Plant Diversity: Land plants evolved from freshwater green algae w/ many shared, derived traits - adaptations to life in land-air environment

Plant Diversity

- Land plants evolved from freshwater green algae
- w/ many shared, derived traits - adaptations to life in land-air environment
- Vascular plants w/ 'plumbing' (ch 35)
- Modern Chara - a pond weed is in sister group to modern plants
- The mitochondrial genome of Chara vulgaris:
  Insights into the mitochondrial DNA architecture of the last common ancestor of green algae and land plants
- Modern land plants w/ fatty-waxy cuticle (Fig 36.12) & stomata (Fig 36.15) - conserve water
- Fig. 29.4 & 29.7. The 'Kingdom Plantae' has been reduced to a sister clade of the green algae clade.

Photosynthesis

- Photosynthesis (ch 10): Life is powered by sunshine.
- Every molecular O₂ that we breathe was once part of two H₂O molecules, liberated by photosynthesis.
- The captured energy is released from our food and fuel.
- Photosynthesis occurs in many bacteria and in chloroplasts of algae, as well as most plants; chloroplasts are 'remains' of ancestral prokaryotic endosymbionts.
- Photosynthesis uses light energy to make ATP & NADPH, and put the 'hydrate' in carbohydrate.
- 2 stages:
  1a capturing energy from light (ch 10.2) w/ photopigment molecules: chlorophylls & carotenoids
  1b using the energy to make reducing (electron accepting) NADPH energy-storing ATP
- 2 the Calvin cycle (ch 10.3): using ATP & NADPH to synthesize complex organic molecules:
- 6CO₂ + 12H₂O → C₆H₁₂O₆ + 6O₂

Photosynthesis uses light energy to split H₂O, release O₂, make ATP & NADPH, and put the 'hydrate' in carbohydrate.

What is in sunlight plants can use? (sec 10.2)

- Light is electromagnetic energy, conveniently thought of as a wave.
- Wavelengths carry greater energy
- Fig 10.6
- Light visible to human retinal pigments is a small portion of the solar spectrum. [birds & insects see down into UV]

Cyanobacteria, green algae & plants use chlorophyll a as main photopigment & chlorophyll b as an accessory

- Carotenoids absorbs blue-green -- inefficiently.
- Leaves look green because chlorophyll does NOT absorb - it absorbs:
- Note: carotenoids do not absorb orange-red

Fig 10.9 Englemann's brilliant 1882 experiment w/ aerobic bacteria distributing themselves along spirogyra algae behind a prism

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bs148h 27 September 2007
Read: Text ch 29 & 30
- plant phylogeny & diversity
- photosynthesis
- light spectral sensitivity
- alternation of generations
  - multicellular gametophyte (n) & sporophyte (n)
- nonvascular mosses etc.
- vascular ferns etc
- flowering plants - sex
- fruit and seed dispersal
- chemical defenses ... and offenses!
Plants have sensory systems and “behavioral” responses: to crowding

**Plant sensory systems** (ch 39); red-light sensitive phytochrome (Fig 39.4, 39.20) exists in interconvertible forms: when Pr absorbs red (~660nm), switches to Pfr when Pfr absorbs far-red (~730nm), switches to Pr

The concentration of Pfr influences stem elongation (etiolation) in shade.

Note low ratio of red/far-red left in light passed through leaves (shade).

Manipulative approaches to testing adaptive plasticity:

Phytochrome-mediated shade-avoidance responses in plants. (text ch 39.3) 


Because chlorophyll selectively absorbs the ratio of red (R) to far-red (FR) wavelengths is an accurate signal of vegetation shade...

Many plants respond to low R:FR with a suite of photomorphogenic changes such as stem elongation, suppression of branching, altered biomass allocation, and accelerated flowering, commonly referred to as the shade avoidance syndrome.

Such responses are often elicited by FR reflected from neighboring plants before canopy closure, indicating that plants can detect and respond to potential future competitors...

(bolt - race up high to compete for scarce light vs branch – spread out low to collect abundant light)

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All plants undergo mitosis (cell multiplication) after meiosis (formation of haploid spores) resulting in a multicellular haploid stage (unlike animals) as well as a multicellular diploid stage (as in animals) - called 'haplo-diplontic' alternation of generations

The diploid sporophyte produces haploid spores - not gametes, by meiosis.

The haploid gametophyte produces haploid gametes by mitosis.

Gametophyte is non-vascular & either confined to moist spots or small.

(if you were a plant, would you be a sporophyte, gametophyte or both?)
Seed plants are the two clades of seed plants that produce seeds. The two clades of seed plants are gymnosperms (non-flowering, 'naked ovules'; seed in cones) and angiosperms (flowers w/ ovules in carpels; seeds in fruit).

Three important reproductive adaptations:
- Reduction of the gametophyte
- The advent of the seed
- And the evolution of pollen.

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- And the evolution of pollen.

Raven et al. + Ginkophyta Ginko male trees OK, female fleshy seeds (not fruit) a mess!

Vascular Flowering Seed Plants – Angiosperms ~90% of all plants

Double fertilization: (ch 38.2)
1. of 1n egg: diploid 2n zygote
2. of 2x1n double haploid cell

Endosperm (3n) is the bulk of cereal grains (grasses: corn, wheat, rice, barley) which directly or indirectly (meat, beer) provide most human nutrition.

Beans have converted 3n endosperm into 2n embryo.

Plants – Angiosperms ~90% of all plants

Fruits are mature ovaries that contain seeds (ch 38.2)

Drupes Single seed enclosed in a hard pit; peaches, plums, cherries.
True berries More than one seed and a thin skin; blueberries, tomatoes, grapes, peppers.
Hesperidia More than one seed and a leathery skin; oranges, lemons, limes.

Pomes - include: apples, pears & quinces.
The core is the ovary (maternal) with seeds (partly maternal, partly recombinant), and the rest (the tastee part) is overgrowth of receptacle.

Beans have converted 3n endosperm into 2n embryo.

Note: For mammal plants, carbohydrate is cheap but nitrogen is dear. Seeds are babies, packed w/ scarce protein & protected from digestion; fruits are cheap enticements to animal dispersers.
Many plants have ripe, fleshy, coloured fruit in order to attract animals that will eat them and then disperse their seeds in droppings. However, the chilli plant has developed another way of ensuring its seeds are spread far and wide.

What raises the roof of your mouth when you eat a chilli is a substance called capsaicin. This stimulates the areas of the skin and tongue that normally sense intense heat and pain, falsely telling the brain that the area affected is burning.

New research has discovered that this characteristic peppery taste repels certain animals – which are?

Grasses are flowering plants

http://www.coltstate.edu/Depts/CoopExt/PUBS/NATRES/06108.html

Most grasses are pollinated by... so that their flowers are highly reduced ... The world's cereal crops are grasses. The world's 5 top crops produce more tonnage than the next 25 combined, and 4 of the top 5 are the cereals!

Human well-being depends on (3n endosperm in) these few grasses, Grasses are the primary source of food for domestic and wild grazing animals ... The total land area devoted to these kinds of croplands is greater than the land area for all other kinds of croplands combined.

Another economically significant use of grasses is lawns ... grasses are well adapted for use in lawns, because their basal meristems (growing points) are not lost with mowing. (or grazing, or burning - used in prairie restoration)

http://www.coltstate.edu/Depts/CoopExt/PUBS/NATRES/06108.html

appeared in the fossil record at the same time in the lower Miocene Epoch about 20 million years ago. (recent!) and have evolved together.

Plants are sensitive creatures!

In touch: plant responses to mechanical stimuli.

Braam J 2005 NEW PHYTOLOGIST 165:373-389

Perception and response to mechanical stimuli are likely essential at the cellular and organismal levels. Elaborate and impressive touch responses of plants capture the imagination as such behaviors are unexpected in otherwise often quiescent creatures.

Touch responses can turn plants into aggressors against animals, trapping and devouring them, and enable flowers to be active in ensuring crosspollination and shoots to climb to sunlit heights.

Signaling molecules and hormones have been implicated in touch responses.

Remarkably, this is widespread: more than 2.5% of Arabidopsis genes are rapidly up-regulated in touch-stimulated plants. Many of these genes encode calcium-binding, cell wall modifying, defense, transcription factor and kinase proteins. ...
Ch 39: Plants have evolved a variety of **defensive mechanisms** to reduce damage from attack by viruses, bacteria, fungi, animals and other plants.

Plants have (or induce) **toxins** to poison herbivores, ex: cyanogenic glycosides & alkaloids also phytoestrogens (ex in soy)

**A deer browse-line on a row of cedars.**

Herbal & folk medicines exploit these, including for disease control: ex: quinine & taxol

Ethnobotany/ethnopharmacology and mass bioprospecting: Issues on intellectual property and benefit-sharing

Soejarto et al. 2005 J. Ethnopharm 100:15-22

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**Induced defenses:** (sec 39.5) Plants allocate more to defense after attack.

see: http://dogbert.gi.alaska.edu/ScienceForum/ASF7/762.html

... and warn their neighbors! ("Talking Trees")

**Sometimes they call for help!** (Fig 39.29)

Herbivore-infested plants selectively attract parasitoids.

De Moraes et al. 1998. NATURE 393:570-573.

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**Bitter Taste Identifies Poisons in Foods**

Scientists at the Monell Chemical Senses Center report that bitter taste perception of vegetables is influenced by an interaction between **variants of taste genes** and the naturally-occurring **toxins** in the vegetable. Scientists have long assumed that bitter taste evolved as a defense mechanism to detect potentially harmful toxins in plants.

**Glucosinolates** in some plants act as anti-thyroid compounds ... inhibit iodine uptake.

... 35 healthy adults were genotyped for the hTAS2R38 bitter taste receptor gene; the three **genotypes** were PA/V/PA (sensitive to bitter-tasting PTC), AVI/AVI (insensitive), and PA/V/AVI (intermediate).

Subjects then rated bitterness of various vegetables; **some** contained glucosinolates (bok choy, kale, kohlrabi, & turnip) while others did not (radicchio, endive, eggplant and spinach).

**Subjects with the sensitive PA/V/PA form of the receptor rated glucosinolate-containing vegetables as 60% more bitter than did subjects with the insensitive (AVI/AVI) form.**

"The sense of taste enables us to detect bitter toxins within foods, and genetically-based differences in our bitter taste receptors affect how we each perceive foods containing particular toxins."

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**BIOENews**

**News of the Week: Parasitic Weed**

Elizabeth Pennisi Science 2006 313, p. 1867

Dodder may be the bloodhound of the plant world. A plant that parasitizes other plants, it sniffs out its victim ...

**Guide Host Location and Host Selection by Parasitic Plants**


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**Research Project Title:** PARASITOID POLYDNAVIRUSES: ... POTENTIAL FOR USE IN BIOLOGICAL CONTROL