Genetic Distance Values – F_{ST}

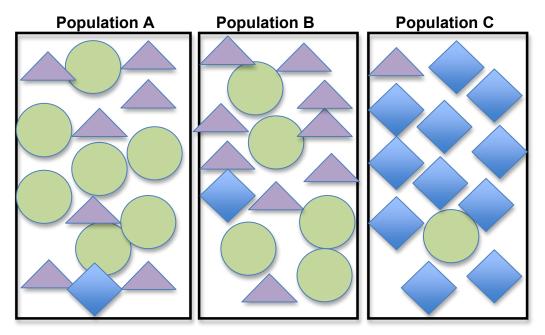| Population A	Population B	Population C

Shapes represent different versions of the same gene (alleles)

How do you measure the breeding levels between these three populations, A, B, C?

Scientists measure the level of breeding between populations by using a mathematical equation to compare the frequency of genes in each population to each other in pairwise comparisons. In the example above, they would compare the frequency of genes in:

1. Population A to Population B
2. Population A to Population C
3. Population B to Population C.

The value that they calculate is called the genetic distance between populations. The greater the genetic distance between populations, the less breeding there is between them and the more isolated they are from one another. The lower the genetic distance between populations, the more breeding there is between them and the less isolated they are from one another. This genetic distance value is a number that is also known as the fixation index or F_{ST} value. It is a measure of the difference in the allele frequency between two populations.

F_{ST} Values

The fixation index can range from 0 to 1, where 0 means complete sharing of genetic material and 1 means no sharing. For values equal to 1(meaning no sharing), scientists say that the populations are fixed. If populations are referred to as fixed, it means that they do not share any alleles with one another, i.e. the do not breed with one another; they are completely isolated from one another. Practically speaking F_{ST} values are never as high as 1 because these values are only utilized to measure breeding between populations of the same species. Different populations of the same species by definition would show some evidence of interbreeding, even if that breeding may no longer occur today.

As a point of reference for the bighorn sheep, F_{ST} values for mammals generally range from 0 to 0.25, with most values being close to 0.1. Values on the high end of this range (close to 0.2) indicate some isolation between populations, and most likely mean that the populations are not currently breeding with one another. Values on the low end of this range (i.e. close to 0) indicate that the populations are sharing their genetic material through high levels of breeding.

Name_____ **Class_____**

Genetic Distance for Populations A, B and C

1. Quickly scan the above diagram. Which population do you think is the most isolated?

   Population C

2. Do you think the FST value for this population would be high or low?

   The FST value should be high

You can see that populations A and B, share many more of the same genes than they do with population C, meaning that the genetic distance or F_{ST} value for populations A and B is low and the F_{ST} value for population C to population A or B is high. The low F_{ST} value for the relationship between population A and B means that they show high levels of breeding and the high F_{ST} value for population C and population A or B means that they show low levels of breeding with one another.

The Bighorn Sheep

Dr. Clinton Epps and his colleagues collected DNA from a number of mountaintop populations of bighorn sheep to determine whether highways act as barrier that prevent bighorn sheep populations from different mountaintops from mating.

3. What would the F_{ST} values need to show to conclude that highways act as a barrier to breeding between sheep populations?
   a. What would the F_{ST} values be for populations that are geographically close without a highway between them?
   b. What would the F_{ST} values be for populations that are geographically close with a highway between them?

Populations that are not separated by a highway and are geographically close would have low F_{ST} values. Populations that are geographically close, but are separated by a highway would have higher F_{ST} values.

4. Write a hypothesis for your prediction above.

F_{ST} values for geographically close populations that are separated by a highway will be higher than F_{ST} values for geographically close populations that are not separated by a highway, if highways act as barriers to breeding between mountaintop populations.

The F_{ST} values that Dr. Epps calculated ranged from 0.001 to almost 0.30.

4. What do the low values indicate (0.001) about breeding and connectivity between populations?

High levels of breeding and high connectivity. Individuals need to be able to migrate between populations for mating to occur.

6. What do the high values indicate (0.25) about breeding and connectivity between populations?

Low levels of breeding and low connectivity. Individuals that cannot migrate between populations will not mate.

Understanding the Maps

Because low F_{ST} values indicate high connectivity between populations (easy connection makes high breeding possible) and high F_{ST} values indicate low connectivity between populations (poor connections makes breeding difficult), we depicted high levels of breeding with many arrows (↕↕↕↕↕↕) to signify the connections between breeding populations. We depicted low levels of breeding with few arrows (↕) to signify the few connections between non-breeding populations.

Below is the scale we used to determine the number of arrows between populations that are illustrated on your maps. Observe the relationship between F_{ST} values and the number of arrows:
0.30 – 0.25 = ↕
0.24 – 0.20 = ↕↕
0.19 – 0.15 = ↕↕↕
0.14 – 0.10 = ↕↕↕↕
0.09 – 0.05 = ↕↕↕↕↕
0.04 – 0.001 = ↕↕↕↕↕↕

Applying the scale to the bighorn sheep mountaintop populations. Fill in the appropriate number of arrows (↕**).**

Breeding Evidence of Cady Sheep		
	Cady Sheep (F_{ST})	**Cady Sheep (↕)**
Old Dad Sheep	0.11	↕↕↕↕
Granite Sheep	0.11	↕↕↕↕
Newberry Sheep	0.26	↕

Breeding Evidence of Eagle-Buzzard Spring Sheep		
	Eagle Buzzard Spring Sheep (F_{ST})	Eagle Buzzard Spring Sheep (↕)
Little San Bernardino Sheep	0.11	↕↕↕↕↕
Orocopeia Sheep	0.11	↕↕↕
Eagle Lost Plains Sheep	0.26	↕↕↕↕↕↕

Breeding Evidence of Hackberry Sheep		
	Hackberry Sheep (F_{ST})	Hackberry Sheep (↕)
Wood Sheep	0.02	↕↕↕↕↕↕
Piute Range Sheep	0.08	↕↕↕↕↕
Providence Sheep	0.06	↕↕↕↕↕

Breeding Evidence of Indian Spring Sheep		
	Indian Spring Sheep (F_{ST})	Indian Spring Sheep (↕)
Clark Sheep	0.20	↕↕
Old Dad Sheep	0.10	↕↕↕↕
Providence Sheep	0.11	↕↕↕↕

Breeding Evidence of Marble Sheep		
	Marble Sheep (F_{ST})	Marble Sheep (↕)
Granite Sheep	0.10	↕↕↕↕
South Bristol Sheep	0.04	↕↕↕↕↕↕
Clipper Sheep	0.05	↕↕↕↕↕

Breeding Evidence of San Gorgonio Sheep		
	San Gorgonio Sheep (F_{ST})	San Gorgonio Sheep (↕)
Cushenbury Sheep	0.07	↕↕↕↕↕
San Gabriel Sheep	0.27	↕
Little San Bernardino Sheep	0.15	↕↕↕

After completing these charts, move on to the map activity.