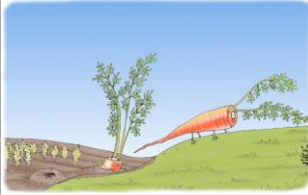


Chapter 21.3 Measuring Evolution of Populations



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?
 - ◆ **that is... a non-evolving population**
 - REMOVE all agents of evolutionary change
 - 1. no **mutation** (no genetic change)
 - 2. no migration (no **gene flow** in or out)
 - 3. very large population size (no **genetic drift**)
 - 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 of NO CHANGE (**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 in a gene pool***
 - ◆ *assume just 2 alleles = **B, b** (**dimorphic**)
 - ◆ if one allele is (**monomorphic; fixed**)
 - ◆ **frequency** of dominant allele (**B**) = **p**
 - ◆ **frequency** of recessive allele (**b**) = **q**
 - frequencies must add to 1.0 (100%), so:

$$p + q = 1$$





Hardy-Weinberg Theorem

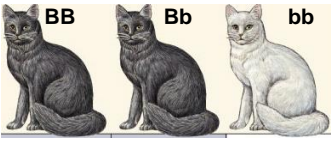
- Counting **Individuals** (or genotypic frequencies with no advantageous phenotypes following one generation random mating)
 - ◆ frequency of **homozygous dominant**: $p \times p = p^2$
 - ◆ frequency of **homozygous recessive**: $q \times q = q^2$
 - ◆ frequency of **heterozygotes**: $(p \times q) + (q \times p) = 2pq$
 - frequencies of **all individuals** must add to 1.0 (100%), so:

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



H-W Formulas

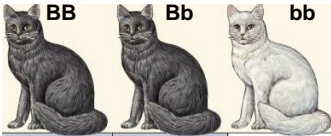
- Alleles: $p + q = 1$

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




Using the Hardy-Weinberg Equation

If in a population of 100 cats (assume H-W equilibrium), there are 84 black and 16 white... How many of each genotype?


q^2 (bb):
 q (b):
 p (B):



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 condition = 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

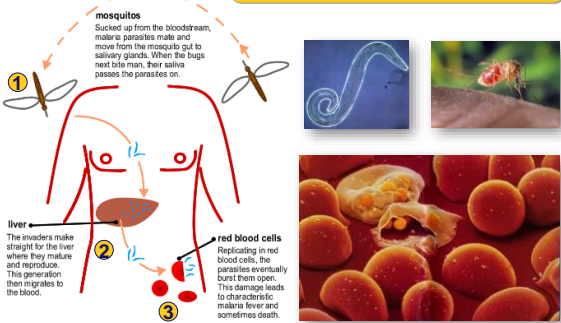
- High frequency of heterozygotes
 - 1 in 5 in Central Africans = H^bH^s
 - unusual for allele with severe detrimental effects in homozygotes
 - H^sH^s usually die before reproductive age

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



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.

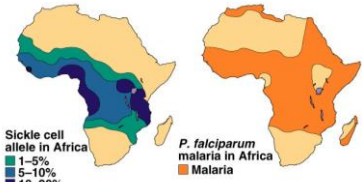
liver
The invaders make straight for the liver where they mature and reproduce. This generation then migrates to the blood.

red blood cells
Residing 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.



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

P. falciparum malaria in Africa
 ■ Malaria

Frequency of sickle cell allele & distribution of malaria