#### BACKGROUND:

Ever since Charles Darwin formulated his hypothesis on how the finches of the Galapagos Islands evolved into 13 different species, islands have been a prime target for the study of evolution. By their very nature, islands are isolated and are essentially a living laboratory of evolution.

The task of your group is to analyze REAL DATA from REAL POPULATIONS from various islands in the Canary Archipelago including:

- 1). lizard morphology (body form)
- 2) geological age estimates
- 3) geographic distances
- 4) genetic differences (DNA sequences)

#### BACKGROUND:

The Canary Islands form an archipelago of 7 volcanic islands just west of the African continent. Geologists theorize that a geologic "hot spot" of upwelling magma has been drifting westward for the past 20 million years, gradually forming the islands as it moves. Thus the MOST EASTERN island, LANZAROTE, is the oldest, while the smaller western island, HIERRO, is the youngest (about 0.8 million years old). Volcanic islands are particularly good laboratories for evolutionary science because they can be dated accurately using radioactive isotope decay and because they start out as lifeless masses of rock emerging from the sea.

The development of ecosystems on volcanic islands is somewhat unpredictable. What plant and animal species will colonize this new environment? Much depends on climate, closeness to other land masses, and chance. This investigation deals with 3 species of lizards (Genus: *Gallotia*) and within one of these species (*Gallotia galloti*), four separate island populations.

The arrival of the Gallotia lizards was probably by RAFTING. Rafts of natural vegetation are often washed out to sea when high river levels cause river banks to collapse, carrying away both plants and clinging animals. Oceanic currents in this region vary with the seasons. Colonization by airborne organisms, such as insects and birds, usually occurs during storms.

In any case, there are some general principles of island colonization:

- 1) the closer the island to another land mass, the higher the probability of colonization
- 2) the older the island, the more likely it will be colonized
- 3) the larger the island, the more species are likely to be established
- 4) Geographic isolation reduces gene flow between populations
  - (Populations that are separated by some geographic feature (Ex: water) can't exchange DNA as easily)
- 5) Over time, colonial populations become genetically divergent from their parent populations due to natural selection, mutation, and/or genetic drift

(random change in allele frequencies that occurs in small populations)

## PART I: PHYLOGENY BASED ON GEOGRAPHIC DISTANCE



Map 1. The Canary Islands Archipelago. (redrawn from Anguita et al., 1986)

<u>Use the map above to measure the distances in kilometers of each island to the</u> <u>mainland (Africa)</u>. (50 Km = 1 cm; so multiply your measurement by 50 to get number of Km)

	<u>CM</u>	<u>KM</u>		
Distance from LANZAROTE to mainland =	=			
Distance from FUERTEVENTURA to mainland =	= =			
Distance from GRAN CANARIA to mainland =	= .			
Distance from TENERIFE to mainland =	=			
Distance from GOMERA to mainland =	=			
Distance from HIERRO to mainland =	=			
Distance from PALMA to mainland =	=			
Which island was most likely to have been colonized first?				
Which island was most likely to have been colonized last?				
Explain why you think so.				



Map 2. Distribution of Gallotia atlantica, G. stehlini, and G. galloti. G. galloti has

Look at the map above showing where each kind of lizard can be found.

USE YOUR CLADOGRAM SHEET to make a CLADOGRAM showing evolutionary relationships between the 6 kinds of lizards listed above.



### PART II: PHYLOGENY BASED ON GEOLOGIC HISTORY

Check your hypothetical cladogram against the geologic data in TABLE 1 below. The maximum age of each island was estimated by sampling volcanic rocks found on all islands using potassium-argon dating.

<b>Table 1.</b> Maximum age of the Canary Islands in millions of years. (Anguita et al.
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Lanzarote & Fuerteventura	Gran Canaria	Tenerife	Gomera	Palma	Hierro
24.0	17.1	15.1	5.3	2.0	0.8

1) Does the data in Table 1 (above) support your phylogeny diagram? YES NO

2) What changes should you make and why?

#### PART III: PHYLOGENY BASED ON MORPHOLOGY

#### Study the drawings from each lizard populations below. Compare and contrast their BODY SIZE with their distribution.

Figure 2. The relative sizes of typical lizards from each population are shown. (Redrawn from Thorpe et al., 1994.)



To be sure differences were genetic, and not environmental, researchers collected individuals from all island populations and bred and raised them in captivity. Their offspring still displayed differences according to their parental characteristics

# \*MAKE ANY CHANGES TO YOUR CLADOGRAM based on morphological similarities and differences.

## PART IV: PHYLOGENY BASED ON MOLECULAR GENETICS

The gene for Cytochrome b, which is coded by DNA found in every cell's mitochondria, was used in this study along with DNA from other genes. Cytochrome b is found in the ELECTRON TRANSPORT CHAIN in mitochondria. It is an important substance for cell metabolism and been around since the first prokaryotes. Changes in the nucleotide base sequence provide us with a kind of evolutionary clock. The rate of mutational change is relatively constant. This means that the more time, the more changes. When two populations are isolated and gene flow between them is restricted, mutational differences will accumulate over time. The longer there is isolation, the greater the differences.

Use the DNA sequences provided and pairings below to compare DNA and fill in the comparison chart. Share your information with the members in your group. There are 21 possible pairings, each team member selects five pairings other than 1/2.

Student #1	Student #2	Student #3	Student #4
1/3	1/4	1/5	1/6
1/7	2/3	2/4	2/5
2/6	2/7	3/4	3/5
3/6	3/7	4/5	4/6
4/7	5/6	5/7	6/7

	1. G. stehlini	2. G. atlantica	3. G. galloti Palma	4. G. galloti N. Tenerife	5. G. galloti S.Tenerife	6. <i>G. galloti</i> Gomera	7. G. galloti Hieπo
1. G. stehlini				C.			
2. G. atlantica	36		-West				
3. G. galloti Palma							
4. G. galloti N.Tenerife			r				
5. G. galloti S.Tenerife							
6. G. galloti Gomera							
7. G. gallori Hierro							

Table 2. Cytochrome b DNA sequence differences for the seven populations of Gallotia.

# \* ADD COLORED LINES TO YOUR MAP TO SHOW THE NUMBER OF DIFFERENCES FROM DATA TABLE ABOVE

## THINK ABOUT WHAT THIS MEANS TO YOUR STORY.