Populations

36-149 The Tree of Life

Christopher R. Genovese
Department of Statistics
132H Baker Hall x8-7836
http://www.stat.cmu.edu/~genovese/

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Plan

1. Book List Selections (coin at the ready)
2. Genetics (Review and Finish up)
3. Populations
4. Blue pages

Review of Last Time

1. DNA (deoxyribonucleic acid) molecules are the principal unit of inheritance passed from parents to offspring.
2. DNA encodes recipes for the body's proteins.
3. RNA (ribonucleaic acid) mediates the production of proteins.
4. The genome is divided into genes, regulatory elements, and various non-coding DNA,
5. DNA molecules replicate during cell division.
6. A variety of errors can occur during replication.
7. Genes are (sometimes) inherited in characteristic Mendelian ratios.

Mendel's Theory

1. Alleles: "Alternative versions of genes account for variation in inherited characters"
2. Diploidy: An organism inherits two copies of each gene, one from each parent.
3. Dominance: If the two inherited alleles differ, one – which we call *dominant* – will be fully expressed; the other – which we call *recessive* – will have no noticeable effect.
4. Segregation: The two copies of each gene will be sorted into separate gametes during meiosis.
5. Independent Assortment: The copy passed to offspring is selected independently for each gene.

Mendelian Examples

Alleles are often labeled by a single letter, with the dominant allele uppercase (e.g., A) and the recessive allele lowercase (e.g., a).

The genotype at one site on the DNA (called a genetic locus) can be indicated by listing the alleles, dominant first (e.g., Aa).

Example: Eye color.

- B brown eyes, dominant allele
- b blue eyes, recessive allele

There are three possibile genotypes: BB (homozygous dominant), Bb (heterozygous), and bb (homozygous recessive).

What is the phenotype for each of the three genotypes?

Crosses:

$\text{BB} \times \text{BB} \longrightarrow ?$ $\qquad$ $\text{bb} \times \text{Bb} \longrightarrow ?$

$\text{BB} \times \text{Bb} \longrightarrow ?$ $\qquad$ $\text{Bb} \times \text{Bb} \longrightarrow ?$

Two Empirical Statements

Consider the following two statements:

> "The speed of light is 299,792,458 m/s."
>
> "Human males are taller than human females."

What is the nature of truth in these two statements?

In what ways, if any, do they each fail to be true?

Populations in the Abstract

- In commmon usage, a "population" is the group of people who live in a particular area.
- In statistical terms, a population refers to a group of entities about which we want to draw some inference from observations. We typically imagine that the population is very large.
- We imagine that each entity has associated with it a set of numbers that correspond to possible measurements we might take.
- The tickets in box abstraction

Populations in the Abstract (cont'd)

- We imagine also that when we make measurements on a random sample of entities from that population, it is like picking tickets at random out of the box and reading off the corresponding numbers.
- Variation
  - What does a population with no variation look like?
  - How can you tell if one population has more variation than another?
- Questions for consideration (and experimentation):
  - How much does a large (small) sample from a population resemble that population in terms of any given measurement?
  - How much can I tell about a population by making measurements on a large (small) sample?

Populations in the Biology

- In biology, a population is a group of individuals of the same species within a common geographic range.
- Over time, populations can grow. They can shrink. They can change.
- In fact, the process of evolution is exactly that — change in a population across generations.

  But change in what?
- Answer: Genetic makeup. The frequency with which different genetic combinations occur.
- An important starting point is to look at the frequency of each allele and the frequency of each genotype at a given genetic locus.

Allele and Genotype Frequency

- Consider a hypothetical population and a single genetic locus for a trait with two alleles (A and a).

  Assume there are eight individuals in the population. Here are their genotypes: Aa AA aa aa AA Aa AA Aa.

- The *genotype frequency* for this population is the proportion of each genotype:

$$D = \text{frequency of AA} = 3/8 = 0.375$$
$$H = \text{frequency of Aa} = 3/8 = 0.375$$
$$R = \text{frequency of aa} = 2/8 = 0.250$$

- The *allele frequency* for this population is the proportion of each allele of the given gene:

  $p = \text{frequency of A} = 9/16 = 0.5625 \qquad q = \text{frequency of a} = 7/16 = 0.4375.$

  Notice that $p = D + H/2$ and $q = R + H/2$.

Evolution of Allele Frequencies

- One way to understand evolution in a population is by modeling gene frequencies across generations.
- Allele frequencies in a population are affected by many factors, including:
  - how individuals select mates,
  - immigration and emigration,
  - which individuals survive and reproduce, and
  - the rate at which mutations occur.

An Equilibrium Model

Let's consider a very simple model of population change

Assumptions

1. Mating is purely random.
2. No flow of genes into or out of the population.
3. No mutation.
4. No differential survival across genotypes.
5. The population is large.

This model is called *Hardy-Weinberg Equilibrium*.

What Should Happen?

Consider one genetic locus with a two-allele gene (A and a) under H-W equilibrium.

Mating Cross	**Mating Probability**	**Offspring**		
$AA \times AA$	D^2	D^2		
$AA \times Aa$	$2DH$	DH	DH	
$AA \times aa$	$2DR$		$2DR$	
$Aa \times AA$	H^2	$H^2/4$	$H^2/2$	$H^2/4$
$Aa \times aa$	$2HR$		HR	HR
$aa \times aa$	R^2			R^2

Genotype frequencies in next generation

$$D' = \text{freq. of AA} = D^2 + DH + H^2/4 = (D + H/2)^2 = p^2$$

$$H' = \text{freq. of Aa} = DH + 2DR + H^2/2 + HR = 2[(D + H/2)(R + H/2)] = 2pq$$

$$R' = \text{freq. of aa} = HR + R^2 = (H/2 + R)^2 = q^2$$

And note $p^2 + 2pq + q^2 = (p+q)^2 = 1$.

Now, $p' = D' + H'/2 = p^2 + pq = p(p+q) = p$ and $q' = R' + H'/2 = q^2 + pq = q(p+q) = q$. The gene frequencies haven't changed.

Activity

Setup

1. From the gene pool, select 10 cards, and then go back to your seat.
2. Count how many 'A' alleles you have and how many 'a' alleles you have and record these.
3. Combine the totals with your class mates (two by two, then four by four, etc.) to get a total count for the class.
4. Calculate the frequencies of A and a in the class and record these numbers.
5. Now *randomly* pair your alleles so that you have 5 gene pairs just like the genotypes of diploid organisms.
6. Count how many 'A' alleles you have and how many 'a' alleles you have and record these.
7. Combine the totals with your class mates (two by two, then four by four, etc.) to get a total count for the class.
8. Calculate the frequencies of each of these combinations in the class and record.

Activity

Mating: The First Generation

9. Spread your 10 cards out in one hand as if you were playing cards. Make sure that you are the only one who can see the alleles. Go around the room and find another person to trade with. Let that person take one of your alleles. You take one of their alleles. (Don't peek!) Now take your new allele and put it away so that you don't trade it again.
10. Trade 4 more alleles with 4 more people (only 1 trade with each person).
11. When you have only 5 alleles left in your hand and 5 new ones that are trades, sit down!
12. Again, pair up your 10 alleles randomly so that you have 5 pairs.
13. Count how many of each allele and each genotype you have in your hand;
14. Combine with classmates as bfore, calculate the frequencies of each of these combinations and record.

Mating: Rinse and Repeat. (It never gets old!)

Blue Pages

What do you think was the murkiest point from either of this weeks classes?