Evolutionary Forces

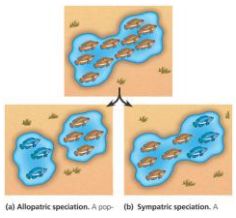
New Groups

So…what is a species?

- Biological species concept
  - defined by Ernst Mayr
  - population whose members can interbreed & produce viable, fertile offspring
  - reproductively compatible

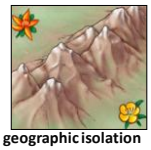
How and why do new species originate?

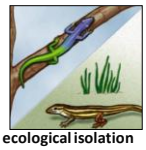
- Species are created by a series of evolutionary processes
  - populations become isolated
    - geographically isolated
    - reproductively isolated
  - isolated populations evolve independently
- Isolation
  - allopatric
    - geographic separation
  - sympatric
    - still live in same area

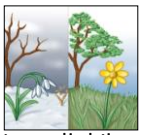


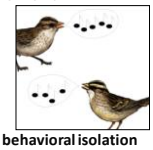
PRE-reproduction barriers

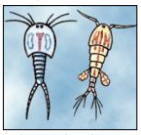
- Obstacle to mating OR to fertilization if mating occurs

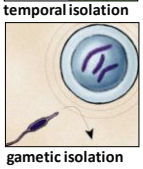

geographic isolation


ecological isolation


temporal isolation


behavioral isolation


mechanical isolation


gametic isolation

POST-reproduction barriers

- Prevent hybrid offspring from developing into a viable, fertile adult
  - reduced hybrid viability
  - reduced hybrid fertility
  - hybrid breakdown

zebroid

Do NOW!
On scrap paper, on your own..

- Pre or Post Zygotic Isolation? What specific type?
  - Two species of frogs mate in the lab, and produce viable but sterile offspring
  - Two species of sea urchins release gametes at the same time, but the sperm fail to fertilize the egg of a different species
  - Two species of mayflies emerge during different weeks in the spring
  - Two similar species of birds have different mating rituals

Post-Zygotic

- Reduced hybrid fertility
  - hybrids are sterile

Pre-Zygotic

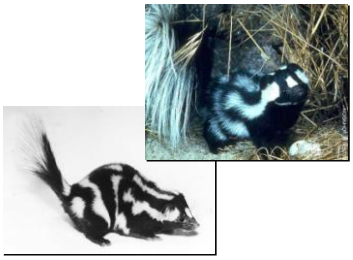
Gametic Isolation

- Sperm of one species may not be able to fertilize eggs of another species
  - Sperm & eggs = gametes

Pre-Zygotic

- Temporal Isolation
  - Species that breed during different times of day, different seasons, or different years

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer



Pre-Zygotic

- Behavioral Isolation
  - Unique behavioral patterns & rituals isolate species, such as courtship rituals and mating calls

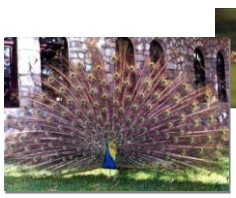
The Blue footed booby mates only after a courtship display unique to their species

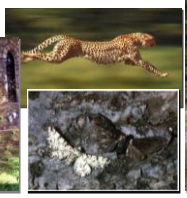
Forces of evolutionary change

- Natural selection
  - traits that improve survival or reproduction will accumulate in the population
    - adaptive change
- Genetic drift
  - frequency of traits can change in a population due to chance events
    - random change

Natural Selection

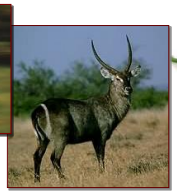
- Selection acts on any trait that affects survival or reproduction
  - predation selection
  - physiological selection
  - sexual selection

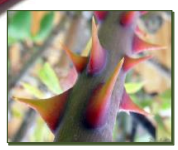




Predation Selection

- Predation selection
  - act on both predator & prey
    - behaviors
    - camouflage & mimicry
    - speed
    - defenses (physical & chemical)

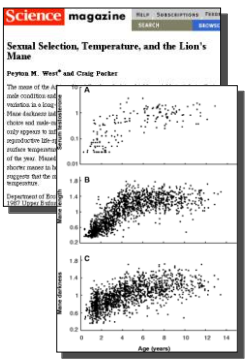




Sexual Selection

- Acting on reproductive success
  - attractiveness to potential mate
  - fertility of gametes
  - successful rearing of offspring

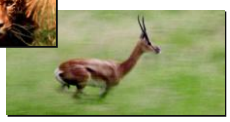
The lion's mane…



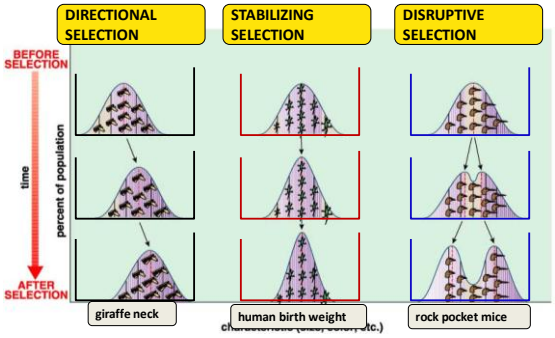
- Females are attracted to males with larger, dark manes
- Correlation with higher testosterone levels
  - better nutrition & health
  - more muscle & aggression
  - better sperm count / fertility
  - longer life
- But imposes a cost to male
  - *HOT!* Is it worth it??

Coevolution

- Two or more species reciprocally affect each other's evolution
  - predator-prey
  - competitive species
  - mutualism
    - pollinators & flowers

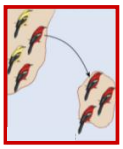


Effects of Selection



Genetic Drift

- Chance events changing frequency of traits in a population
  - *not* adaptation to environmental conditions
    - *not* selection
  - founder effect
    - small group splinters off & starts a new colony
  - bottleneck
    - some factor (disaster) reduces population to small number & then population recovers & expands again but from a limited gene pool



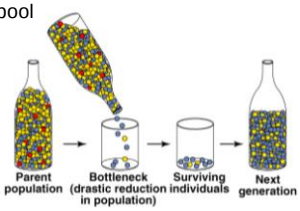
Founder effect

- When a new population is started by only a small group of individuals
  - just by chance some rare alleles may be at high frequency; others may be missing
  - skew the gene pool of new population
    - human populations that started from small group of colonists
    - example: colonization of New World

albino deer Seneca Army Depot

Bottleneck effect

- When large population is drastically reduced by a disaster
  - famine, natural disaster, loss of habitat…
  - loss of variation by chance event
    - alleles lost from gene pool
      - not due to fitness
    - narrows the gene pool

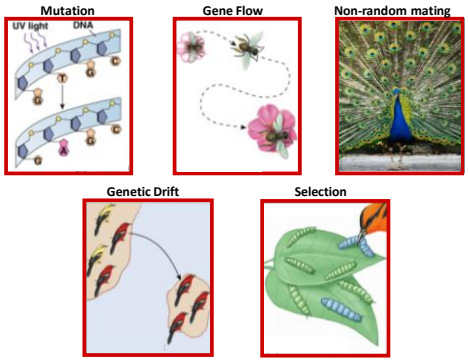


Measuring Evolution of Populations

What are the reasons populations evolve?

Evolution = change in *allele frequencies*

5 Agents of evolutionary change



Populations & gene pools

- Concepts
  - a population is a localized group of interbreeding individuals
  - gene pool is collection of alleles in the population
    - remember difference between alleles & genes!
  - allele frequency is how common is that allele in the population
    - how many A vs. a in whole population
      - Ex: the incidence of the sickle cell allele is less than 0.5% in the US, but 15% in parts of Africa

Evolution of populations

- Evolution = change in allele frequencies in a population
  - hypothetical: what conditions would cause allele frequencies to not change?
  - non-evolving population

    REMOVE all agents of evolutionary change
    1. very large population size (no genetic drift)
    2. no migration (no gene flow in or out)
    3. no mutation (no genetic change)
    4. random mating (no sexual selection)
    5. no natural selection (everyone is equally fit)

Hardy-Weinberg equilibrium

- Hypothetical, non-evolving population
  - preserves allele frequencies
- Serves as a model (null hypothesis)
  - natural populations rarely in H-W equilibrium
  - useful model to measure if forces are acting on a population
    - measuring evolutionary change

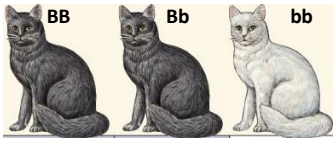
G.H. Hardy
mathematician

W. Weinberg
physician

Hardy-Weinberg theorem

- Counting Alleles
  - assume 2 alleles = B, b
  - frequency of dominant allele (B) = p
  - frequency of recessive allele (b) = q
    - frequencies must add to 1 (100%), so:

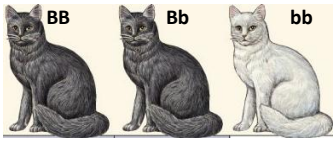
$$p + q = 1$$



Hardy-Weinberg theorem

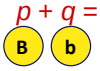
- Counting Individuals
  - frequency of homozygous dominant: $p \times p = p^2$
  - frequency of homozygous recessive: $q \times q = q^2$
  - frequency of heterozygotes: $(p \times q) + (q \times p) = 2pq$
    - frequencies of all individuals must add to 1 (100%), so:

$$p^2 + 2pq + q^2 = 1$$

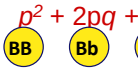


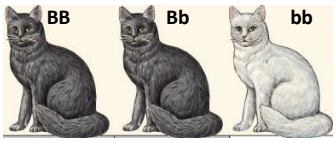
H-W formulas

- Alleles: $p + q = 1$



- Individuals: $p^2 + 2pq + q^2 = 1$

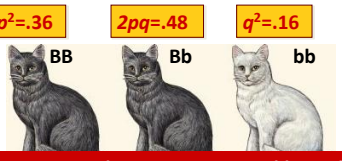




Using Hardy-Weinberg equation

population:
100 cats
84 black, 16 white
How many of each genotype?

q^2 (bb): 16/100 = .16
q (b): √.16 = **0.4**
p (B): 1 - 0.4 = **0.6**

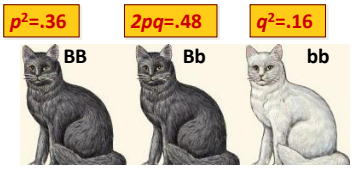


Must assume population is in H-W equilibrium!

Using Hardy-Weinberg equation

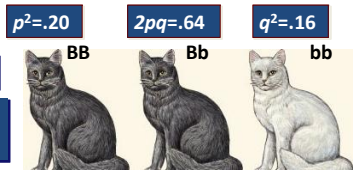
Assuming H-W equilibrium

Null hypothesis



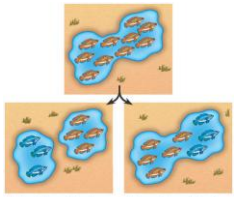
Sampled data

How do you explain the data?



Speciation

How do we create a new species?



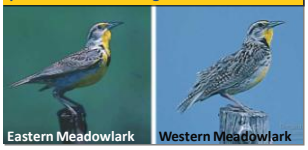
(a) Allopatric speciation. A popu- (b) Sympatric speciation. A

2007-2008

So…what is a species?

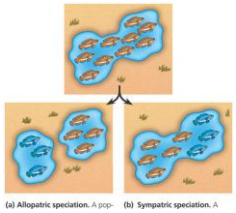
- Biological species concept
  - population whose members can interbreed & produce viable, fertile offspring
  - reproductively compatible

Distinct species:
songs & behaviors are different enough to prevent interbreeding



How and why do new species originate?

- Species are created by a series of evolutionary processes
  - populations become isolated
  - isolated populations evolve independently
- Allopatric
  - "other land"
- Sympatric
  - "same land"



Geographic isolation

- Species found in different areas separated by a physical barrier

Harris's antelope squirrel inhabits the canyon's south rim (L). Just a few miles away on the north rim (R) lives the closely related white-tailed antelope squirrel

Ecological isolation

- Species occur in same region, but occupy different habitats

2 species of garter snake, *Thamnophis*, occur in same area, but one lives in water & other is terrestrial

Temporal isolation

- Species that breed during different times of day, different seasons, or different years

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer

Behavioral isolation

- Unique behavioral patterns & rituals isolate species, such as courtship rituals and mating calls

Blue footed boobies mate only after a courtship display unique to their species

Mechanical isolation

- Morphological differences can prevent successful mating

Gametic Isolation

- Sperm of one species may not be able to fertilize eggs of another species
  - Sperm & eggs = gametes

POST-reproduction barriers

- Prevent hybrid offspring from developing into a viable, fertile adult
  - reduced hybrid viability
  - reduced hybrid fertility

zebroid

Reduced hybrid viability

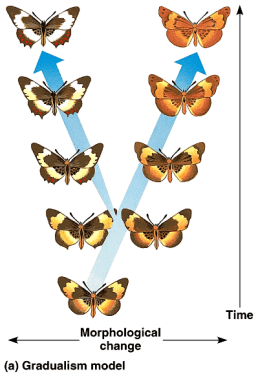
- The hybrid species does not develop properly, and does not live long enough to reproduce

Reduced hybrid fertility
hybrids are sterile

How Does Speciation Occur?

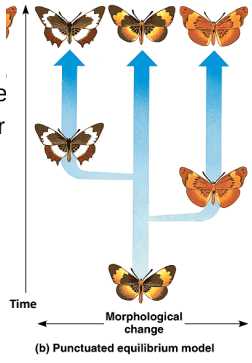
Gradualism

- Gradual divergence over long spans of time
  - Also known as *microevolution*



Punctuated Equilibrium

- Rate of speciation is not constant
  - rapid bursts of change
  - long periods of little or no change



Evolution is not goal-oriented

An evolutionary trend does not mean that evolution is goal-oriented.

Surviving species do not represent the peak of perfection. There is compromise & random chance involved as well

Remember that for humans as well!