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Plants, Fungi and the Colonization of Land

Bio 103

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2 What is a plant?

✓**Plants**

– classification

- **Domain Eukarya**
- **Kingdom Plantae**

– mutlicellular, photosynthetic autotrophs

– examples include trees, grasses, herbs

– multicellular green algae might be moved into this kingdom

3 What is a plant?

✓**How are multicellular green algae different from plants?**

– **multicellular green algae**

- adapted for aquatic life
- supported by surrounding water
- anchored by holdfast
- generally has no rigid supporting tissues
- entire body has direct access to water to obtain carbon dioxide & minerals from it
- almost all parts of the organism are photosynthetic

4 What is a plant?

✓**How are multicellular green algae different from plants?**

– **multicellular green algae**

- reproduction and development
  - water surrounds algae
    - » ensures that gametes and offspring remain moist
    - » provides a means for dispersal of gametes and offspring
  - many produce gametes in **gametangia**

5 What is a plant?

✓**How are multicellular green algae different from plants?**

– **plants**

- adapted for terrestrial life
- waxy cuticle to minimize water loss to air
- gas exchange occurs through opening, called stomata, in leaf surface,
- holds itself upright, no support from air
- obtains chemicals from both air and the soil

6 What is a plant?

✓**How are multicellular green algae different from plants?**

– **plants**
  • have true vascular tissue for conducting
    – water upward from roots to plant parts via
      » **xylem**
    – sugars throughout plant via
      » **phloem**

7 What is a plant?
✓**How are multicellular green algae different from plants?**
– **Plants**
  • reproduction and development
    – gametes and developing embryos must be protected from drying out
    – produce gametes in gametangia
    – most rely on wind or animals for dispersal of offspring

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9 Plants probably evolved from green algae called charophytes
✓Plants and green algae have several homologous features
– which support the theory that plants evolved from green algae
  • chloroplasts
  • certain photosynthetic pigments
  • cell walls of cellulose
  • store carbohydrates as starch
  • cytokinesis via cell plate

10 Plants probably evolved from green algae called charophytes
✓Algal ancestors of plants
– may have carpeted moist fringes of lakes and coastal marshes as early as 500 MYA
  • at a time when continents were relatively flat and periodically flooded
    – as a result, natural selection would have favored algae that could survive periodic droughts
      » over time, some species may have accumulated adaptations that enabled them to survive above the water line

11 Plants probably evolved from green algae called charophytes
✓Algal ancestors of plants
– **charophytes**
  • a modern group of green algae
  • may resemble an early plant ancestor
    – grow at edges of lakes
    – has disk-like multicellular colonies
      » that resemble plants in that they have jacketed zygotes

12 Figure Charophytes: *Chara* (top), *Coleochaete orbicularis* (bottom)

13 Figure : *Chara*

14 Plants probably evolved from green algae called charophytes
✓Earliest plants

- would have thrived on land
- earliest known terrestrial organism
  - represented only by 415 MYO fossils
  - simple plants called *Cooksonia*
    - grew along lake shores
    - upright stem w/ primitive vascular tissues
    - lacked leaves
    - tips of some branches bore a **sporangium** that produced reproductive cells called **spores**

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16 Plant diversity provides clues to the evolutionary history of the plant kingdom

✓Two main lineages arose early from ancestral plants

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✓One lineage gave rise to bryophytes

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✓A major step in plant evolution was the appearance of seed plants

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✓Gymnosperms, such as pines, are called naked seed plants

24 Plant diversity provides clues to the evolution history of plants

✓Major events in history of the plant kingdom

- origin of plants from aquatic ancestors
- evolution of vascular plants (seedless) from earliest plants
- evolution of seed plants (vascular) from earliest vascular plants
- evolution of the flowering plants (vascular seed) from the earliest seed plants

25 Figure :Some highlights of plant evolution

26 Plant diversity provides clues to the evolution history of plants

✓origin of plants from aquatic ancestors

- most likely from green algae called charophytes
- about 400 MYA
- giving rise to a group of plants called **bryophytes**
  - resemble modern plants in that they have
    - a cuticle
    - embryos that develop in gametangia
  - unlike modern plants they

- lack vascular tissues
- have flagellated sperm
- lack internal support

27 Plant diversity provides clues to the evolution history of plants

✓evolution of first **vascular plants** from original plants

- resemble modern plants in that they have
  - a cuticle
  - embryos that develop in gametangia
  - vascular tissues
  - internal support
- unlike later vascular plants they
  - have flagellated sperm
  - lack seeds

28 Plant diversity provides clues to the evolution history of plants

✓evolution of vascular **seed plants** from earliest seedless vascular plants

- they have
  - a cuticle
  - embryos that develop in gametangia
  - vascular tissues
  - internal support
  - unflagellated sperm
  - seeds
- don't have
  - flowers

29 Plant diversity provides clues to the evolution history of plants

✓evolution of vascular **seed plants** from earliest seedless vascular plants

- key adaptations
  - make seeds
    - survival packets for life on land
  - don't require water layer for fertilization
    - pollen transfers nonflagellated sperm-forming cells to female parts of the plant
- **gymnoperms** were earliest seed plants to appear
  - said to have "naked seed" because seed is not enclosed in fruit

30 Plant diversity provides clues to the evolution history of plants

✓evolution of the **flowering plants** from the earliest seed plants

- they have
  - a cuticle
  - embryos that develop in gametangia
  - vascular tissues
  - internal support
  - unflagellated sperm
  - seeds
  - flowers

31 Plant diversity provides clues to the evolution history of plants

✓evolution of the **flowering plants** from the earliest seed plants

– called **angiosperms**

- have seed enclosed in fruit
- have **flowers**
  - complex reproductive structure s
  - develop seeds within protective chambers
- majority of modern plants fall into this group

32 Plant diversity provides clues to the evolution history of plants

✓Four key adaptations of plants to life on land

– **gametagnia**

– **vascular tissue**

– **seeds**

– **flowers**

33 Plant diversity provides clues to the evolution history of plants

✓Four key adaptations of plants to life on land

– **gametagnia**

- present in all plants
- protect gametes, zygotes embryos from drying out

– **vascular tissue**

- transport water and nutrients through plant body
- provide internal support for upright stems

34 Plant diversity provides clues to the evolution history of plants

✓Four key adaptations of plants to life on land

– **seeds**

- protects embryoes and provides nourishment
- aids in dispersal

– **flowers**

- develop seeds within protective chambers
- attracts pollinators

35 Haploid and diploid generations alternate in plant life cycles

✓Plants have alternating generations

– **sporophyte (sporophyte generation)**

- is diploid (2*n*)
- produces 1 type of haploid spore by meiosis
- a spore develops by mitosis into a multicellular haploid gametophyte

– **gametophyte (gametophyte generation)**

- is haploid (n)
- each sex produces haploid gametes by mitosis
- two gametes join to produce a diploid zygote

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37 Mosses have a dominant gametophyte

✓**Nonvascular, nonseed plants**

– generally referred to as bryophytes

– represented by the **mosses**

- gametophyte stage is dominant
- sporophyte stage is dependent on gametophyte stage
- lack vascular tissue
- have flagellated sperm

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Figure : Bryophytes

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Figure: Hornwort

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Figure: Quillwort

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42 Ferns, like most plants, have a dominant sporophyte

✓**Vascular, nonseed plants**

– represented by **ferns**

- sporophyte stage is dominant
- gametophyte stage is independent of the sporophyte stage
- has vascular tissue
- has flagellated sperm
- lacks seeds

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Figure : The stem of *Polypodium*, a fern (a pteridophyte)

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Figure: Xylem and phloem in the stem of *Polypodium* , a fern (a pteridophyte)

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Figure : Fern sporophyll, a leaf specialized for spore production

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Figure 29.23x2 Life cycle of a fern: sorus

49 

Seedless plants formed vast “coal forests”

✓Ferns and other seedless plants once dominated ancient forests

– Their remains formed coal

✓Gymnosperms that produce cones, the conifers, largely replaced the ancient forests of seedless plants

– These plants remain the dominant gymnosperms today

50 

51 A pine tree is a sporophyte with tiny gametophytes in its cones

✓**Vascular, seed plants**

– represented by the **pine tree**

- sporophyte stage is dominant
- gametophyte stage is dependent on the sporophyte stage

- has vascular tissue
- has nonflagellated sperm
  - pollen grain delivers sperm producing cells to female gametophyte
- has seeds

52 A pine tree is a sporophyte with tiny gametophytes in its cones

✓**Vascular, seed plants**

- represented by the **pine tree**
  - **cones** are a significant adaptation to land
    - microscopic stages that grow inside them are the gametophyte generation
    - two types are produced
      - » female cone
      - » male cone

53 A pine tree is a sporophyte with tiny gametophytes in its cones

✓**Vascular, seed plants**

- pine tree produces two types of **cones**
  - female cone
    - larger, woody, persistent
    - has radiating scales, each bearing a pair of **ovules**
      - » after pollination, ovule undergoes meiosis to produce haploid spore cells
      - » a haploid spore cell develops into a female gametophyte (**egg**) over a course of many months

54 A pine tree is a sporophyte with tiny gametophytes in its cones

✓**Vascular, seed plants**

- pine tree produces two types of **cones**
  - male cone
    - smaller, softer, short-lived
    - scales produce many sporangia, which make many haploid spores by meiosis
      - » male gametophytes (**pollen grain**) develop from these spores
    - **pollination** occurs when a pollen grain lands on and enters an ovule
      - » it takes months for sperm to develop in the pollen grain

55 Figure: Phylum Coniferophyta: Douglas fir

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57 **Figure: Sequoias**

58 **Figure : Phylum Coniferophyta: Cypress**

59 **Figure : Phylum Coniferophyta: Pacific yew**

60 **Figure: Phylum Coniferophyta: Common juniper**

61 **Figure: Phylum Coniferophyta: A pine farm**

62 **Figure: Phylum Coniferophyta: Wollemia pine**

63 **Figure : Bristlecone Pine**

64 **Figure: Frasier fir**

65 Angiosperms dominate most landscapes today

✓**Flowering plants** also called **angiosperms**

- dominate most land areas
  - gymnosperms dominate in northern areas

– constitute nearly 80% of all plants
– supply nearly all our food, much fiber for textiles
– several unique adaptations account for their success
  • broad, flat leaves that are very effective collectors of solar energy
  • thick, strong cell walls
  • flowers

66 **Figure 30.11 Representatives of major angiosperm clades**

67 The flower is the centerpiece of angiosperm reproduction
✓Angiosperms make a showy display of their sex life
– the flowers of angiosperms
  • expose the plant's male and female parts
  • are the sites of pollination and fertilization
  • generate fruits
    – which contain the angiosperm's seeds

68 The flower is the centerpiece of angiosperm reproduction
✓Anatomy of a flower
– a **flower** is a short stem with four kinds of modified leaves
  • **sepals**
  • **petals**
  • **stamens**
  • **carpels**

69 The flower is the centerpiece of angiosperm reproduction
✓Anatomy of a **flower**
– **sepals**
  • occur at bottom of flower
  • are usually green
  • enclose the flower before it opens (flower bud)

70 The flower is the centerpiece of angiosperm reproduction
✓Anatomy of a **flower**
– **petals**
  • occur above the sepals
  • usually the most striking part of the flower
    – have a variety of shapes and colors
  • are often important in attracting pollinators

71 The flower is the centerpiece of angiosperm reproduction
✓Anatomy of a **flower**
– **stamens**
  • male reproductive structures
  • many are present on each flower
  • consists of a stalk bearing a sac called an **anther**

– the male organ in which **pollen grains** develop

72 The flower is the centerpiece of angiosperm reproduction

✓Anatomy of a **flower**

– **carpels**

• female reproductive structures

• one or more occur on each flower

• each one consists of a stalk with

– a sticky tip (**stigma)** which traps pollen

– a swollen base called an **ovary**

» a protective chamber that contains one or more **ovules** that develop into **eggs**

73

74 The angiosperm plant is a sporophyte with gametophytes in its flowers

✓**Flowering plants**

– sporophyte stage is dominant

– gametophyte stage is dependent on the sporophyte stage

– has vascular tissue

– has nonflagellated sperm

• pollen grain delivers sperm producing cells to female gametophyte

– has seeds

– has flowers

75 The angiosperm plant is a sporophyte with gametophytes in its flowers

✓**Flowering plants**

– meiosis in the anthers produces haploid spores

• which undergo mitosis to form the male gametophytes, the pollen grains

– meiosis in the ovules produces haploid spores

• which undergo mitosis to form the female gametophyte, the ovule, which produces an egg

76 The angiosperm plant is a sporophyte with gametophytes in its flowers

✓**Flowering plants**

– pollination

• occurs when a pollen grain lands on the stigma

• a tube grows from the pollen grain to the egg and produces sperm cells

– fertilization

• occurs when a sperm fuses with an egg to form a zygote

– a seed develops from each ovule

– a fruit forms to enclose the seeds

77

78 The angiosperm plant is a sporophyte with gametophytes in its flowers

✓Several features have contributed to the success of angiosperms
- packaging seeds inside fruits
- evolution of mutually dependent relationships with animals
- ability to produce seed rapidly
  - fertilization occurs about 12 hours after pollination and seeds are produced within a few days to weeks
    - compared to gymnosperms which typically take over a year to produce seeds

79 Fungi and plants moved onto land together

✓Associations of plant roots with fungi helped make the colonization of land possible
- these associations are called **mycorrhizae**
- prior to the colonization of land by plants
  - fungi may have thrived only in aquatic environments
- the first fungi on land may have been the mycorrhizal partners of early plants

80 Fungi and plants moved onto land together

✓**Fungi**
- are found everywhere
  - in soil and all types of aquatic environments
  - parasites of plants and other organisms
  - predators of small animals
  - decomposers

81 Figure: Painting of indigo milk cap (*Lactarius indigo*) fungus as an example of the variety in color and types of fungi

82 **Figure: Decomposers**

83 **Figure 31.1 Fungal mycelia**

84 **Figure 31.2 Examples of fungal hyphae**

85 **Figure Septate hyphae (left) and nonseptate hyphae (right)**

86 Fungi absorb food after digesting it outside their bodies

✓**Fungi**
- classification
  - **Domain Eukarya**
  - **Kingdom Fungi**
- nutrition
  - heterotrophs
  - digest their food externally
    - absorb the nutrient molecules that result
- most are multicellular
  - yeasts are unicellular

87 Figure 31.4 Phylogeny of fungi

88 Table 31.1 Review of Fungal Phyla

89 Fungi absorb food after digesting it outside their bodies

✓**Fungi**
- structure
  - consists of a net-like mass of filaments called **hyphae**
    - which may exists as

» a single mass of cytoplasm with multiple nuclei
» chains of cells
– surrounded by a plasma membrane covered by a cell wall
» most are made with chitin

90 Fungi absorb food after digesting it outside their bodies

✓ **Fungi**
– structure
• **hyphae**
– start as single filaments (or chain of cells) and then branch repeatedly
» forming a **mycelium**
– motility
• most are nonmotile
– do not move about in search of food, mates
– lack of mobility is made up for by phenomenal growth rate of the mycelium

91

92 Many fungi have three distinct phases in their life cycle

✓ Fungal life cycles range from simple to complex
– yeasts reproduce only by mitotic cell division
– many other fungi have three distinct phases in their life cycles
• diploid phase
• haploid phase
• **dikaryotic phase**
– in which cells contain two haploid nuclei

93 Many fungi have three distinct phases in their life cycle

✓ Life cycle of a mushroom
– mushroom is the fruiting body
– zygotes develop in specialized cells on underside of cap
• zygote is the only diploid life stage in life cycle
– a diploid nucleus resulting from fertilization
» the fusion of the two haploid nuclei
– zygote undergoes meiosis to form haploid spores
– fruiting body releases huge numbers of spores
– when spores land in favorable environment, they germinate to become haploid mycelia

94 Many fungi have three distinct phases in their life cycle

✓ Life cycle of a mushroom
– zygotes develop in special cells underside of cap
• zygote is the only diploid life stage in life cycle
– a diploid nucleus resulting from fertilization
» the fusion of the two haploid nuclei
– zygote undergoes meiosis to form haploid spores
– fruiting body releases huge numbers of spores
– spores germinate to become haploid mycelia
• occur in 2 distinct **mating types**
• dikaryotic stage begins when 2 compatible mycelia grow together, but nuclei don't fuse
• fruiting body is extension of dikaryotic mycelium

95 **Figure Basidiomycetes (club fungi): Greville's bolete (top left), turkey tail (bottom left), stinkhorn (right)**

96 Figure: *Coprinus comatus*, Shaggy Mane

97 **Figure: *Geastrum* triplex**

98 Figure: *Tremella messenterica,* Witch's Butter

99 **Figure: Stinkhorn**

100 **Figure: *Amanita***

101

102 Figure 31.12 The life cycle of a mushroom-forming basidiomycete

103 **Figure: Gills**

104 **Figure: A fairy ring**

105 **Figure: A moldy orange (left), *Penicillium* (right)**

106 **Figure: Budding yeast**

107 Lichens consist of fungi living mutualistically with photosynthetic organisms

- ✓**Lichens** are mutualistic associations of
  - photosynthetic organisms
    - provides food it produces by photosynthesis
      - green algae (Kingdom Protista)
      - cyanobacteria (Kingdom Eubacteria)
    - receives water, housing, minerals
  - fungus
    - provides water, housing minerals
    - receives food

108 **Figure Lichens**

109

110 **Figure Anatomy of a lichen**

111 **Figure Anatomy of a lichen**