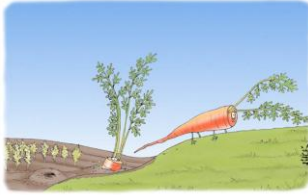


Chapter 22

Measuring Evolution of Populations



The next great step in carrot evolution.



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

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** (**polymorphic**)
 - ◆ if one allele is (**monomorphic; fixed**)
 - ◆ **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

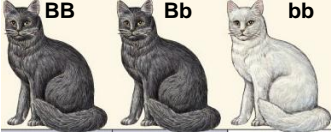
- Counting **Individuals** (genotypic frequencies w/ no advantageous phenotypes following one generation random mating)
 - ◆ frequency of **homozygous dominant**: $p \times p = p^2$
 - ◆ frequency of **homozygous recessive**: $q \times q = q^2$
 - ◆ frequency of **heterozygotes**: $(p \times q) + (q \times p) = 2pq$
 - 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 the Hardy-Weinberg Equation

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

$q^2 (bb): 16/100 = .16$
 $q (b): \sqrt{.16} = 0.4$
 $p (B): 1 - 0.4 = 0.6$


$p^2 = .36$ $2pq = .48$ $q^2 = .16$



Must assume population is in H-W equilibrium!

Application of H-W Principle

- Sickle cell anemia
 - inherit a mutation in gene coding for hemoglobin
 - oxygen-carrying blood protein
 - recessive allele = H^sH^s
 - normal allele = H^b
 - low oxygen levels causes RBC to sickle
 - breakdown of RBC
 - clogging small blood vessels
 - damage to organs
 - often lethal




Sickle Cell Frequency

- High frequency of heterozygotes
 - 1 in 5 in Central Africans = H^bH^s
 - unusual for allele with severe detrimental effects in homozygotes
 - 1 in 100 = H^sH^s
 - usually die before reproductive age

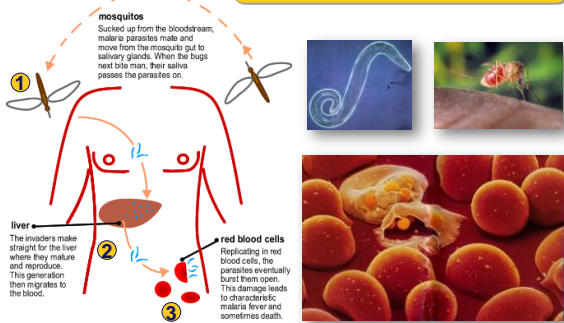
Why is the H^s allele maintained at such high levels in African populations?

Suggests some selective advantage of being heterozygous...



Malaria

Single-celled eukaryote parasite (*Plasmodium*) spends part of its life cycle in red blood cells



mosquitoes: Sucked up from the bloodstream, malaria parasites mate and move from the mosquito to gut to salivary glands. When the bugs next bite man, their saliva passes the parasites on.

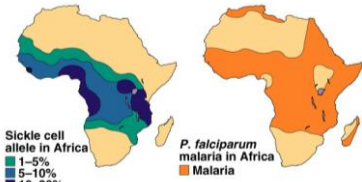
liver: The invaders make straight for the liver where they mature and reproduce. This generation then migrates to the blood.

red blood cells: Replicating in red blood cells, the parasites eventually burst them open. This damage leads to characteristic malaria fever and sometimes death.

Heterozygote Advantage

- In tropical Africa, where malaria is common:
 - homozygous dominant (normal) die of malaria: H^bH^b
 - homozygous recessive die of sickle cell anemia: H^sH^s
 - heterozygote carriers are relatively free of both: H^bH^s
 - survive more, more common in population

Hypothesis: In malaria-infected cells, the O_2 level is lowered enough to cause sickling which kills the cell & destroys the parasite.



Frequency of sickle cell allele & distribution of malaria

Sickle cell allele in Africa: 1-5%, 5-10%, 10-20%

P. falciparum malaria in Africa: Malaria