

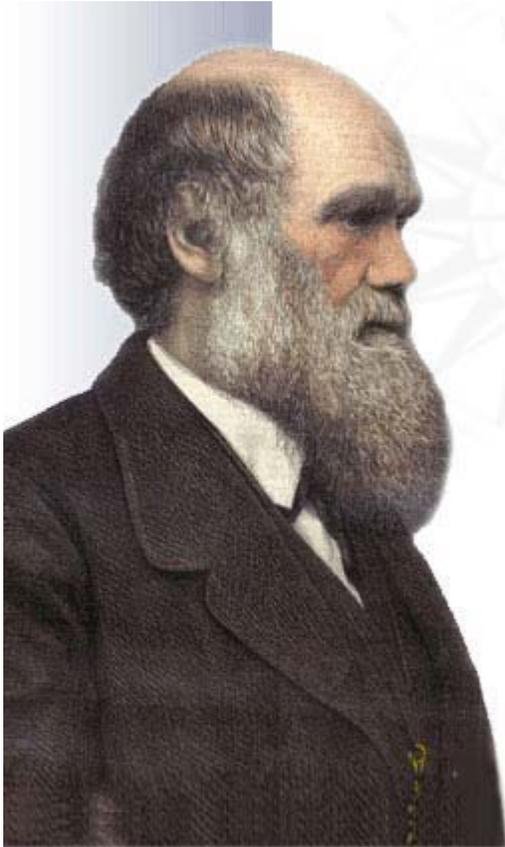
Biotic Adaptations

ESP 30 Lecture 4

Purpose

- The biome concept depends upon an adaptive fit of organisms to environment
- Ergo, we'd like to know how adaptations come about
- The basis for many natural historical observations is to ask the question “what might this structure be for?”
 - Sometimes the answer is hard to guess
 - Sometimes you can make a pretty good guess, which is fun
 - Sometimes the answers other naturalists have come up with are amazing
 - Some answers, including many that are stranger than fiction have serious scientific support!

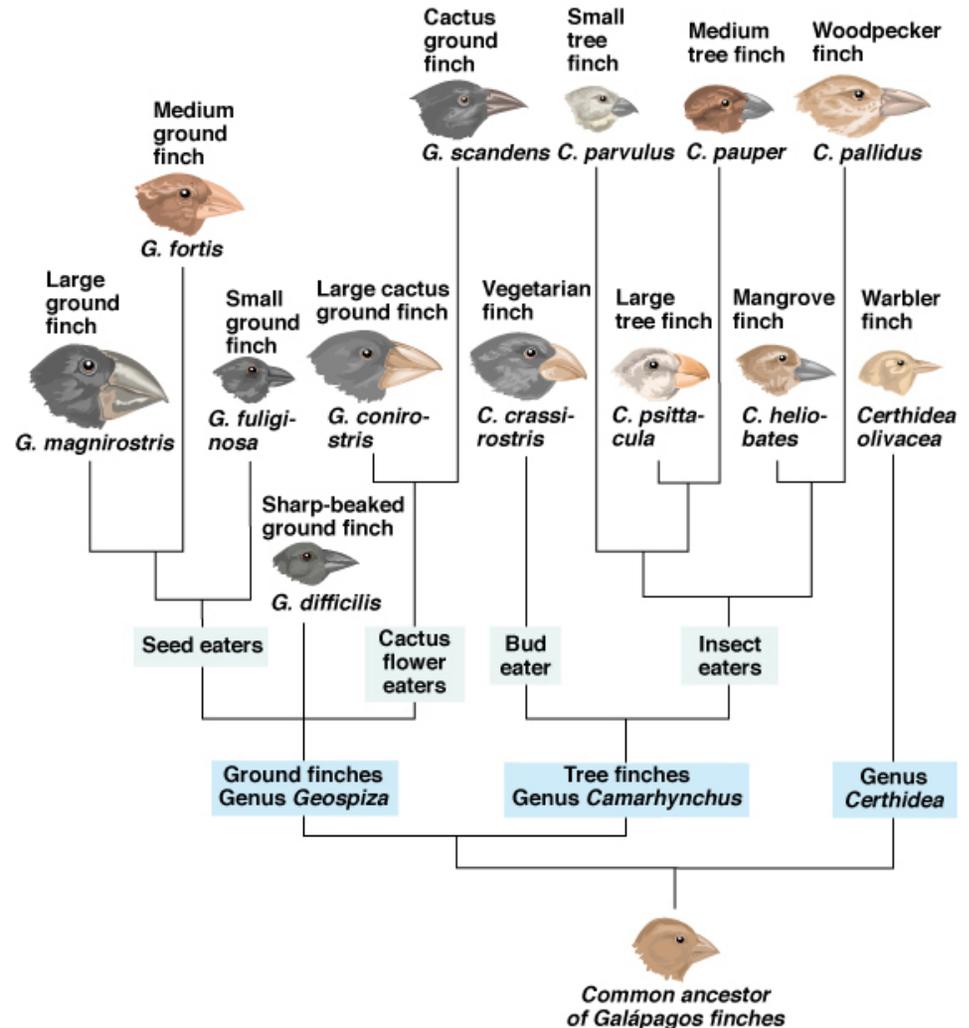
Evolution by Natural Selection



- Darwin observed heritable variation in organisms
- Populations tend to increase exponentially, therefore must come to compete
- Competition for resources will favor the variants that compete best
- Biology since Darwin has built many palaces upon this simple foundation

The famous Galapagos finch radiation story

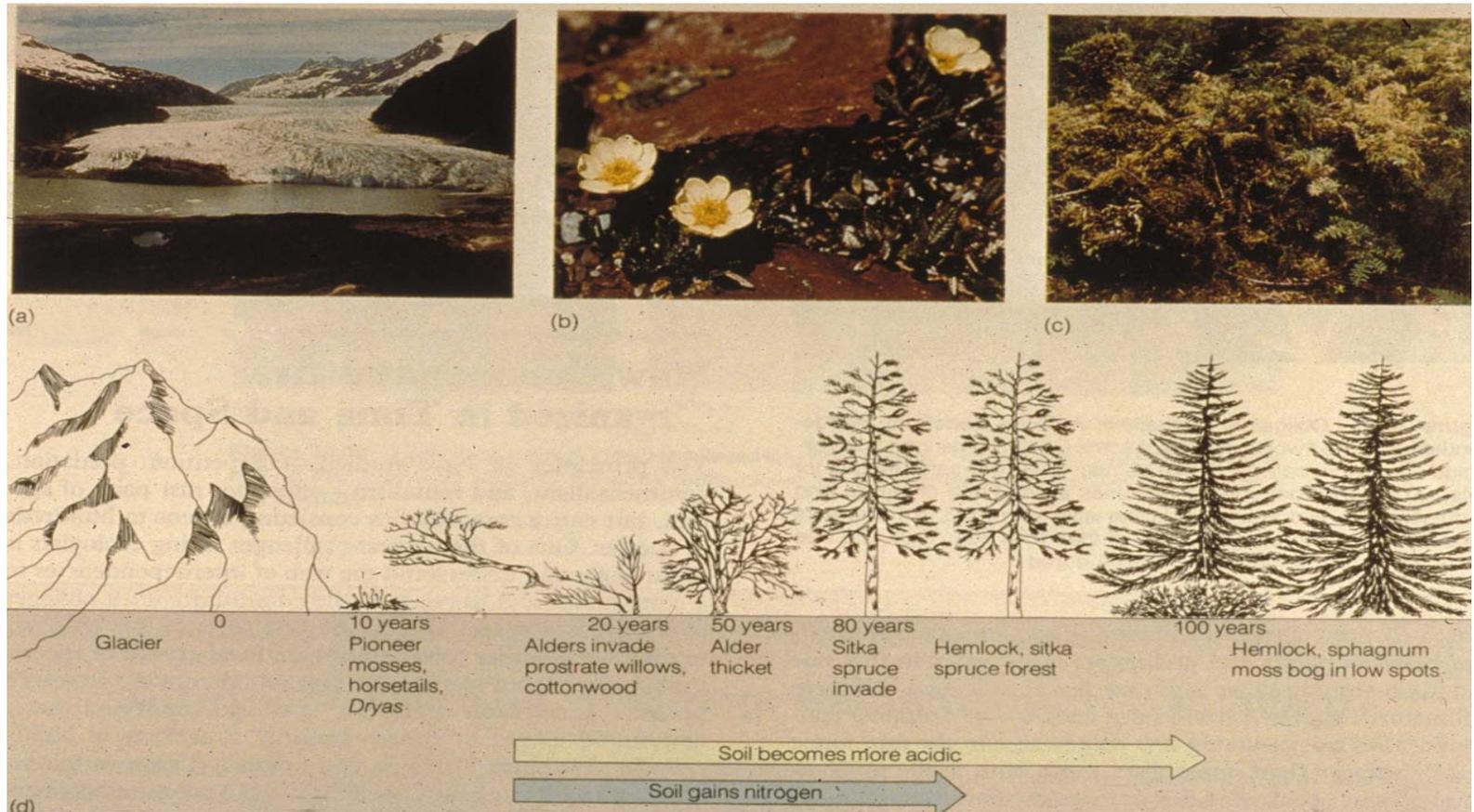
Darwin collected a series of finches on the Galapagos Islands that taxonomists could show were related and derived from a recent South American ancestor. But they had quite diverse adaptations. Darwin imagined that the ancestor arrived and ate the sizes of seeds that it was adapted to eat in South America. As the population built up, seeds of that sort became scarce. Variant birds with bigger beaks or smaller beak could prosper by eating seeds the ancestor type could not. Eventually, quite different feeding strategies evolved as new adaptations arose on an island with no competitors from insect eating birds. These radiations can be quite rapid. In Lake Victoria Africa, a few hundred species of Cichlid fish evolved from perhaps 4 ancestors in about 100,000 years.



Evolution by competitive exclusion

- Ecosystems evolve when one species is replaced by another
- Species vary in their adaptations
- Ecosystems are surrounded by other ecosystems that keep up a steady pressure invasion
- Adaptively superior species will out-compete less well adapted ones
- If the environment changes, formerly successful species will be competitively excluded by invading newcomers
- This process is quite rapid and you can often see traces of it on the landscape, as in the successive invaders of an abandoned field, overgrown garden, or vacant lot.

Ecosystem evolution as soils develop after the retreat of a glacier



To illustrate the dynamics here, alders' bacterial symbionts can fix nitrogen from the air, an adaptation they share with many plants in the pea family, but with few others. They can persist until they have built up soil nitrogen to the point that spruce can invade by growing taller and shading out the alders. The alders are said to "pioneers" whose activities lead to their own demise.

Plant adaptations: life form

- Herbs
 - Annual
 - Perennial
- Woody plants
 - Shrubs
 - vines (lianas)
 - trees
- “Geophytes,” plants with bulbs or other major underground storage organs

Life form: Competitive tradeoffs

- Trees and shrubs
 - Compete well for light
 - But wood is expensive
 - Weather conditions harsher away from the ground
- Vines
 - Can parasitize the structure of shrubs and trees
 - But there has to be a tree or shrub!
- Herbs
 - Easily shaded by taller plants
 - Most reproductive material per unit nutrients (the most productive crops are annual herbs like wheat and corn; we cut down the forests to grow them)
 - Geophytes store nutrient reserves in a protected place, but many pests are looking for them
 - Annuals weather the harsh season as very tough seeds

Leaf form

- Leaf form reflects many tradeoffs
- Thin deciduous leaves are cheap to make, and so can be shed during the harsh season and regrown
- Thick evergreen leaves are expensive to make, but can be retained for a few years, resist water loss and are tougher for animals to eat

Deciduous California wild grape leaf. In the mediterranean biome we find many “sclerophylls,” plants with thicker tougher evergreen leaves. Most deciduous trees and shrubs in California grow near streams where they don't suffer much drought stress. Keep your eyes open for patterns like this that testify to the tradeoffs inherent in different adaptations.



“Phenological” adaptations

- Plants fit their cycle of activity to the seasons
- Leaf drop and leafing out
 - Adaptation to drought stress
 - Adaptation to cold stress
- Flowering and fruiting
 - Attracting pollinators and seed dispersers

Water transport adaptations

- “Poikilohydric” plants (mosses a common example)
 - Have no or weak water transport mechanisms
 - Must live at relative humidity approaching 100%
- “Homeohydric” plants
 - Can efficiently transport water and nutrients from soil to leaves
 - Use osmotic gradients to move water into from roots into special vessels and from vessels to leaf cells
 - The whole process of water uptake by plants and its evaporation into the air is called “transpiration.”
 - Transpiration cools leaves as well as transports nutrients



Water evaporates from leaves. This concentrates dissolved substances in the leaf cells so that they can draw water out of the conducting tubes of the xylem.

The conducting tubes of the xylem are like very fine, very fancy drinking straws that allow leaves to suck water up from the roots. Plant physiologists still have a hard time explaining how tall trees can accomplish this without the column of water breaking.

Roots extract water from soil by having higher concentrations of dissolved chemicals than the soil water does. Water moves into the roots by osmosis

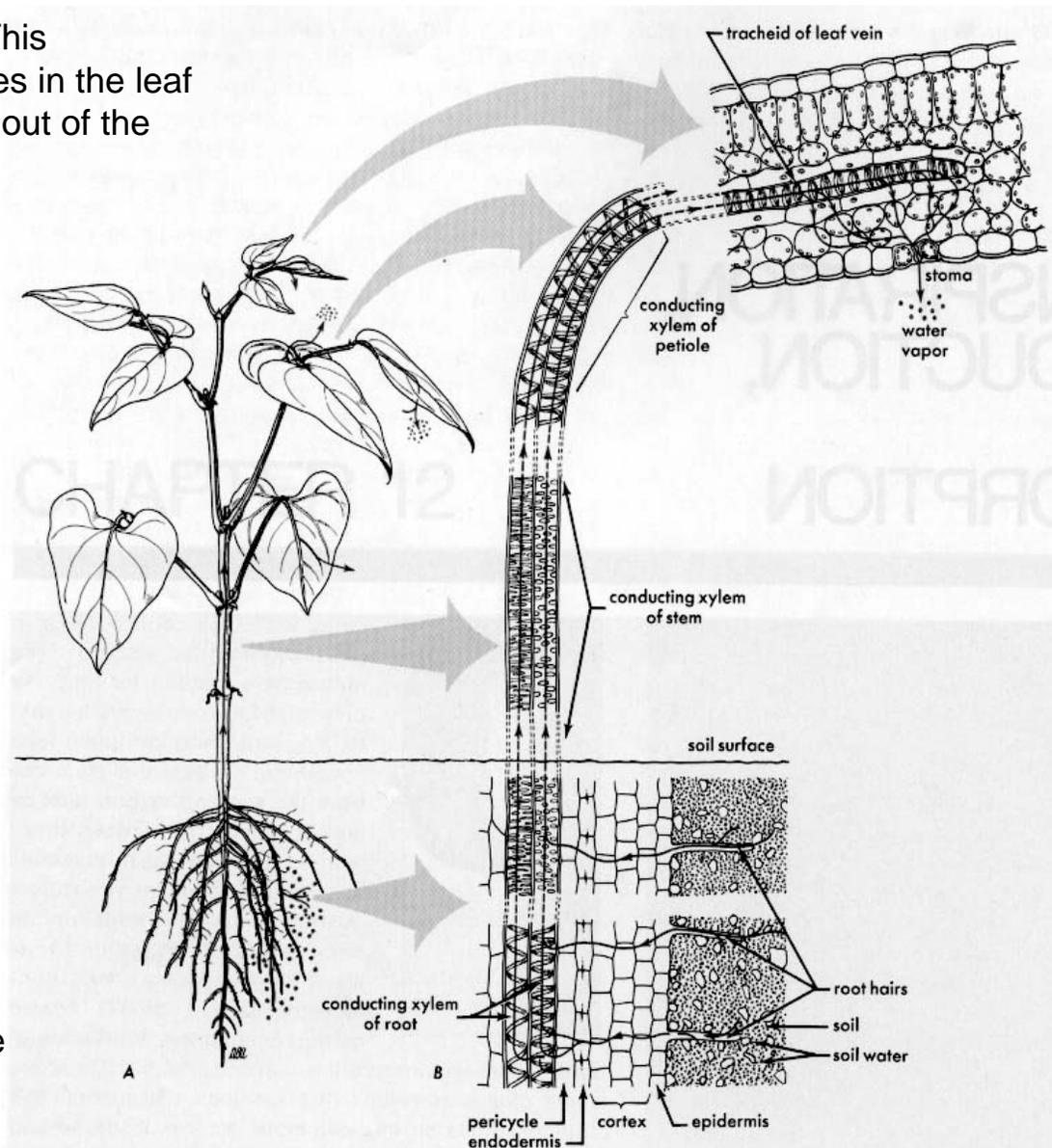


Figure 12.2

A, diagram showing water movement in a whole bean plant. B, details of xylem pathway.

Other important plant adaptations

- Hardiness
 - Some plants undergo physiological changes that permit them to pass a cold or dry season
- Photosynthetic pathways
 - Some plants use methods of photosynthesis that economize on water loss.
 - The jargon: C-3 plants are typical plants. C-4 plants are adapted to hot and dry conditions and include many grasses of arid regions. Maize and sugarcane are important crops that use the C-4 photosynthesis. CAM plants are desert plants that only need to take up carbon dioxide at night, minimizing water loss.
- “Secondary plant compounds”
 - Many plants have poisonous or noxious chemicals to deter herbivores

Major animal adaptations

- Body size
 - Large size deters predators, makes metabolism more efficient
 - Small body size allows concealment, exploitation of small resource packages
- Cellulose use
 - Cellulose the most abundant plant energy source
 - Animals need specialized guts managing microbial symbionts to digest cellulose
- Water conservation
- Temperature management
- Cold vs warm blooded (“Homeothermy” vs “Poikilothermy”)
 - Cold blooded animals have low energy overhead but are inactive in cool and cold conditions
 - Warm blooded animals have high energy overhead but can be very active even at low temperatures
 - Very small animals are forced to be cold blooded because they lose heat too fast to sustain warm blood