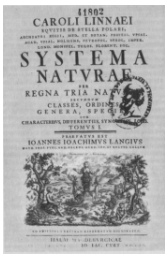
EVOLUTION: Descent with modification

Before Darwin: "Species are fixed."

Linnaeus (late 1700s) – founded "**taxonomy**", **naming & classifying organisms into hierarchical groups**; "God creates, Linnaeus arranges"; introduced the **binomial naming of species (genus & species)**



Before Darwin: "Life Evolves."

Lamarck's theories of "**use & disuse**" & "**inheritance of acquired characteristics**" (early 1800s) – **first to propose a comprehensive model for a mechanism of evolution but was discredited** & ruthlessly ridiculed by the scientific community; first to note that "**adaptation**" to environment is an important product of evolution

The Darwinian Revolution

Darwin

Wallace

- by proposing a mechanism of evolution that WORKS, the idea that "**life evolves"** was **finally accepted** by the **scientific community**; that mechanism is the **theory** of "**evolution by natural selection**".

Evidence of evolution

- **Fossil record** – patterns observed (older fossils more different from existing organisms, recent fossils, more similar) strongly support evolutionary explanations
- occurrence of **transitional forms** as predicted by the evolutionary process are actually **numerous**

Evidence of evolution

- **Biogeography -** different biological communities found in different continents & similarities within the same biogeographical region are predicted by evolution

  e.g., marsupial communities found only in southern hemisphere continents, especially Australia





Evidence of evolution

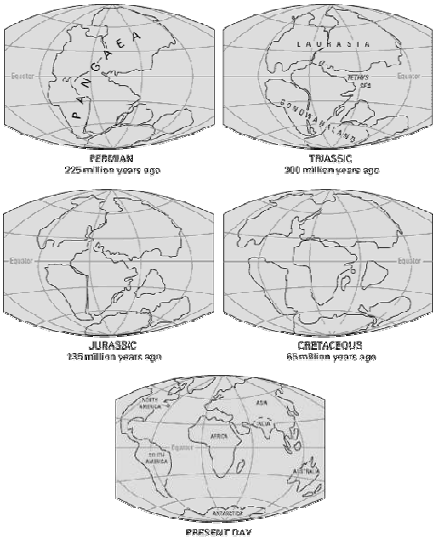
e.g, cacti naturally occur only in new world deserts





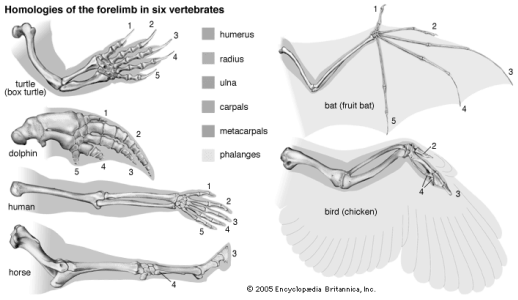

Evidence of evolution

- **restricted distribution of marsupials in** Australia and **cacti** in SW US is explained by evolution & **continental drift.**



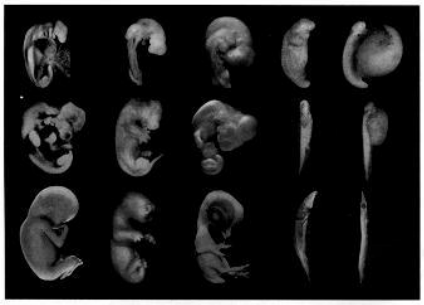
Evidence of evolution

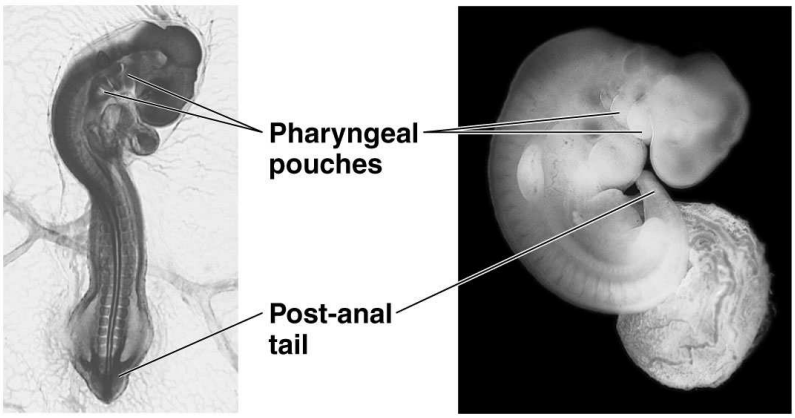
Comparative Anatomy occurrence of **homologies** (similar characteristics of related species resulting from common ancestry), as predicted by evolution, are numerous; e.g., forelimbs of all mammals are homologous (arms in humans, forelegs in 4-legged mammals, fins of whales, bat wings)



Evidence of evolution

- **Comparative Embryology –** similarity in embryonic development is a reflection of similar ancestry , another prediction by evolution



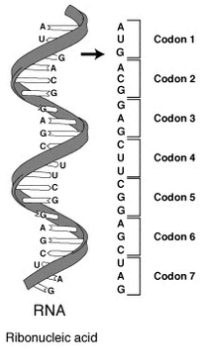


Chick embryo (LM)

Human embryo

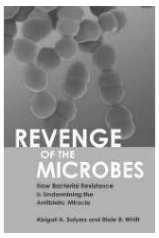
Evidence of evolution

Molecular Biology – universality of the genetic code & molecular homologies (in DNA base sequence) are what we will predict if we all evolved from the same ancestral cells!



Evidence of evolution

- **Natural selection in action, e.g., evolution of antibiotic-resistant bacteria, drug-resistant HIV, insecticide-resistant insects, examples from human evolutionary history**



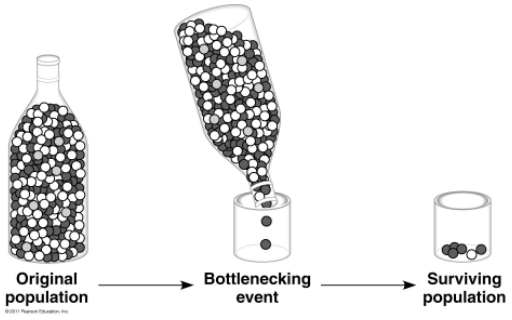
Evolution of Populations

- **Note that although natural selection acts on individuals, it is the POPULATION that evolves, not within a lifetime of an individual, but over many generations.**
- **A population has undergone microvolution if genetic structure (described by proportion of alleles, genotypes & phenotypes) changed across generations.**
- **Note: A nonevolving population is in "Hardy Weinberg Equilibrium".**

Mechanisms of Evolution

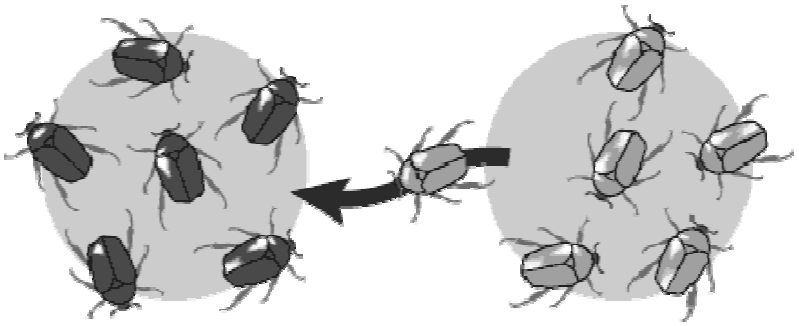
Genetic drift – effect of "small sample size" due to **bottleneck** or **founder** effects

may result in less genetic variation, random changes, may keep "bad" alleles in population



Mechanisms of Evolution

Gene Flow – effect of migration between populations, may change proportions (frequencies) of alleles across generations



Mechanisms of Evolution

Mutations e.g., alleles converted into another form, including defective forms, will change allele frequencies across generations

Mechanisms of Evolution

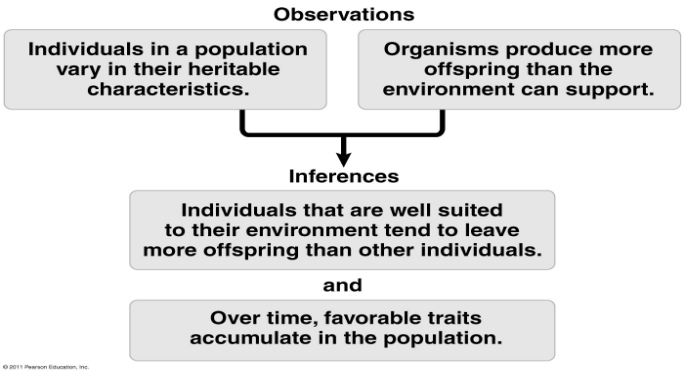
Nonrandom (assortative) mating (selecting mates), may change allele frequencies across generations

Special example: **inbreeding** (mating with close relatives), will increase homozygous individuals & decrease heterozygotes

Mechanisms of Evolution

natural selection – differential success in survival and reproduction resulting from the environment (nature) "selecting" among (genetically) variable individuals within a population

- will increase frequencies of "beneficial" alelles across generations
- the only mechanism able to produce "**adaptations**", which are the traits coded by the beneficial alleles



Month	0	8	12
Mosquitoes Resistant* to DDT	4%	45%	77%

Source: C. F. Curtis et al., Selection for and against insecticide resistance and possible methods of inhibiting the evolution of resistance in mosquitoes, *Ecological Entomology* 3:273–287 (1978).

*Mosquitoes were considered resistant if they were not killed within 1 hour of receiving a dose of 4% DDT.

Products of natural selection

1. **"Adaptations" (are traits that allow organisms to reproduce better in a given environment):** note that the environment <u>does not create</u> beneficial traits.

Instead, the environment SELECTS organisms carrying these traits to reproduce more.

Note: adaptations are environment-dependent, adaptation in one environment may be detrimental in another

2. **Diversity of life forms** as a result of adaptations to different environments

Terms related to natural selection:

Darwinian fitness – reproductive success, i.e, more offspring, higher fitness

Selection agent – the environmental factor responsible for "natural selection"

Adaptation – the trait being selected resulting in a "match between organism & the environment"

Origin of Species: SPECIATION

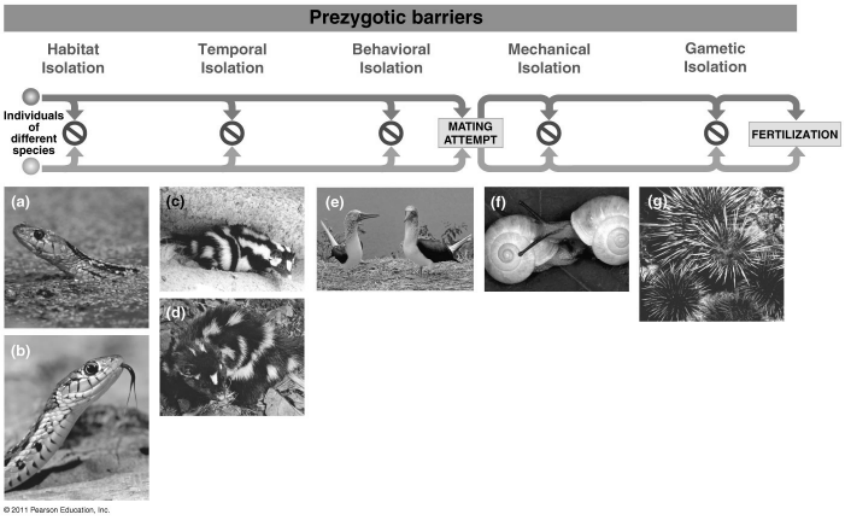
Species – "one type of organism"

What is the **biological species concept**?

Members of the same species can **potentially interbreed with each other** but are **reproductively isolated from other species** due to **reproductive barriers**

What is the **morphological species concept?**

Members of the same species are morphologically similar (i.e., they look alike).


Prezygotic barriers
Habitat Isolation
Temporal Isolation
Behavioral Isolation
Mechanical Isolation
Gametic Isolation
Individuals of different species
MATING ATTEMPT
FERTILIZATION
(a)
(b)
(c)
(d)
(e)
(f)
(g)
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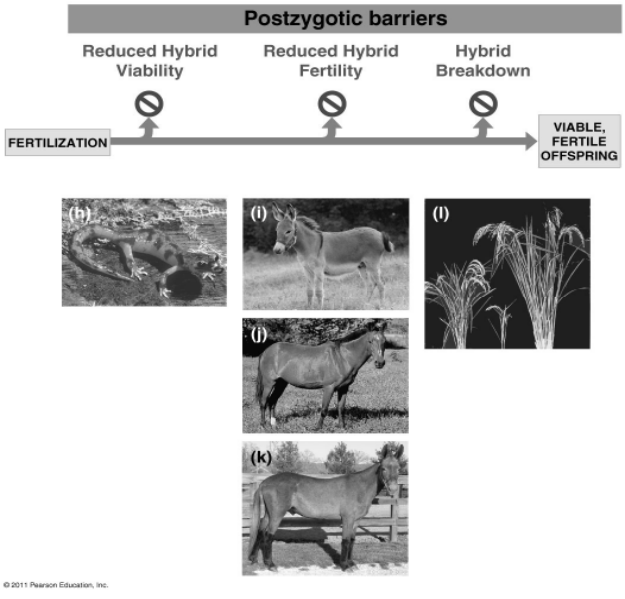
Postzygotic barriers
Reduced Hybrid Viability
Reduced Hybrid Fertility
Hybrid Breakdown
FERTILIZATION
VIABLE, FERTILE OFFSPRING
(h)
(i)
(j)
(k)
(l)
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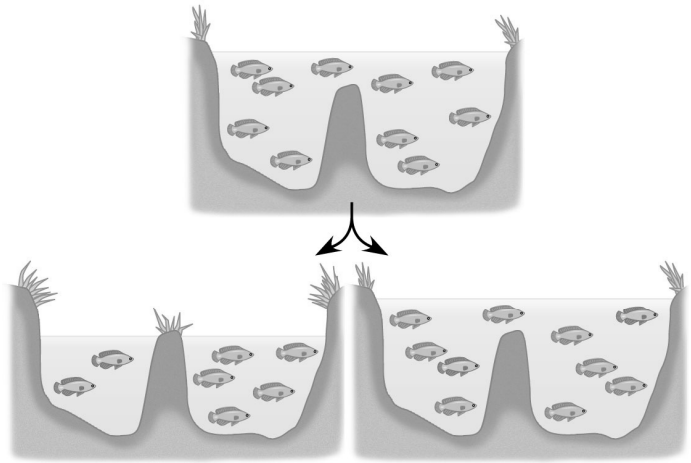
Modes of Speciation

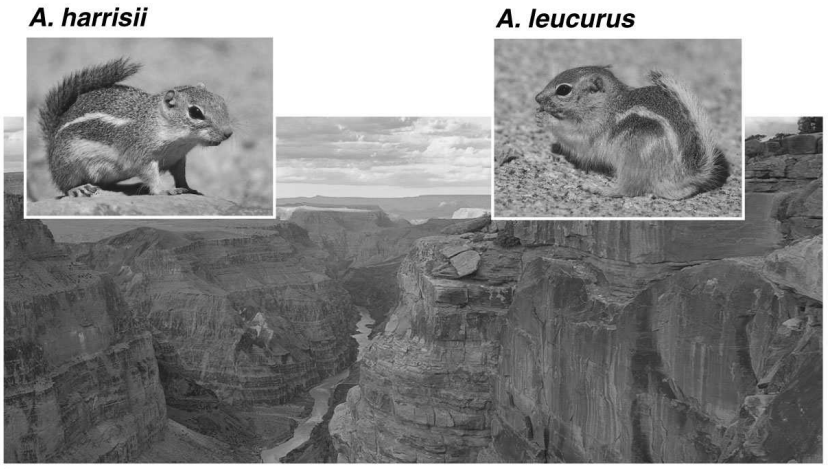
- **Allopatric speciation –** requires a geographic barrier , e.g, adaptive radiation in island chains
- **Sympatric speciation –** factors within the population itself alter gene flow e.g., tetraploids resulting from mistakes in meiosis are viable & reproductively isolated from parental diploids



(a) Allopatric speciation. A population forms a new species while geographically isolated from its parent population.

(b) Sympatric speciation. A subset of a population forms a new species without geographic separation.

Allopatric speciation of antelope squirrels on opposite rims of the Grand Canyon



Sympatric speciation via mistakes in meiosis