POPULATION GENETICS

- The study of how frequently alleles occur in a population.
- A population is composed of individuals each individual will have two alleles for each gene (They may be homozygous or heterozygous)
- How do the frequency of alleles change in a population?

Important Ideas Related to DNA

- Mutations are changes in DNA sequence
- Mutations create new alleles
- Mutations create variation in genotypes and phenotypes for natural selection to act upon.
- Mutations can only be passed on to the next generation if they are passed to gametes

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Hardy Wienberg

- Assumes
  - Large populations
  - Random Mating
  - No selection
  - No immigration or emmigration
- Predicts
  - If above assumptions are met no change in allele frequency will occur in a population

Hardy - Wienberg

- p = probability of drawing dominant allele
- q = probability of drawing recessive allele
- Probability of both dominant =p^2
- Probability of heterozygote =2pq
- Probability of both recessive = q^2
- Frequency of genotypes in next generation is $p^2+2pq+q^2$
- AA+Aa+aa=1
- P hasn't changed

H-W Theory An Analogy

An Example:

Answers:

What is the probability that the first ball we grab will be black?

600/1000 or 0.6 = p

What is the probability the second ball we grab will be black?

≈ 600/1000 or 0.6 = p

What is the probability that anytime we grab two balls we will get two black balls.

0.6*0.6 or p^2 = 0.36

36% of the time reproduction occurred the resulting individual will have two "black" or dominant alleles.

H-W Theory An Analogy

An Example:

We know allow reproduction to occur.

What is the probability that the first ball we grab will be white?

What is the probability the second ball we grab will be white?

What is the probability that anytime we grab two balls we will get two white balls.

H-W Theory An Analogy

An Example:

Answers:

What is the probability that the first ball we grab will be white?

400/1000 or 0.4 = q

What is the probability the second ball we grab will be black?

≈ 400/1000 or 0.4 = q

What is the probability that anytime we grab two balls we will get two black balls.

0.4*0.4 or q^2 = 0.16

16% of the time reproduction occurred the resulting individual will have two "white" or recessive alleles.

H-W Theory An Analogy

An Example:

What is the probability that the first ball we grab will be white and the second ball black?

What is the probability the first ball we grab will be black and the second ball will be white?

H-W Theory An Analogy

An Example:

What is the probability that the first ball we grab will be white and the second ball black?

0.4*0.6 or p*q = 0.24

What is the probability the first ball we grab will be black and the second ball will be white?

0.6*0.4 or p*q = 0.24

Note: the order the alleles were drawn does not matter the individual with two different alleles will express the trait of the dominant allele.

What is the probability that the individual will be heterozygous?

p*q + p*q or 2pq =0.48

48% of the offspring produced will be heterozygotes

H-W Theory An Analogy

Calculated frequencies of genotypes of offspring in the next generation

$(p+q)^2$

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

0.36 +0.48+0.16 = 1

If we created a new generation of offspring this would calculate the frequency of different genotypes in that generation. What about the frequency of alleles?

H-W Theory An Analogy

If 16% of all offspring have two white alleles and the probability of two white alleles is calculated as q^2 then…

$\sqrt{q^2}$ = Frequency of white alleles = q =0.40

Since q=1-p the frequency of black alleles will be 0.4=1-p, p=0.6

H-W Theory Abstraction

- If the assumptions of H-W are met the frequency of alleles will stay constant from one generation to the next.
- The above is true regardless of p and q.
- Segregation, Assortment and Recombination of alleles alone would not cause evolution.
- If If the assumptions of H-W are met evolution does not occur.

Hardy-Weinberg Theory

Assumptions

1. Large Population
2. Random Mating
3. No Selection
4. No Migration

Violations of any and or all these assumptions may result in evolution.

Evolution is know defined as a change in the frequency of alleles in a population over time.

Evolution and Population Size

- Consequences of breaking the assumption of large population size.

- Bottlenecks
- Founder Effects
- Genetic Drift

Mimulus flower color example

Monkey Flowers of the Desert Southwest.

If genotype AA or Aa (homozygous dominant or heterozygous) flowers are pink-red.

If genotype is aa (homozygous recessive) flowers are yellow-white.

Mimulus flower color example

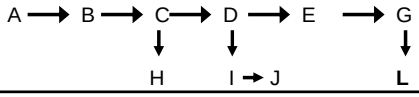
Why are the flowers red?

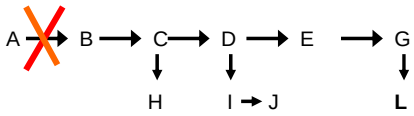
Ultimate Causes

Proximate Causes

Six different anthocyanin pigments. (purple)
One carotene pigment (yellow)

Many different genes are involved in controlling the synthesis of the anthocyanin pigments. In a multi-step process.





If a single enzyme is not present and early step in the synthetic pathway will not happen.

Genes are strands of DNA located at fixed locations on chromosomes.

Each strand of DNA consists of varying sequences of Base Pairs (A,T,C,G).

Every three base pairs (a codon) codes for a single amino acid.

A string of amino acids is a protein.

A single gene codes for a protein (an enzyme).

- If a mutation causes the sequences of base pairs to change a different amino acids to be coded for and a different protein to be produced.
- The “different” protein may not function as an enzyme as well.
- In this case a single mutation can prevent any anthocyanin from being produced.
- An individual homozygous recessive for this gene will not produce purple flowers.

Mimulus flower color example

Pollen contains the male gametes of flowers

Pollinators transfer the pollen (and gametes) to the stigma of another flower.

The pollen grows into the stigma and allows the male and female gametes to fuse.

A seed develops in the ovary of the flower

Mimulus flower color example

Red Mimulus flowers are visited by Hummingbirds.

Yellow Mimulus Flower are visted by bumblebees.

Each color flower thus tends to mate more frequently with its own type.