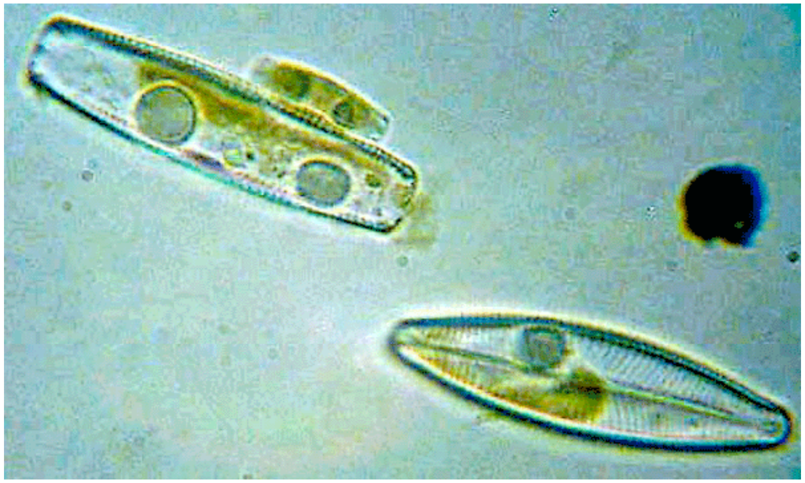
- All life forms are formed by cells containing DNA
- Prokaryotic cells lack internal organization
- Eukaryotic cells present internal structuring

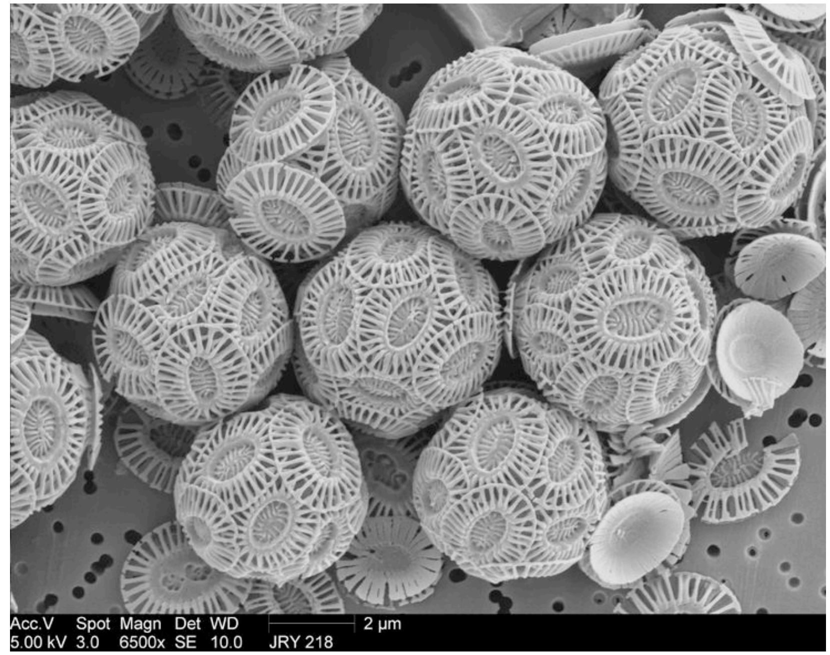
Domain Eukarya

- Eukarya include:
  1. Protists
  2. Plants
  3. Fungi (mushrooms)
  4. Animals

1. Protists

- Include many kinds of single-celled organisms and a few kinds of simple multicellular organisms
- Plant-like protists (algae) are photosyntehtic
  - dinoflagellates, diatoms, coccolithophores
    - all these are very important in the fossil record
- Animal-like protists (or protozoans)
  - amoebas, zooflagellates, ciliates
    - radiolarians and foraminifera are amoeba-like protists that are also very important in the fossil record





Clockwise from upper left: live Diatoms; Coccolithophores; live Foraminifer; live Radiolarian

Nekton, Benthos, Plankton

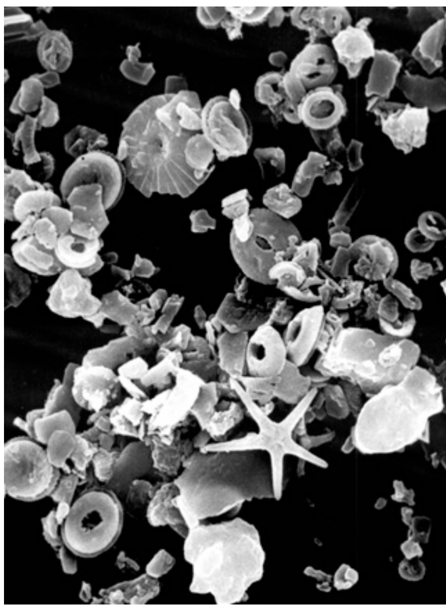
- Organisms that live in the ocean can be classified as:
  - **Nekton**: swimmers
      - example: dolphins, octopuses, squids, whales
  - **Benthos**: bottom dwellers
    - sessile (standing in one place, like a tree on land)
      - example: sea lilies
    - mobile (on the surface – **epifauna**; digging into the substrate – **infauna**)
      - example: crabs and lobsters
  - **Plankton**: floaters

Important Planktonic Protists in the fossil record

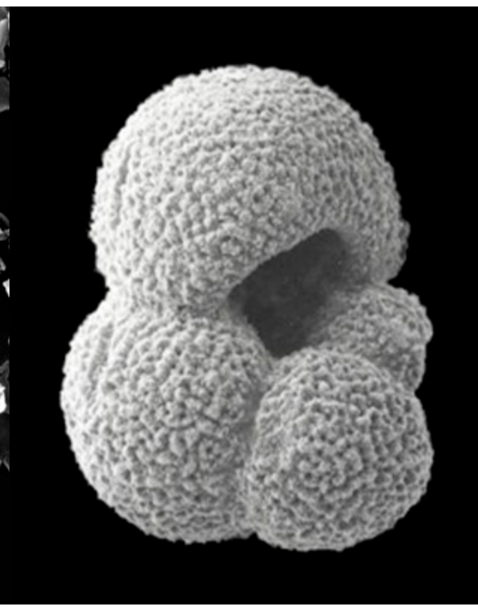
- **Phytoplankton** (plant-like)
  - Diatoms and Coccolithophores
- **Zooplankton** (animal-like)
  - Radiolarians and Foraminifera
- These organisms secrete a skeleton (also called a “test”, or a shell)
- When they die, these skeletons sink to the bottom of the ocean and form a rock

All these organisms are microscopic: they can only be observed under a microscope.
Coccolithophores are so small that they can only be imaged with a SEM (Scanning Electron Microscope)

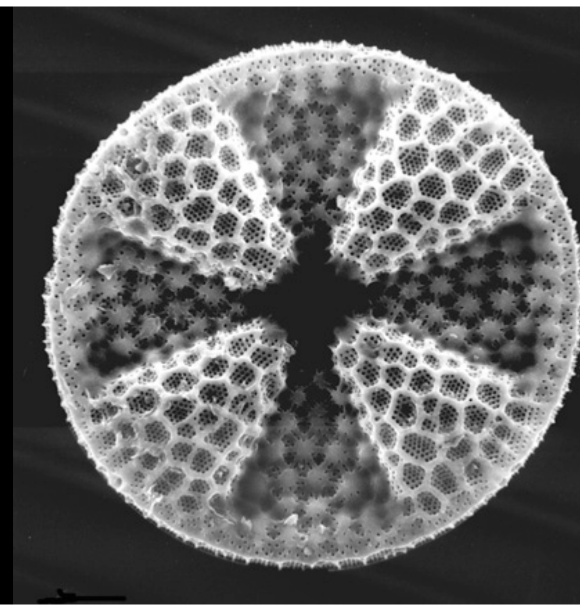
	$CaCO_3$ shell	SiO_2 shell
Phytoplankton	**Coccoliths** (disks from Coccolithophores)	**Diatoms**
Zooplankton	**Foraminifera**	**Radiolarians**



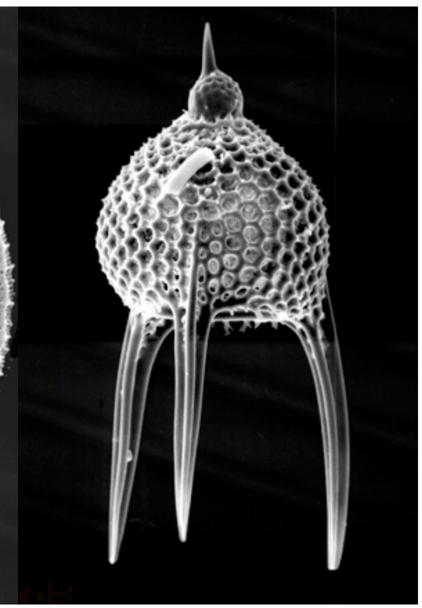
Coccoliths



Foraminifer



Diatom



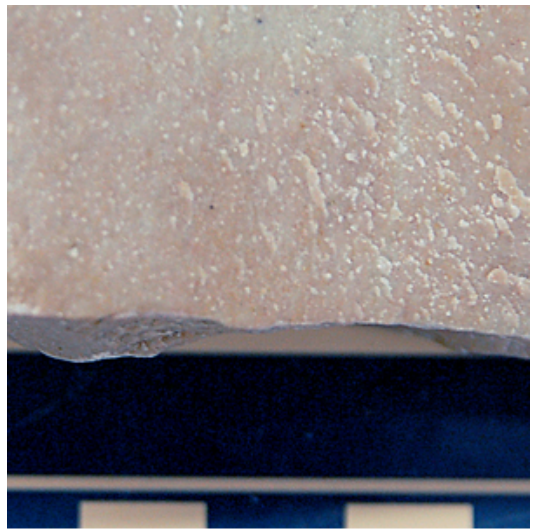
Radiolarian

Chemical Sedimentary Rocks

formed from Protists' skeletons

- Calcareous oozes
  - Chalk
  - Micrite
- Siliceous oozes
  - Diatomaceous Earth and Radiolarite
  - Chert

Chalk



Micrite

Chert

2. Plants

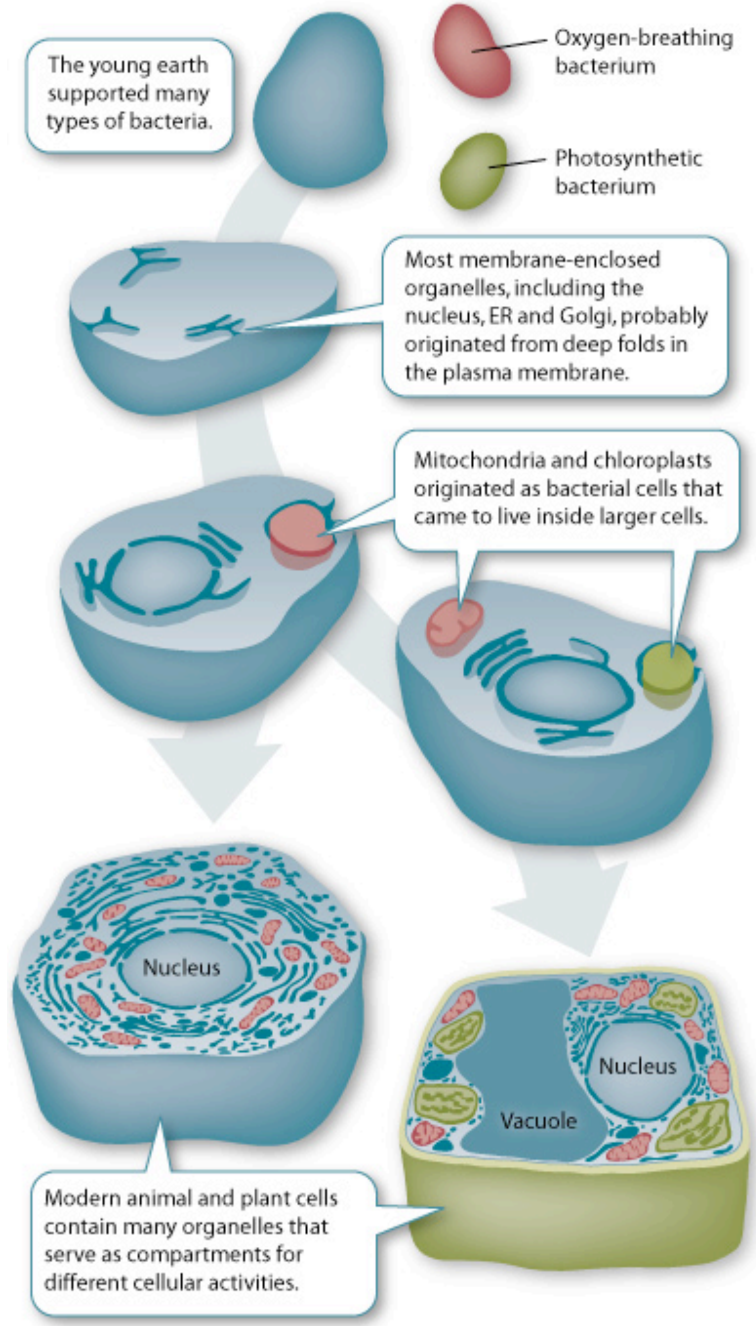
- All plants evolved from algae that developed a condition called endosymbiosis

- Symbiosis occurs when two kinds of organisms live together in a manner that benefits them

- “Endo” means “inside”

endosymbiosis

- During the Precambrian, a photosynthetic bacterial cell was “eaten” by a non photosynthetic one
- The second could not digest the first
- The eaten cell became a chloroplast, the organelle inside a plant cell where photosynthesis occurs

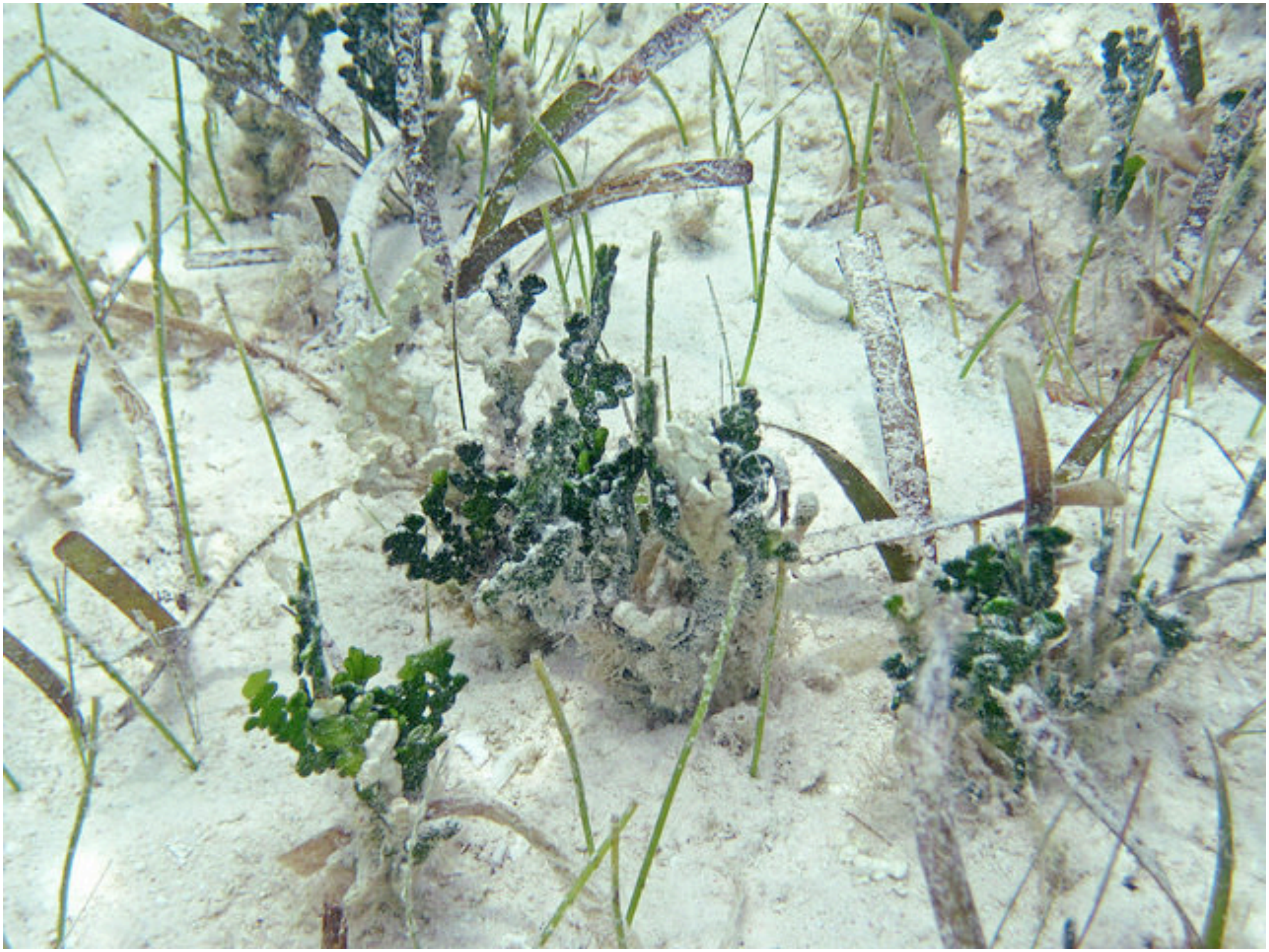


Plants: Green Algae

- Most scientists classify Green Algae as Plants

- Some multicellular algae are adrift in the ocean, while some others are anchored to the bottom

- Most are soft, fleshy organisms, but some secrete a skeleton of calcium carbonate ($CaCO_3$)
- Fragments of such skeletons are major constituents of marine limestones



Halimeda incrassata **(Ellis, 1768) on shallow, aragonitic sandy seafloor**

Halimeda is a calcareous green algae containing chips of calcium carbonate (in this case, aragonite). After the algae die and the soft parts decay away, the aragonitic chips become sand-sized seafloor sediments. These sediments will in time turn to limestone.

Plants: land plants

- Land plants are different because their bodies are divided into **tissues**
  - Tissues are connected groups of similar cells that perform a particular function
- Also, they are different from algae because of **reproduction**
  - Algae shed eggs and sperm into water: fertilization is external and offspring develop independently
  - In Land Plants, eggs are fertilized within the parent plant, and the embryo remains protected within their parents' body for a time

Land Plants

- Problems with living on land:
  - lack of support from water
    - development of rigid structures (roots, stems, trunks) for support
  - dry conditions
    - roots can absorb water from soil
    - development of **vessels** (vascular plants) for water and nutrient transport

- All plants are either non-vascular or vascular

Nonvascular Plants

- Liverworts, mosses, hornworts
- Lack conducting vessels
- Rely on diffusion for transport cell to cell
- Have a scant fossil record
- Have not changed much in geologic time since Lower Paleozoic

Vascular Plants

- Vascular plants have special tissues and canals to transport moisture and nutrients from the soil to the chlorophyll-bearing leaves, where photosynthesis is accomplished

- Vascular plants also have features that prevent desiccation, support the weight of the plant, and facilitate reproduction on land

- There are three major groups of vascular plants:
  - Seedless vascular plants
  - Vascular plants with naked seeds (Gymnosperms)
  - Vascular plants with protected seeds and flowers (Angiosperms)

Seedless Vascular Plants

- First plants to invade land were spore-bearing, seedless vascular plants
- Possibly from Ordovician
- Adult plants produce **spores**
- Spores do not require fertilization
- Spores fall to moist ground and develop into a gametophyte
- A gametophyte produces eggs and sperm
- That would develop a new spore-generating plant
- Two main groups
  - Lycophytes
  - Monilophytes

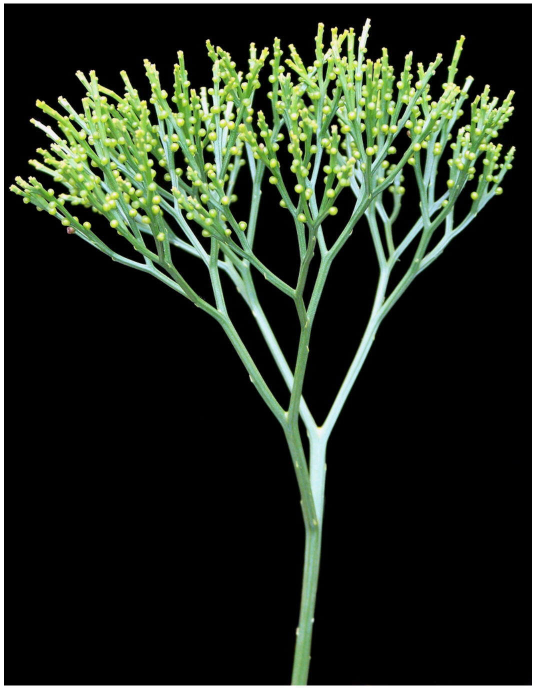
Lycophytes

- Much smaller and uncommon today
- Very important and big in size during the Paleozoic
- Leaves left diamond-shaped scars on trunks: "scale trees"
- Huge forests during the Late Paleozoic died and formed peat
- Peat turned into coal (Carboniferous: Mississippian and Pennsylvanian)
  - Curiosity: arrival of these plants on land caused an enormous absorption of CO_2 from atmosphere and release of O_2, thus creating a cooling effect

Monilophytes

- Ferns
- Horsetails
- Psilotum

Fern leaves with spores



Right: Horsetails (Equisetum)

Left: Psilotum

from Spores to Seeds

- Seed plants include most species of large land plants today
- Seeds are durable structures that disperse the offsprings of these plants
- Evolution of seeds during Paleozoic triggered a great ecological expansion of land plants: no need for moist environments like for spores
- Seed disperse in different ways:
  - blown in the wind
  - attached through barbs to mobile animals
  - surrounded by fruits eaten by animals
  - animals move around and expel seeds in feces, which are used as fertilizers

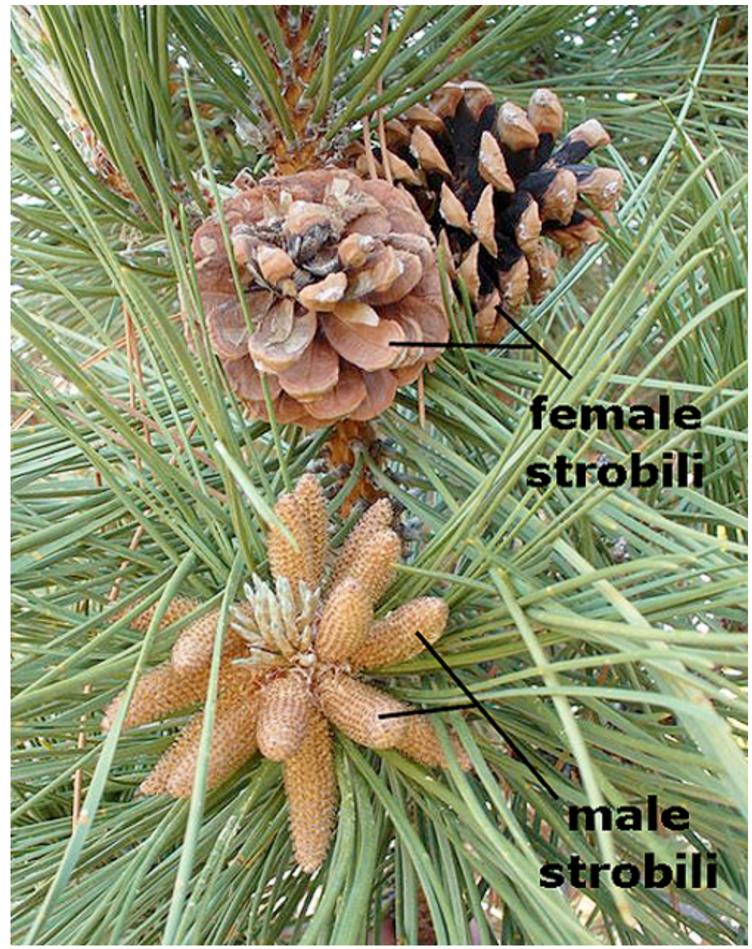
Naked Seeds Plants (Gymnosperms)

- "Naked" because at the time of pollination the seeds are not completely enclosed by the tissues of the parents
- Include:
  - Seed ferns (extinct during the Cretaceous)
  - Glossopteris (seen in Wegener's continental drift)
  - Conifers
  - Cycads
  - Gynkgoes

Glossopteris

Conifers

- Pines, spruces, firs, redwoods, cedars
- Distinctive, smaller male cones produce pollen grains containing sperm
- Bigger female cones contain ovules where eggs develop
- Fertilized seeds develop on top of scales that form a cone
- Appeared during Late Carboniferous



Male and female cones (strobili) from a pine tree

Conifers: pine cones and nuts

Pine nuts (in shells) from female cones

Unshelled and shelled pine nuts

Cycads and Ginkgoes

- Cycads were common in the Mesozoic but many species are now extinct
- Those surviving today are known as "sago palms"

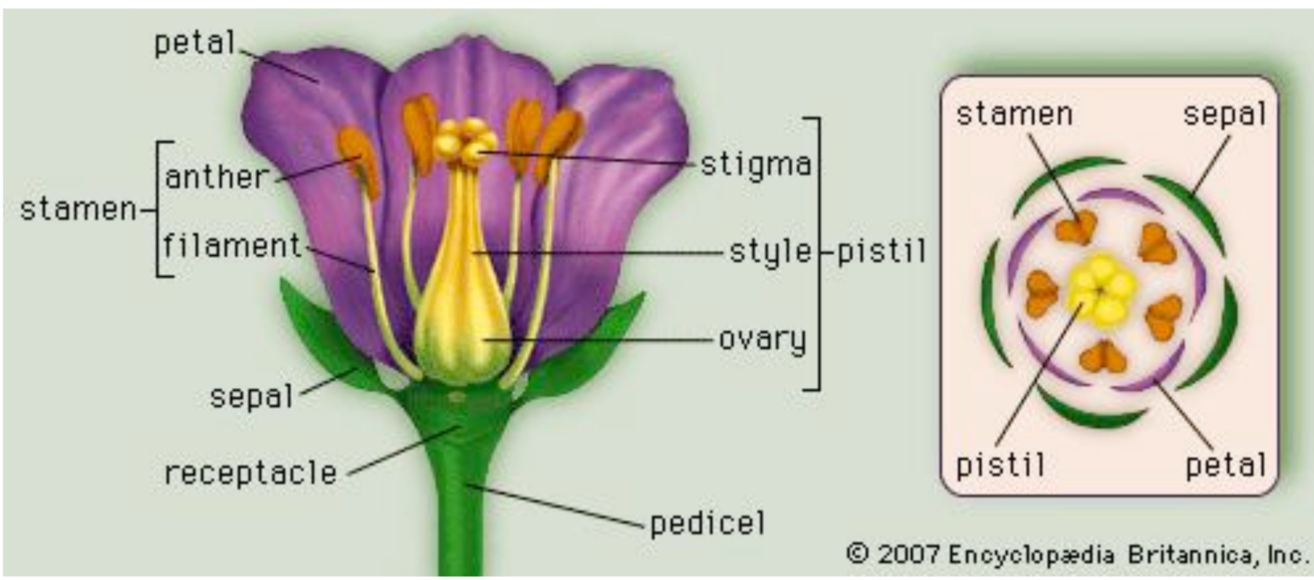
- Ginkgoes are characterized by bilobed fan-shaped leaves
- Appeared during Permian, boomed in Triassic and Jurassic
- Today, only *Ginkgo biloba* survives

Protected Seeds and Flowers Plants (Angiosperms)

- Started in the Cretaceous and boomed right after
- One of most dramatic events in plant evolution
- Most plants alive today are angiosperms ("seeds within a vessel")

fertilization in Angiosperms

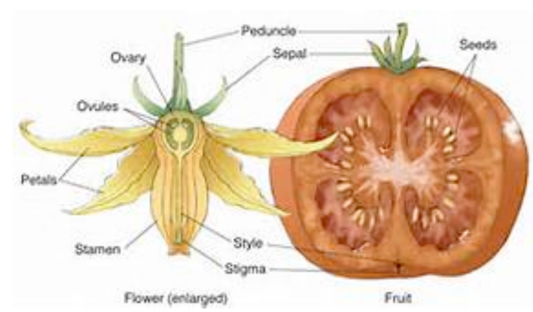
- Seeds develop in a chamber of the flower called ovule, or ovary
- Pollen is produced on stamens, then transferred to pistils
- A pollen tube develops when pollen rests onto a pistil, through which sperm moves and fertilizes the egg in the ovary



fertilization in Angiosperms

from flower to fruit

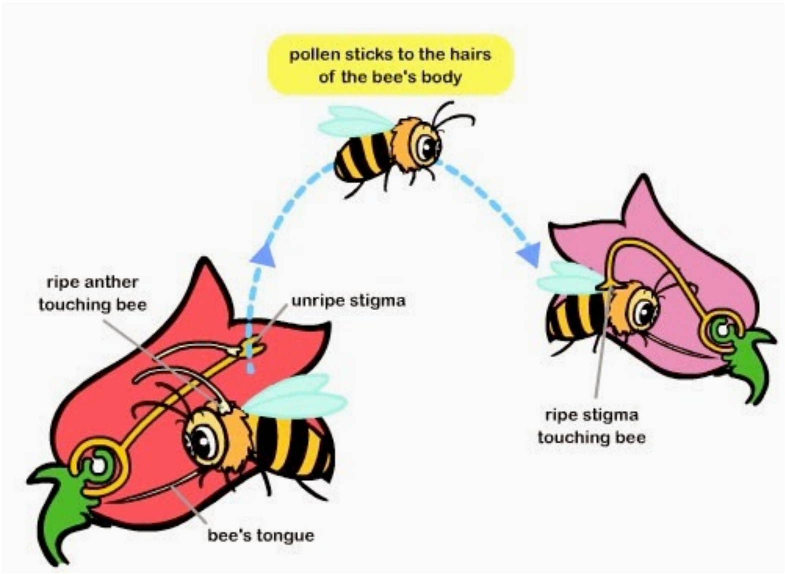
- fertilization of the egg produces a fruit with seeds



- enclosed seeds allow formation of edible fruits
- edible fruits enhance dispersal of seeds by animals that eat them

fertilization in Angiosperms

- colored petals attract bird and insect pollinators
- there is a direct relationship between angiosperm and insect evolution



Angiosperms through time

- Angiosperms diversified rapidly after their Cretaceous early start
- By the end of the Cretaceous, all the major groups of today had appeared
- Many of those plants are very similar to the ones of today
- Grasses finally appeared by the mid-Cenozoic

similarity between Early Cenozoic and today’s Angiosperms

- Left: Angiosperms and Gymnosperms fossils (leaves, cones, berries) from Florissant, Colorado (about 35 my ago)
- Bottom: Angiosperms leaves from Fossil Butte, Wyoming (about 50 my ago)

Palynology

- Often, **spores** and **pollens** from plants are much more abundant in the fossil record than plants themselves
- They can be transported to great distances by water currents and winds
- Their study is called palynology

Fossils and Fossilization
Life Forms: Protists and Plants

end of part 3