Descent with Modification

Theme:

- Evolutionary change is based on the interactions between populations & their environment which results in adaptations (inherited characteristics) to increase fitness

Evolution = change over time in the genetic composition of a population

Darwin's Theory of Natural Selection:

1. Populations produce more offspring than can possibly survive.
2. Individuals in a population vary extensively from each other, mostly due to inheritance.
3. Struggle to survive: individuals whose inherited characteristics best fit to environment leave more offspring than less fit.
4. Unequal ability of individuals to survive and reproduce leads to gradual change in pop, with favorable characteristics accumulating over generations.

- *Populations* evolve, not individuals.
- Fitness is determined by the environment.

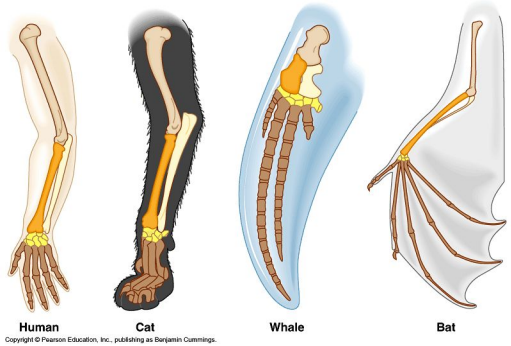
In summary:

Natural Selection = differential success in reproduction

Product of natural selection = adaptations of populations to environment

Evidence for Evolution

1. Biogeography
   - Geographic distribution of a species
   - Geographic, reproductive isolation
2. Fossil Record – transitional forms
3. Comparative Anatomy
   1. Homologous structures
   2. Vestigial structures
5. Embryonic Development
6. Molecular Biology
   - DNA, proteins



- If any of the Hardy-Weinberg conditions are not met → microevolution occurs

- Microevolution = generation to generation change in a population's allele frequencies

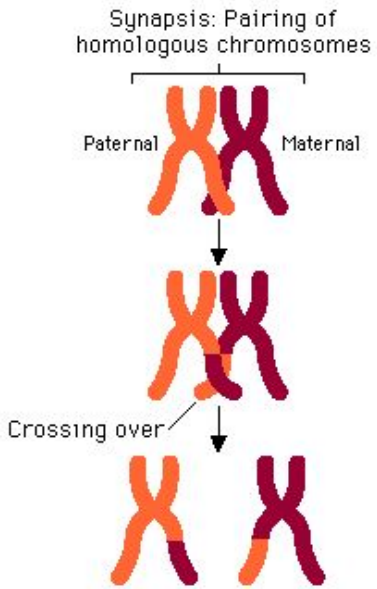
Main Causes of Microevolution

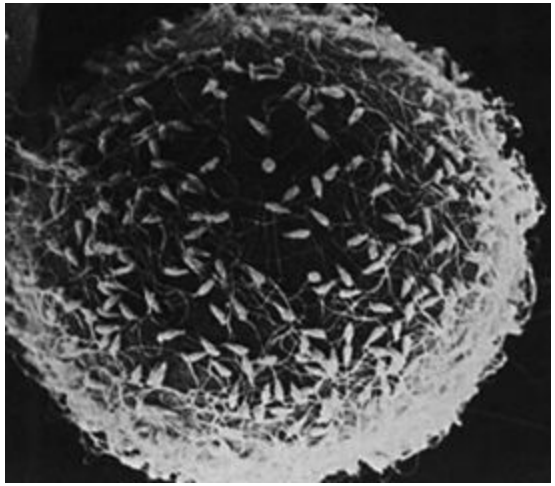
1. Mutations – changes in DNA
   - Point mutations
   - Gene duplication

Mutation will alter or create new alleles in a population.

Main Causes of Microevolution

2. Sexual Recombination
   - Rearrange alleles into fresh combinations every generation





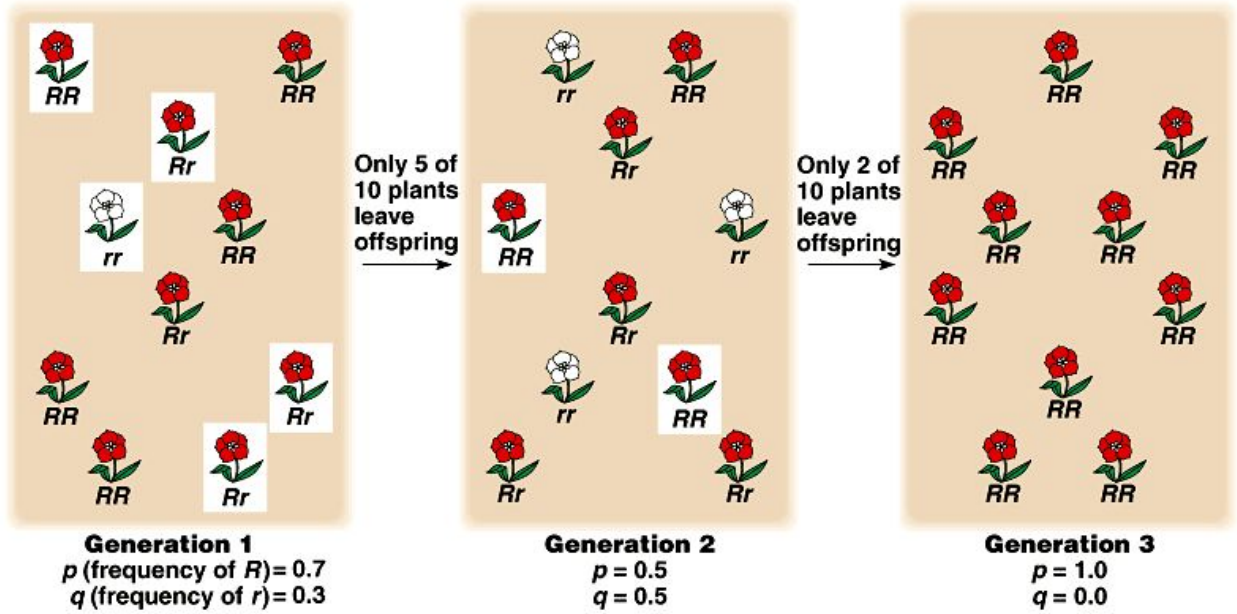
Main Causes of Microevolution

3. Natural selection

Douglas fir trees only release their seeds during fires.
Fire rarely occurs in the river bottom of this valley.

Main Causes of Microevolution

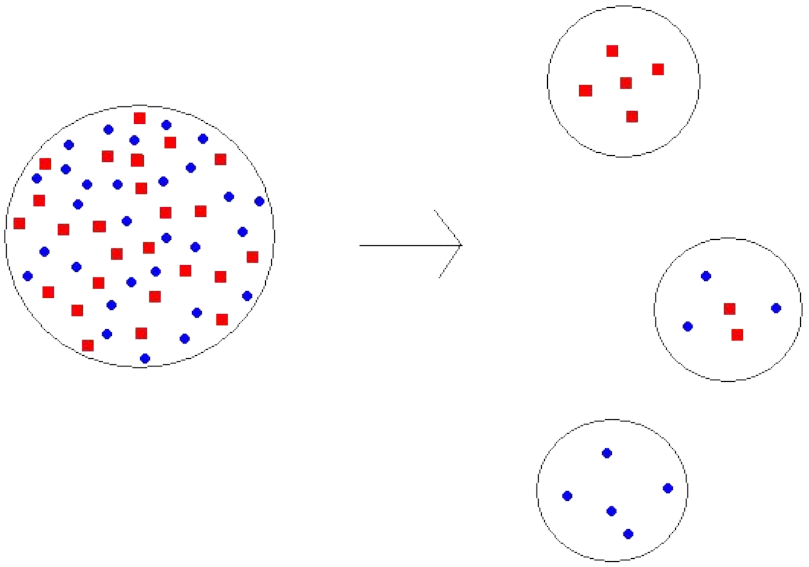
4. Genetic drift: a change in a population's allele frequencies due to chance
   - bottleneck and founder effect

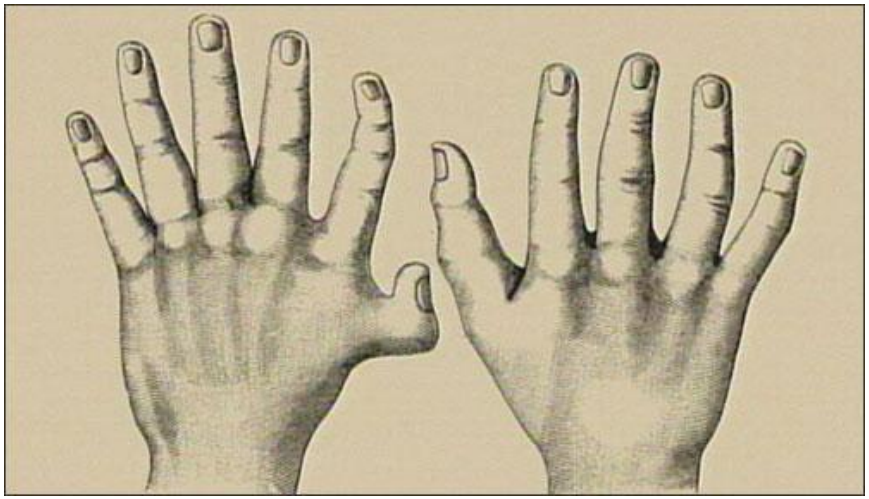


A. **<u>Bottleneck Effect</u>** – genetic drift due to drastic reduction in population size
   - Certain alleles may be over/under represented

Northern elephant seals hunted nearly to extinction in California

B. **<u>Founder effect</u>** – few individuals become isolated from larger population → certain alleles over/under represented





Polydactyly in Amish population

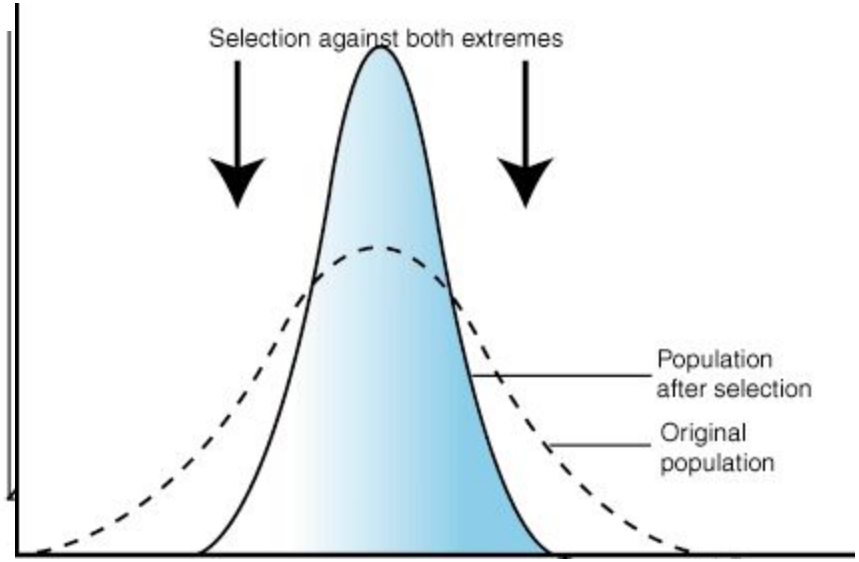
Main Causes of Microevolution

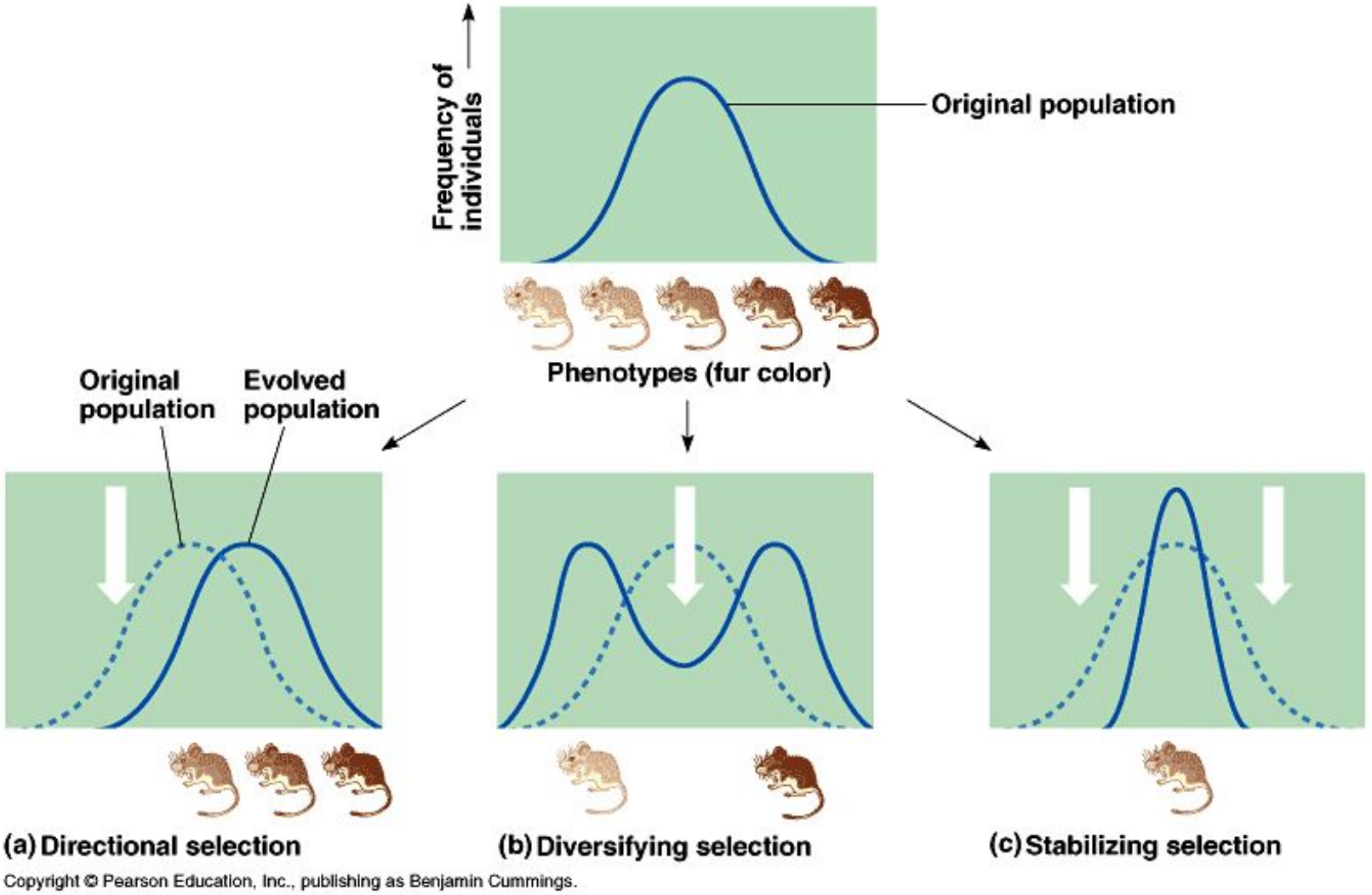
5. Gene flow – genetic exchange due to migration of fertile individuals
   - i.e. wind storm blows pollen to another field
   - Reduces differences between populations

Fitness : the contribution an individual makes to the gene pool of the next generation

Natural selection can alter frequency distribution of heritable traits in 3 ways:

1. Directional selection
2. Disruptive (diversifying) selection
3. Stabilizing selection





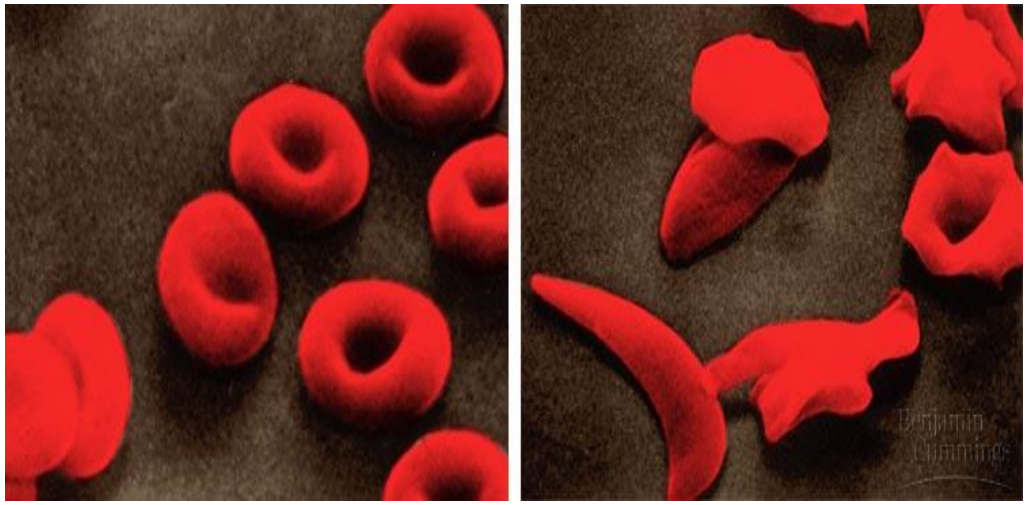
Directional Selection: eg. beak sizes of birds during wet/dry seasons in Galapagos

Diversifying Selection: eg. small beaks for small seeds; large beaks for large seeds

Stabilizing Selection: eg. average human birth weight

Preserving Genetic Variation

- Heterozyote Advantage:
  - People hybrid for sickle cell anemia protected against malaria.



Darwinian Fitness : ability to survive AND reproduce AND pass on alleles to offspring

- Sexual selection for mating success
  - Intra (within same sex) – competition for mate
  - Inter (out) – mate choice

Sexual selection may lead to pronounced secondary differences between the sexes

Evolution of Populations

- Remember:
  - Individuals are selected
  - Populations evolve
- Terms:
  - Population = localized group belonging to same species
  - Species = members of a population that can interbreed and produce fertile viable offspring
  - Gene pool = total combo of genes in a population at any one time
  - Fixed population = all members are homozygous for trait (usually not the case)

Speciation = origin of species

- Microevolution: changes within a single gene pool
- Macroevolution: evolutionary change above the species level
  - cumulative effects of speciation over long periods of time

(a) **Similarity between different species.**

Biological Species Concept

- Proposed by Ernst Mayr (1942)
- Species = population or group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring
  - Reproductively compatible
- Reproductive isolation = barriers that prevent members of 2 species from producing viable, fertile hybrids

Types of Reproductive Barriers

Prezygotic Barriers:

- Impede mating/fertilization

Types:

- Habitat isolation
- Temporal isolation
- Behavioral isolation
- Mechanical isolation
- Gametic isolation

Postzygotic Barriers:

- Prevent hybrid zygote from developing into viable adult

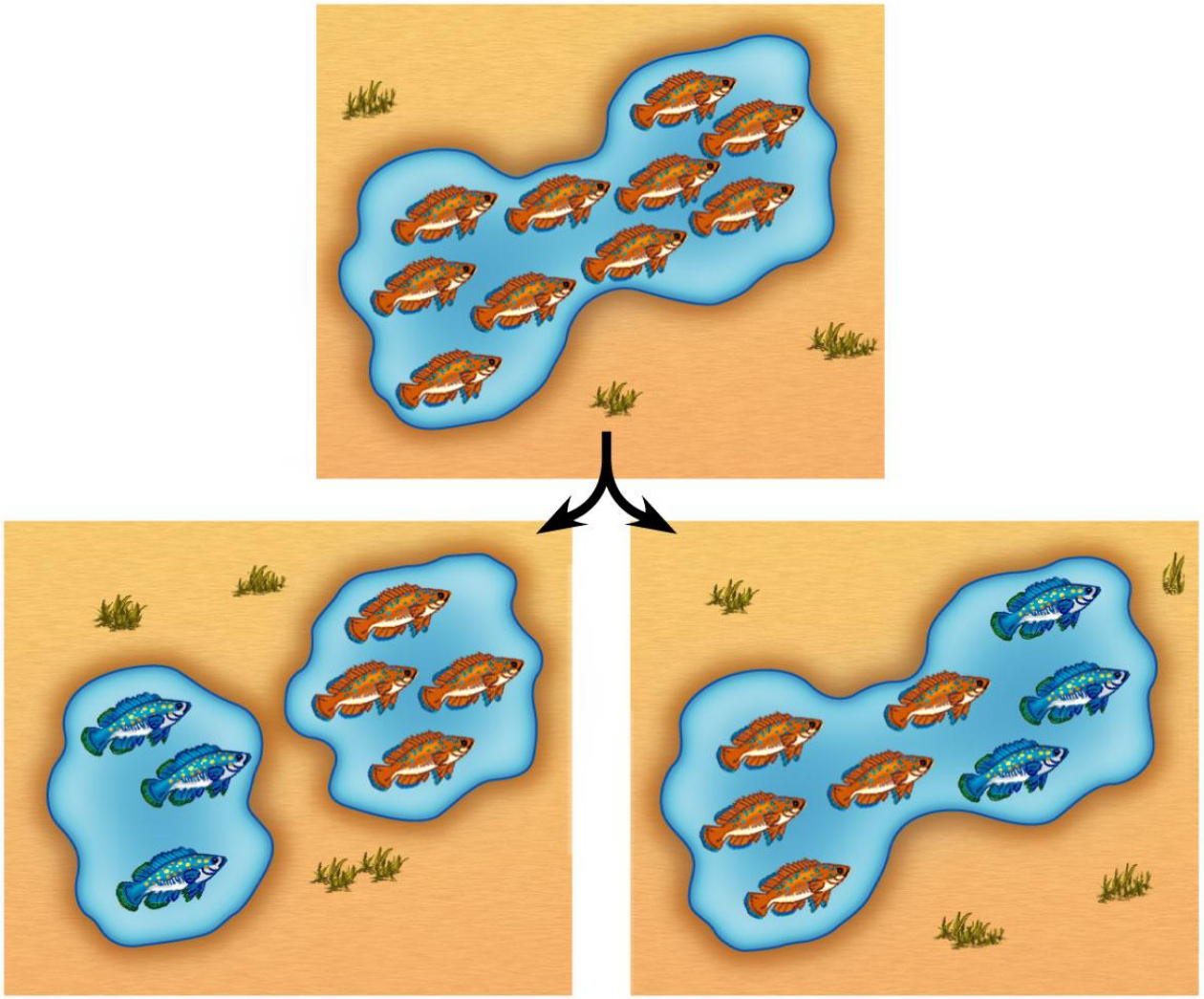
Types:

- Reduced hybrid viability
- Reduced hybrid fertility
- Hybrid breakdown

Other definitions of species:

- Morphological – by body shape, size, and other structural features
- Paleontological – fossil record
- Ecological – niche/role in community
- Phylogenetic – unique genetic history, branch on tree of life

Two main modes of speciation



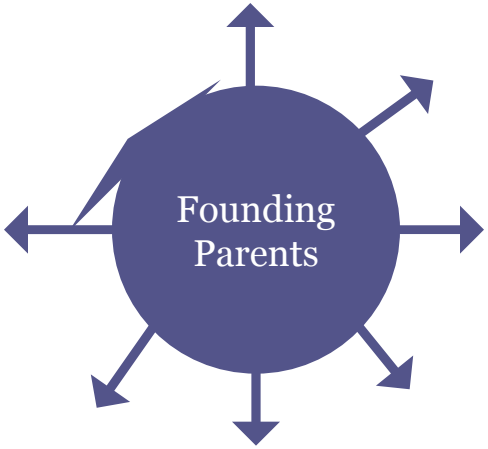
(a) **Allopatric speciation** (b) **Sympatric speciation**

Two main modes of speciation:

Allopatric Speciation *"other" "homeland"*	**Sympatric Speciation** *"same" "homeland"*
Geographically isolated	Overlapping populations within home range
Evolves by natural selection & genetic drift	Subset of population isolated from parent pop. change due to: • chromosomal changes • nonrandom mating • habitat differentiation
Eg. Galapagos finches	Eg. polyploidy in plants (oats, cotton, potatoes, wheat)

Adaptive Radiation

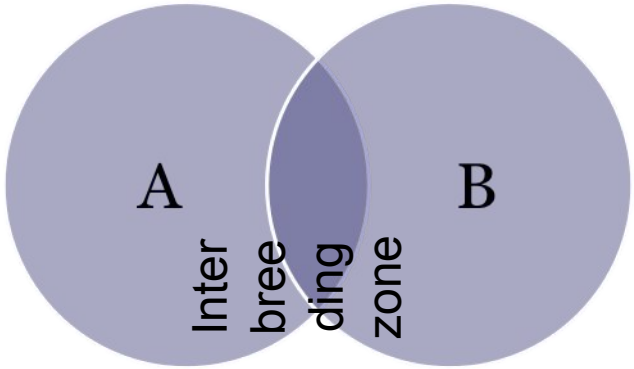
- Emergence of numerous species from a common ancestor introduced into new environment
- Occurs when:
  - ➢ A few organisms make way to new, distant areas (allopatric speciation)
  - ➢ Environmental change → extinctions → new niches for survivors
- Eg. Hawaiian archepelago



When 2 splintered groups rejoin geographically:

Possibilities:

1. Still one species
2. Two distinct species (no interbreeding)
3. Hybrid zone



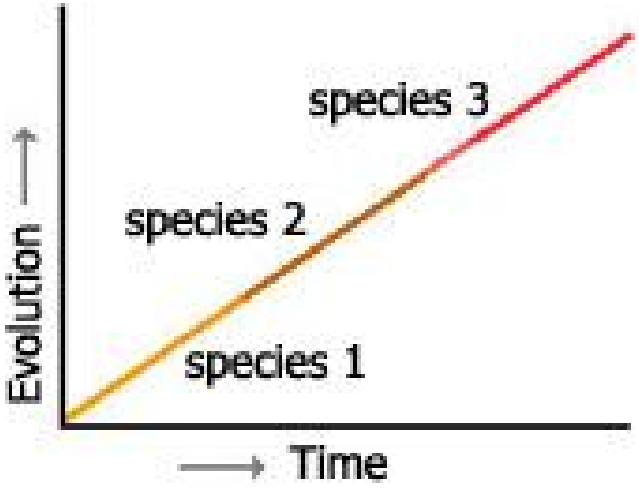
Tempo of Evolution

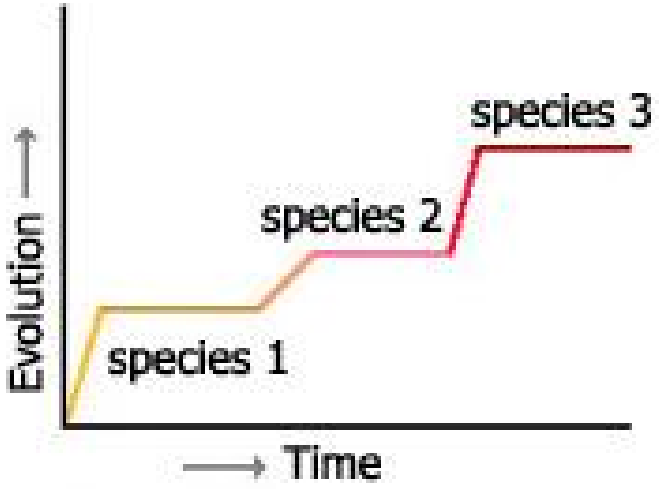
Gradualism

- Darwin
- Slow, constant change
- Less likely

Punctuated Equilibium

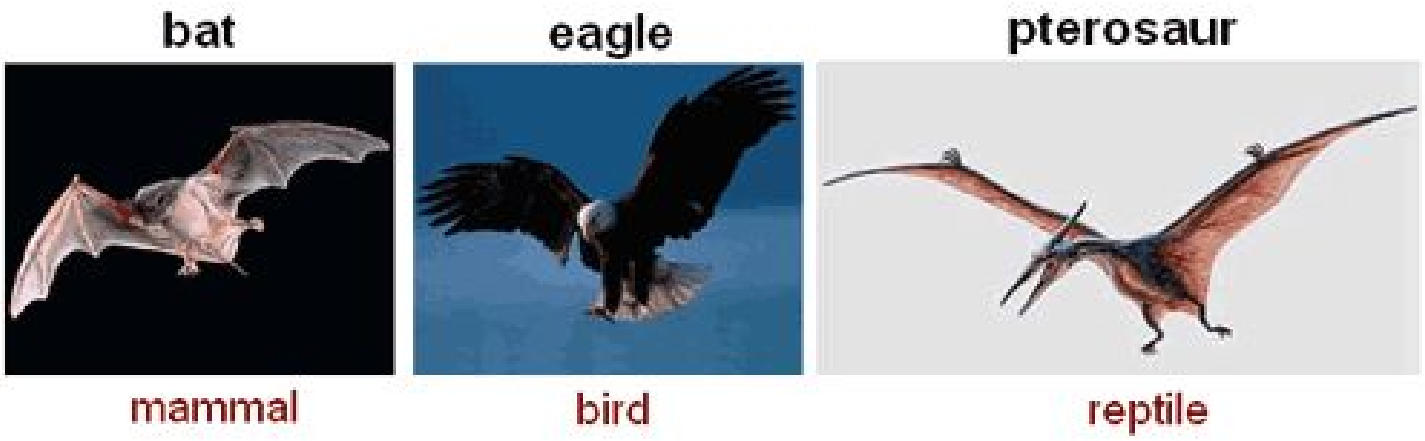
- Eldridge & Gould
- Long period of minor change are interrupted by short bursts of significant change
- More likely

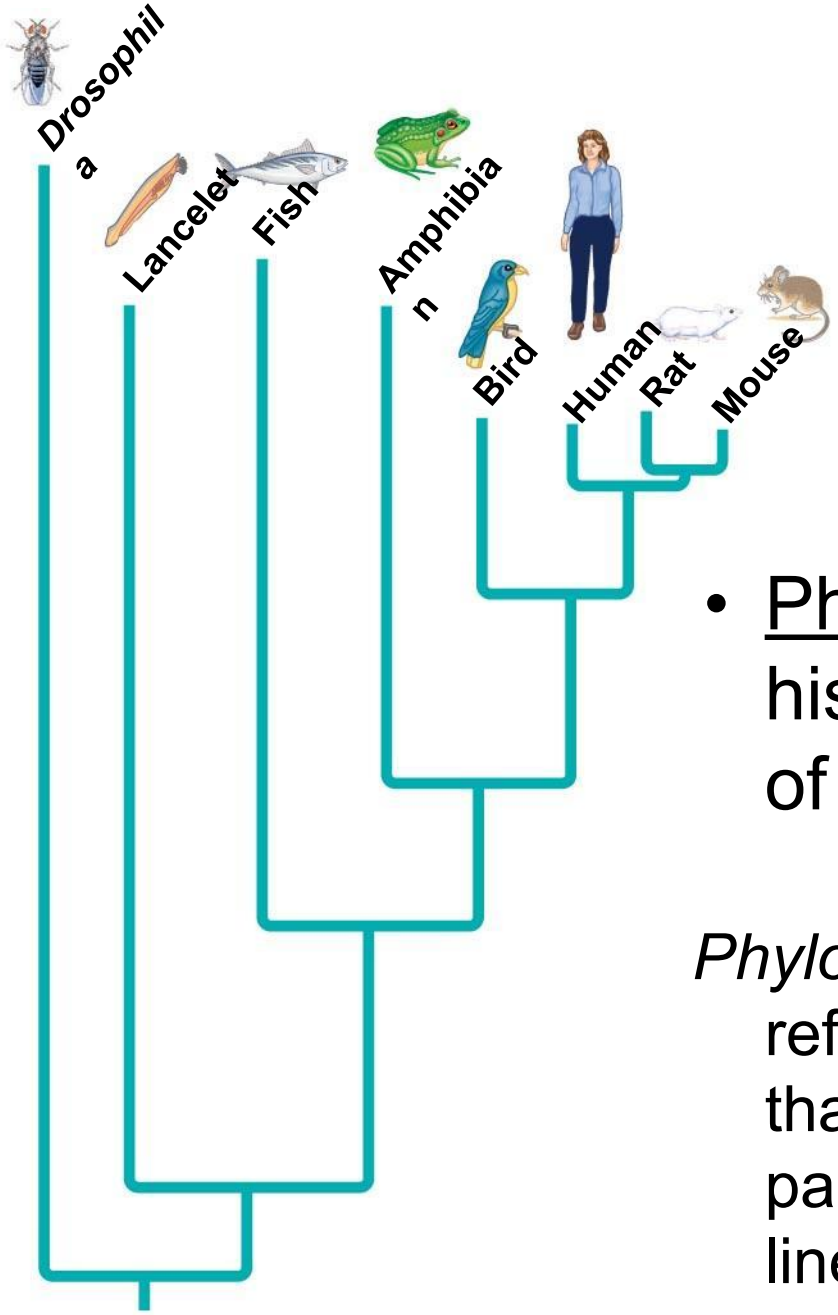




Convergent Evolution

- Independent development of similar features between 2 unrelated species
- Similar environments
- Analogous structures
- Eg. wings on bees & wings on birds



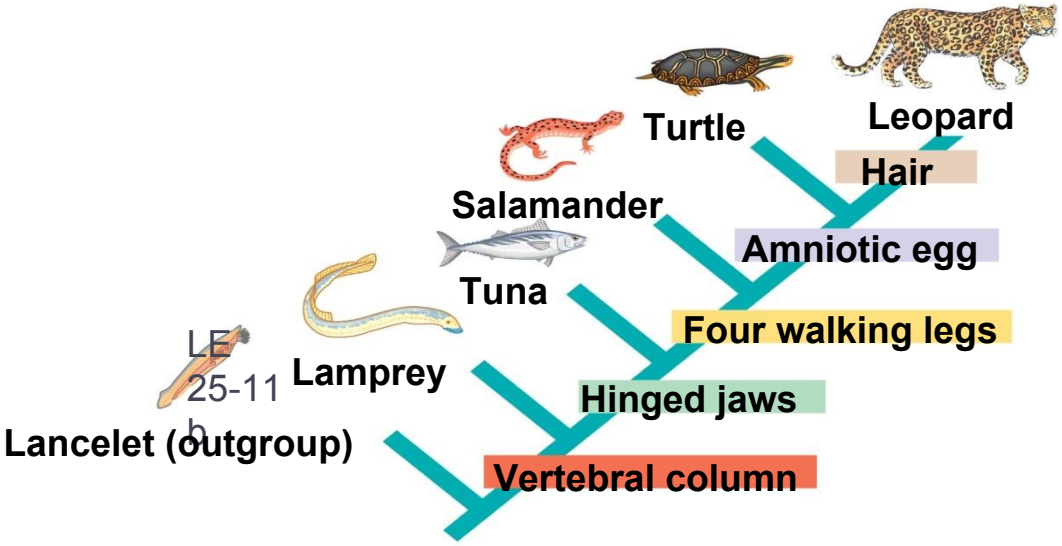


- Phylogeny = evolutionary history of a species or group of species

Phylogram: the length of a branch reflects the number of changes that have taken place in a particular DNA sequence in that lineage

Cladistics : a form of systematics

- Cladogram: diagram of evolutionary relationship of organisms
  - Shared characteristics due to common ancestry
  - Uses *parsimony* – simplest explanation, fewest DNA base changes for tree ("keep it simple")



(b) Cladogram

Comparison of Structures

Homology

- Results from:
  - Adaptive radiation
  - Common ancestor
  - Similar origin
- Different functions
- Eg. wing of bat, human arm, dolphin flipper

Analogy

- Results from:
  - Convergent evolution
  - Different ancestors
  - Different origin
- Similar functions
- Eg. wings of bird, wings of insect

Remember:

•Adaptive radiation – *emergence of many species from common ancestor*

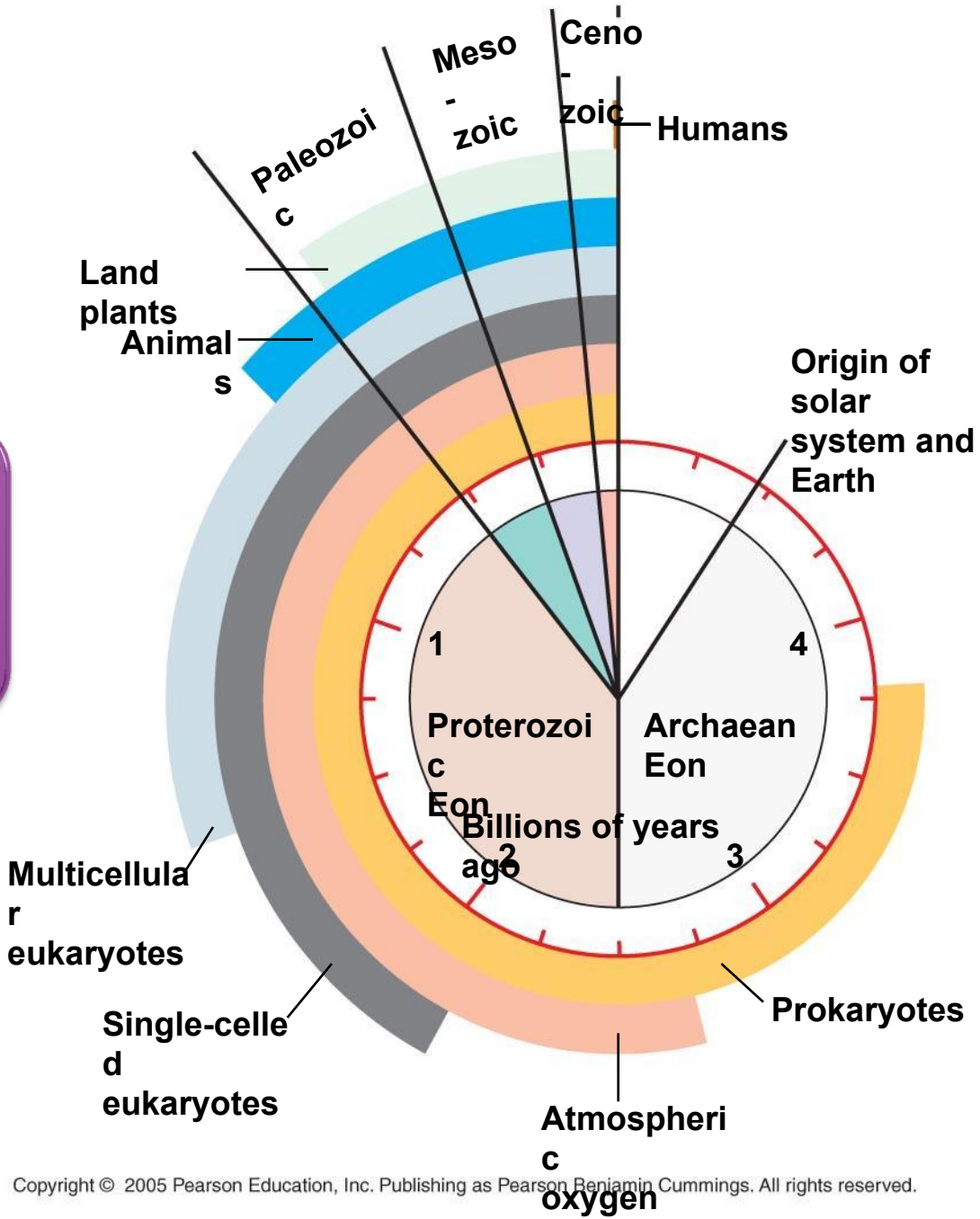
•Convergent evolution – *unrelated species independently evolve similarities when adapting to similar environments*

Major events during each Era

- Precambrian: microscopic fossils (stromatolites)
  - Photosynthesis, atmospheric O2
  - Eukaryotes (endosymbiont theory)
- Paleozoic: Cambrian Explosion
  - Plants invade land, many animals appear
  - Permian Extinction (-96% species)
- Mesozoic: "Age of Reptiles", dinosaur, plants
  - Formation of Pangaea supercontinent
  - Cretaceous Extinction – asteroid off Mexico's coast
- Cenozoic: primates

Note: All end with **major extinction** & start with **adaptive radiation**

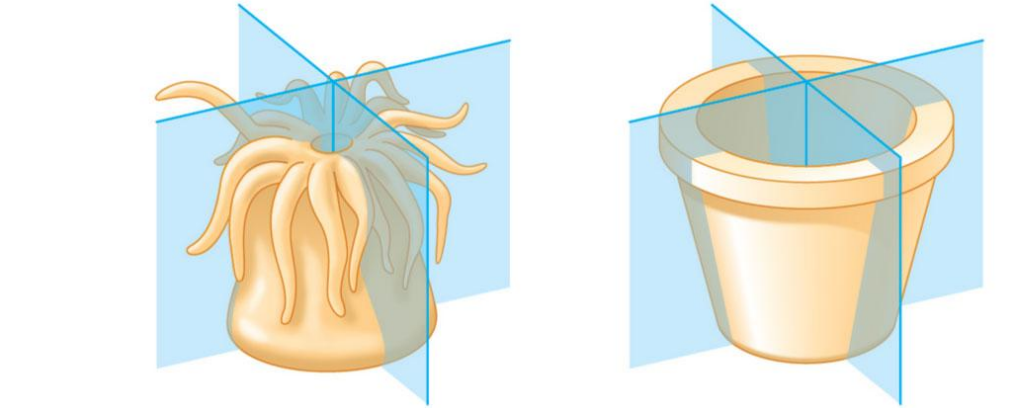
Clock Analogy of Earth's History



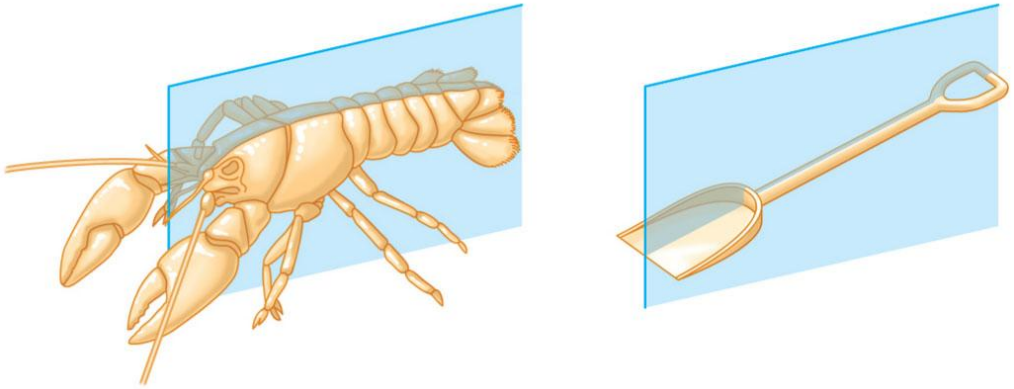
Evolution of Plants

- Non-Vascular (liverworts, hornworts, mosses)→ Seedless Vascular (ferns) → Seed Vascular (gymnosperms, angiosperms)
- Mosses: *Gametophytes = dominant form*
- Ferns: 1st with vascular tissue (xylem, phloem
  - wet environment (fertilization in water)
  - *Sporophyte = dominant form*
- Gymnosperms: "naked" seeds on cones
  - Conifers
- Angiosperms: flowering plants

Evolution of Animals – Body Plan

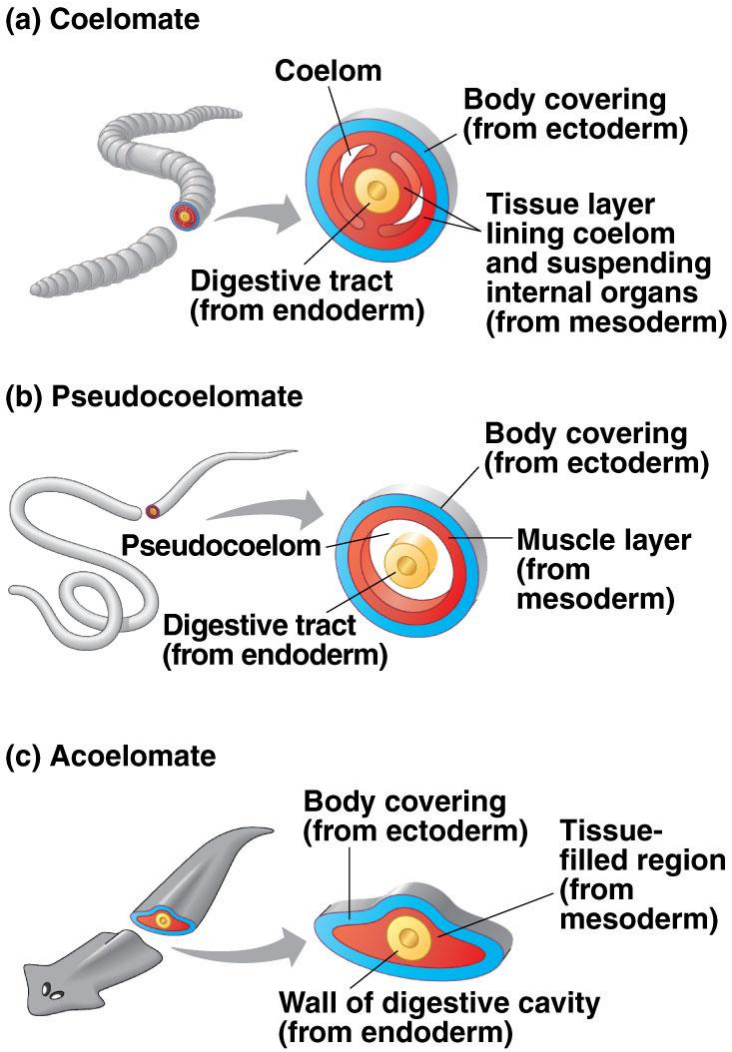


(a) Radial symmetry

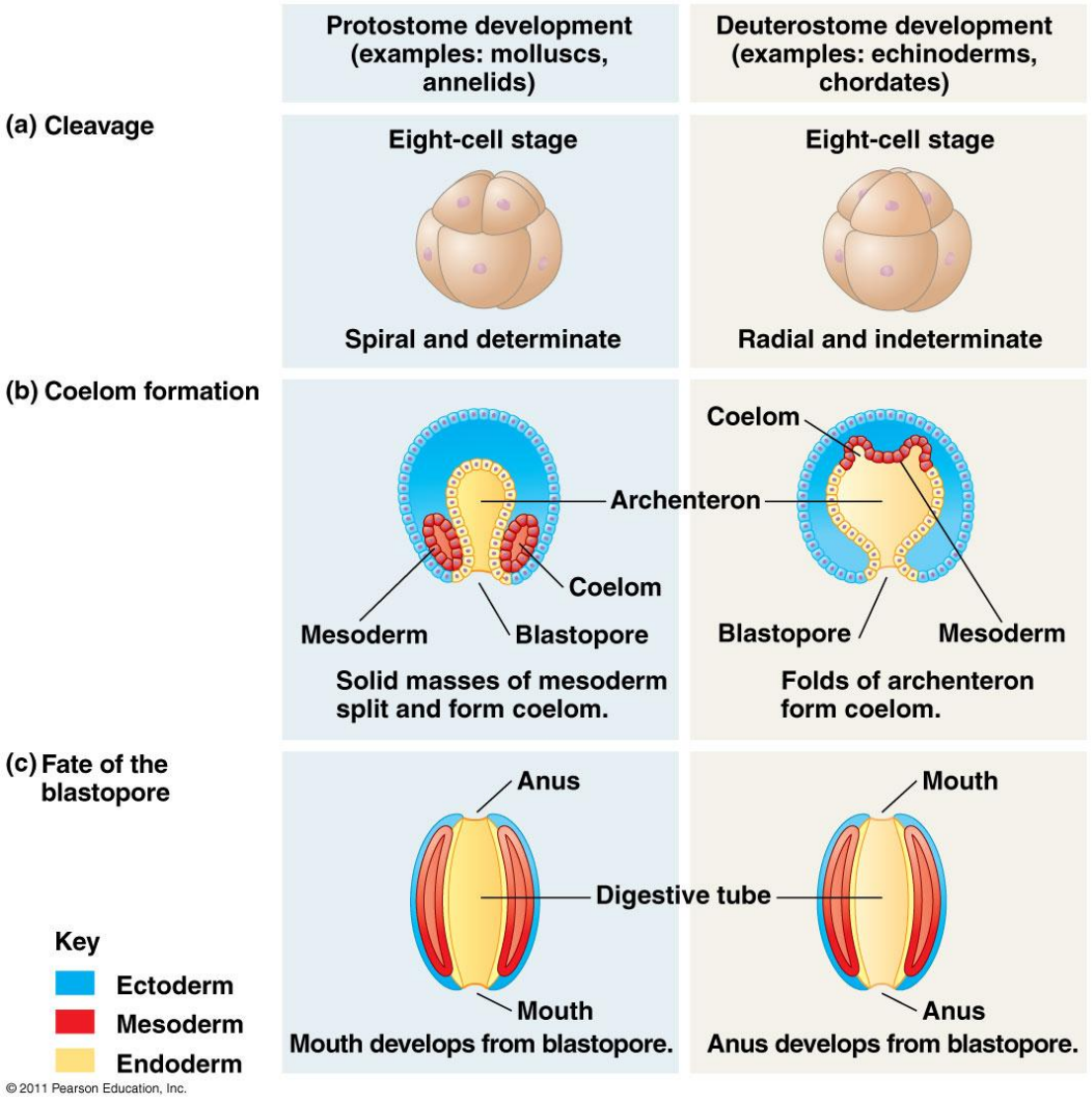


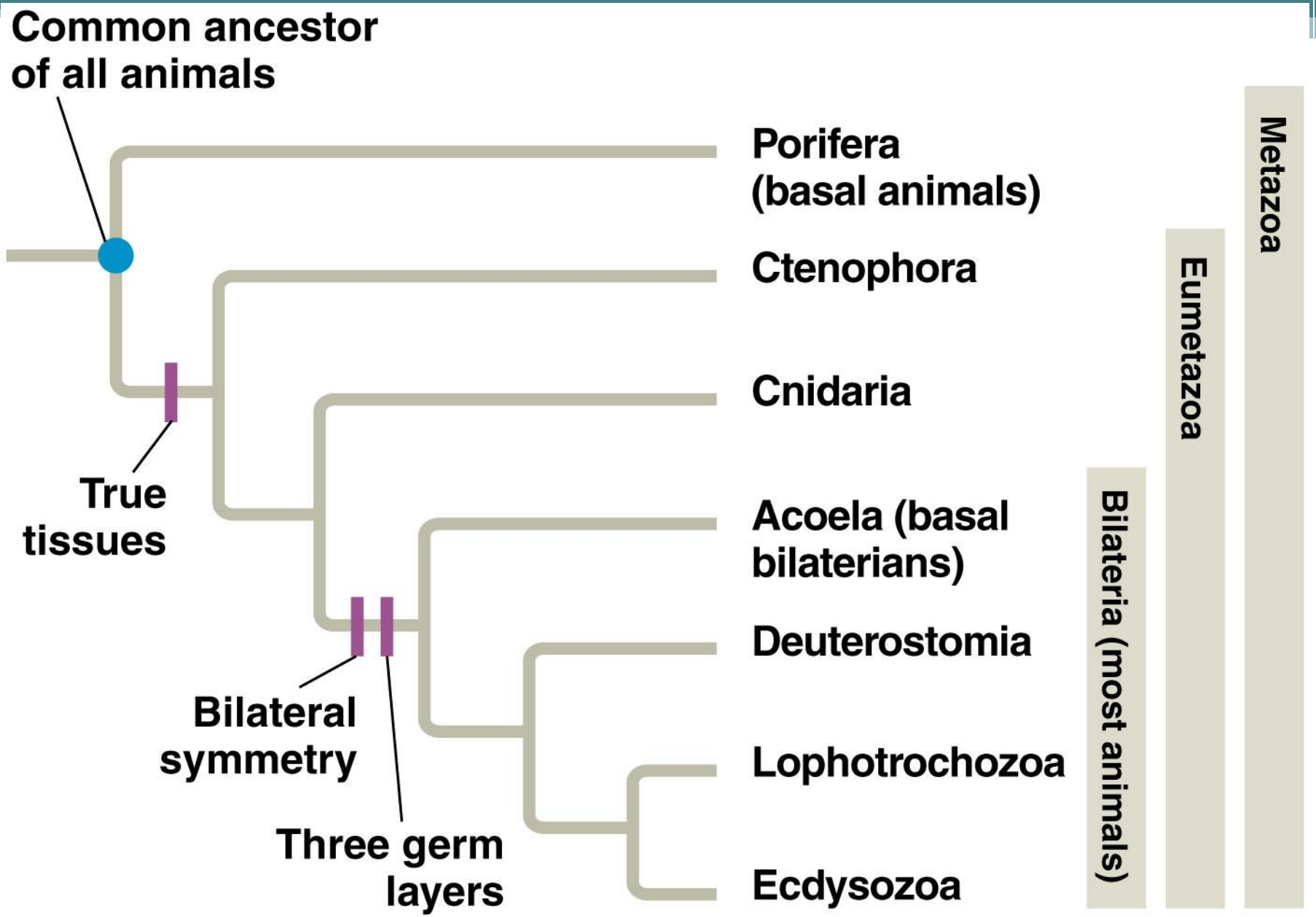
(b) Bilateral symmetry

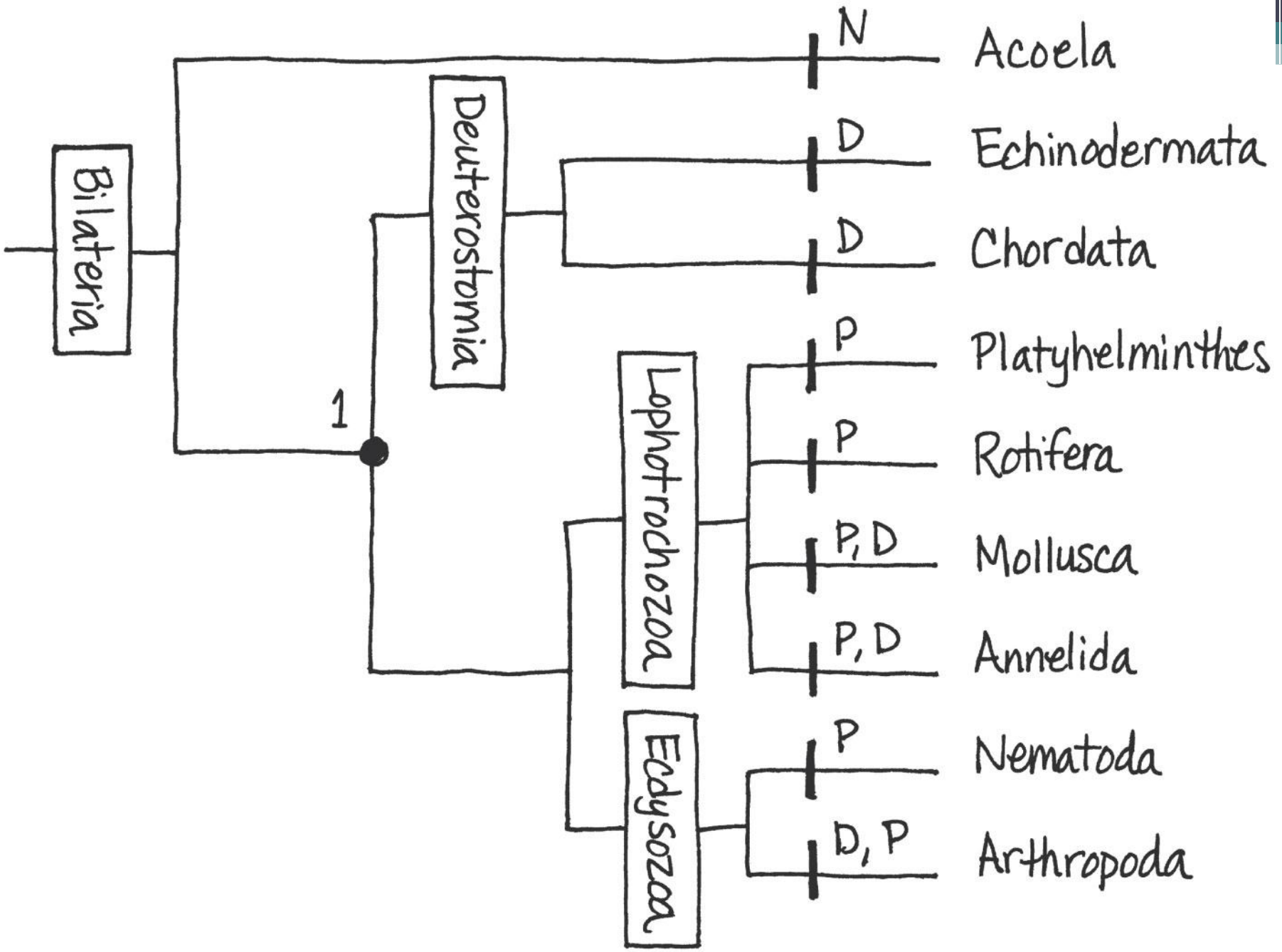
Evolution of Animals – Body Cavities



Evolution of Animals – Development



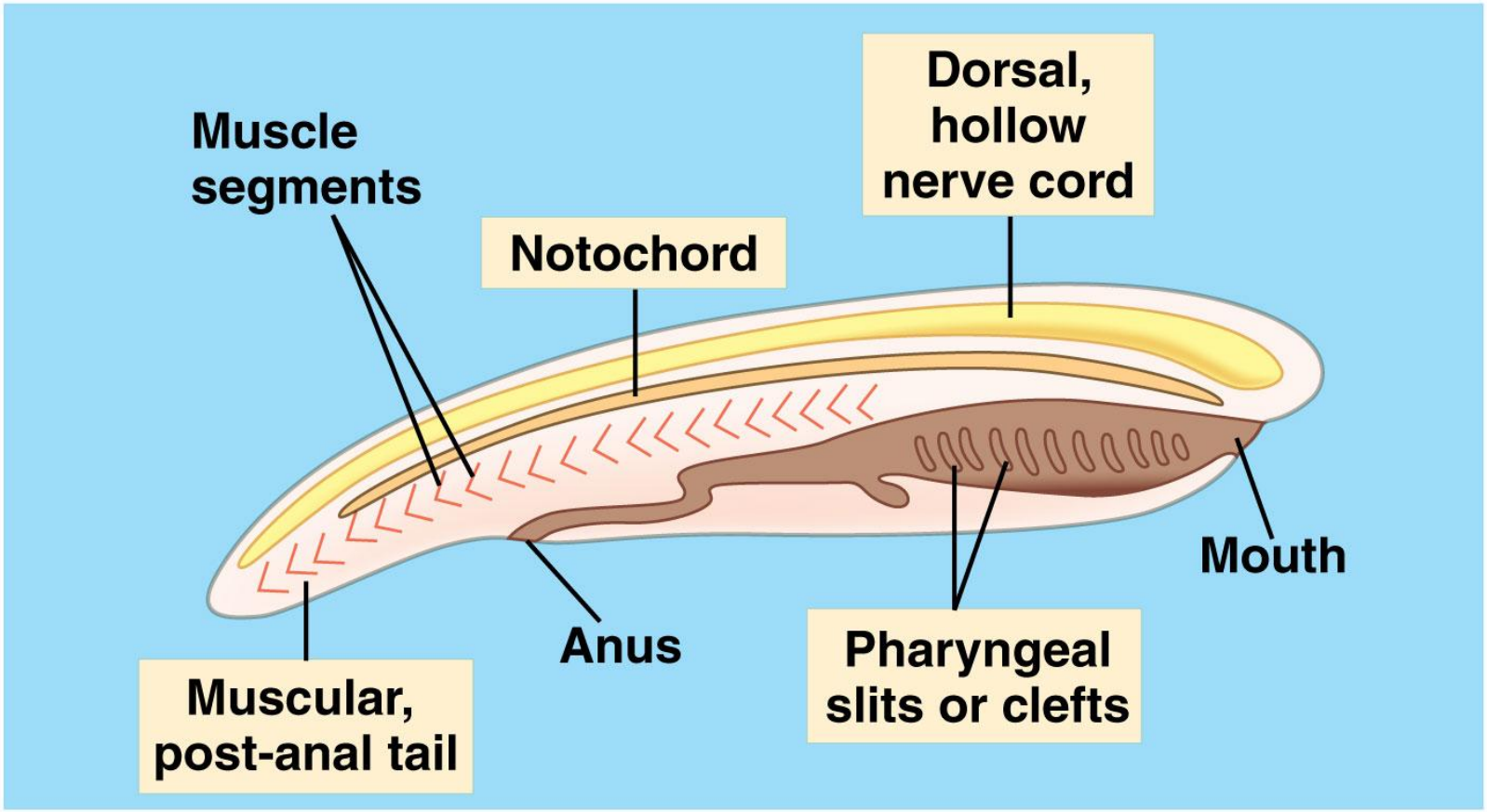




Evolution of Animals

- Porifera (sponge)
- Cnidarian (jellyfish, hydra)
- Flatworms (planaria)
- Mollusc
  - Gastropod (snail), bivalve (clams), cephalopod (octopus)
- Annelid (earthworm)
- Arthropods (insects, crustaceans)
- Echinoderms (“spiny skin” = starfish, sea urchins)
- Chordates (vertebrates)

Chordate Characteristics



Phylogeny of living chordates