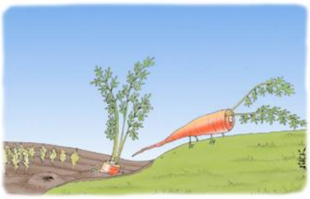
Chapter 21.3

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?
  - **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

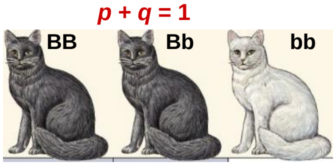
G.H. Hardy
mathematician

W. Weinberg
physician

Hardy-Weinberg Theorem

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

$$p + q = 1$$



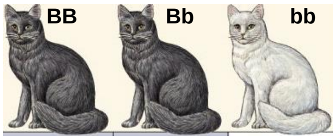
Hardy-Weinberg Theorem

- 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:** $p + q = 1$
  - B b
- **Individuals:** $p^2 + 2pq + q^2 = 1$
  - BB Bb bb



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

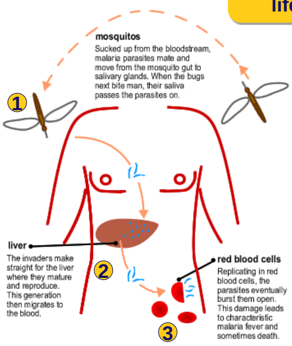
- Sickle cell anemia
  - inherit a mutation in gene coding for <u>hemoglobin</u>
    - oxygen-carrying blood protein
    - recessive allele = H^sH^s
      - normal allele = H^b
  - low oxygen levels causes RBC to sickle
    - breakdown of RBC
    - clogging small blood vessels
    - damage to organs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

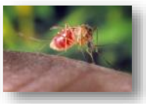
Sickle Cell Frequency

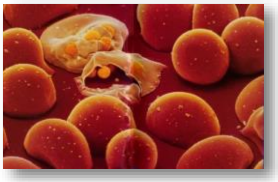
- High frequency of heterozygotes
  - 1 in 5 in Central Africans = H^bH^s
  - unusual for allele with severe detrimental effects in homozygotes
    - 1 in 100 = H^sH^s
    - usually die before reproductive age

Malaria

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



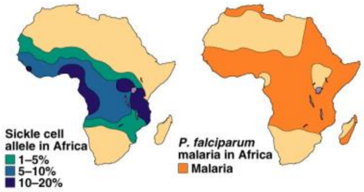




Heterozygote Advantage

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

<u>Hypothesis</u>: 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