I. Populations

A. Evolution is change over time

(change in the frequency of heritable phenotypes & the alleles that govern them)

B. Populations are the units of evolution
I. Populations

A. Evolution is change over time

B. Populations are the units of evolution

Microevolution detected here
Allelic and phenotypic freq. change in pops.

Contrast with macroevolution
1. Speciation
2. Extinction
3. Transitions from water to land, etc.

II. Evolution

A. Forces of evolution
1. Mutation (e.g., Drosophila data)
   • 70% deleterious
   • 30% neutral or weakly advantageous

2. Nonrandom Mating
   - Primarily referring to individual traits or genes: matings may or may not be random.
   - At organismal level:
     - most matings restricted geographically
     - mate selection (sexual selection)
II. Evolution

Croaking used to attract mates
(by males in most species, but also
females in some frogs)

Force air through larynx,
but vocal sacs amplify.
Species-specific
Which means its selected for.
II. Evolution
Male peafowl (peacock) plumage
Displayed prominently during courtship

Fitness benefits
Attraction of peahens

Fitness costs
Increase metabolic cost
Increased visibility & decreased flight speed in relation to predators?

These two graphs point to two advantages peahens may have in using tailfeathers to select mate.

1. 
2. 

II. Evolution

Fitness benefits
Attraction of peahens

Fitness costs
Increase metabolic cost
Increased visibility & decreased flight speed in relation to predators?
Artificial selection is human-controlled non-random mating (selective breeding).

Artificial selection is human-controlled non-random mating (selective breeding).

II. Evolution

A. Forces of evolution
   1. Mutation (e.g., Drosophila data)
   2. Nonrandom Mating
   3. Migration (gene flow)
3. Migration

Population before

4 diploid individuals
Black allele (f = 0.50)
Red allele (f = 0.50)

3. Migration

Population after

3 diploid individuals
Black allele (f = 0.67)
Red allele (f = 0.33)
3. Migration

4 diploid individuals
Black allele (f = 0.50)
Red allele (f = 0.50)

Population before

3. Migration

immigration

3. Migration

5 diploid individuals
Black allele (f = 0.50)
Red allele (f = 0.40)
Purple allele (f = 0.10)

Population after
II. Evolution

A. Forces of evolution
   1. Mutation (e.g., Drosophila data)
   2. Nonrandom Mating
   3. Migration
   4. Genetic drift

   Chance-driven changes in trait frequencies. Occurs more rapidly in small populations

4. Genetic drift
   a. General

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Larger population

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4. Genetic drift
   a. General

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Chance death or failure to mate of one individual

Generation 0

Generation 1

4. Genetic drift
   b. Some things that produce small populations and potentially drastic changes

1) Founder Effect
Amish immigration – 1700s

1. Small founding population’s allele freqs diff than parent population
   1 couple carried recessive allele for Ellis-van Creveld Syndrome (limb dwarfism, extra digits, etc.)

2. Interbreeding in small populations has kept freq. high.

3. Drift has influenced Amish population.

4. Genetic drift
   b. Some things that produce small populations and drastic changes
      1) Founder Effect
      2) Bottle Necks
II. Evolution

A. Forces of evolution
1. Mutation (e.g., Drosophila data)
2. Nonrandom Mating
3. Migration
4. Genetic drift
5. Natural selection (differential “fitness” based on phenotype)

- a. Types of natural selection:
  1) Stabilizing, 2) Directional, 3) Disruptive
Birthweight in humans

- Weakness causing difficulty eating, low fat content causing difficulty thermoregulating.
- Delivery complications related to pelvic size, etc.

What type of selection here?
- Directional
- Stabilizing
- Disruptive

Pepper moths in Britain
Pepper moths in Britain

**pre1850** – White-mottled morph most frequent. Camouflaged on trees with lichens.

1850 – Industrial Revolution in Britain

1850-1920 – Pollution and soot kill lichens, blacken trees. Black morph becomes more abundant.

1920-present – Cleaner fuel technology, emissions standards: lichens return, trees lighten, white morph becomes more abundant.

What type of selection here between 1850-1920?

a. Directional
b. Stabilizing
c. Disruptive

Pepper moths in Britain

Testing this hypothesis: Experiment 1

Equal numbers of black & white morphs reared in captivity

Expose to selective regime (e.g., birds & dark bark)

Results

Pepper moths in Britain

Testing this hypothesis: Experiment 2

Equal numbers of black & white morphs reared in captivity

Expose to selective regime (e.g., birds & dark bark)

Results
Pepper moths in Britain

Conclusions:
1) Selective Agent = predatory birds
2) Selective Regime (birds plus bark color frequencies) can and likely has influenced peppered moth evolution.

a. Types of natural selection:
4) Balancing selection (e.g., heterozygote advantage)
Where multiple alleles (even some “negative” ones) are actively maintained at freqs above that by which mutation alone would produce.

Balancing Selection Case Study: Sickle-cell mutation
Sickle-cell mutant

- Hemoglobin β gene on c-some
- Missense substitution of 1 bp
- Results: GAA to GUA

[Change to GAG would have been a silent mutation]

- Mutant hemoglobin aggregates into long rods.
- Deforms RBC
- Deformed RBC:
- Hinders blood flow to small capillaries.
- Fragile & break
Sickle-cell Genetics

- 2 co-dominant alleles:
  - $H^w$
  - $H^m$
- $H^wH^w$ are generally okay symptoms only w/ low $O_2$
  - no affect on mortality
- $H^wH^m$ have sickle cell disease anemia, organ damage, joint pain, high mortality

Sickle-cell Evolution

- Carrier Ratios In United States:
  - 1 in 100,000 whites
  - 1 in 1400 Hispanics
  - 1 in 12 blacks
- Carrier Ratios In Central Africa:
  - 1 in 3 Africans

Sickle-cell Evolution

- Why so high in Africa?
Sickle-cell Evolution

- Why so high in Africa?
- Malaria:
  - Plasmodium protist (infects and destroys RBC)
  - Mosquitos are vectors

- Carriers (heterozygotes):
  - Plasmodium reproduction in RBC lowers O2 levels, causing cells to sickle.
  - Sickled (infected) RBC destroyed.

Parents: $H_w H_m$ $X$ $H_w H_m$

<table>
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<td>$H_m H_m$ (sickle cell disease)</td>
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Sickle-cell Evolution

Why so high in Africa?

Parents: $H_w H_w \times H_w H_m$

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Conclusion: $H_w H_m$ are more fit than $H_w H_w$ (or $H_m H_m$)

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Sickle-cell Evolution

Why lower in African American population?

- Carrier Ratios in United States:
  - 1 in 100,000 whites
  - 1 in 1400 hispanics
  - 1 in 12 blacks

- Carrier Ratios in Central Africa:
  - 1 in 3 Africans

Conclusion:
  - Mutation Rate from $H_w$ to $H_m$ lower in N America?
  - Migration (gene flow)?
  - Nonrandom mating?
  - ~400 yrs of Nat Sel toward higher $H_w$ freq.
  - $H_w H_w$ ($H_w H_m$) are less fit than $H_w H_m$
**Sickle-cell Evolution**

Punnett Square Demonstrates Reduced fitness of HwHm when selective regime doesn't include malaria

Parents: HwHm X HwHm

<table>
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<tr>
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(sickle cell disease)