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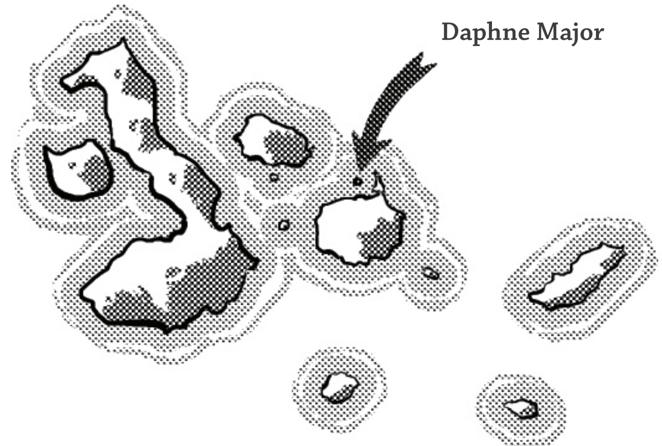
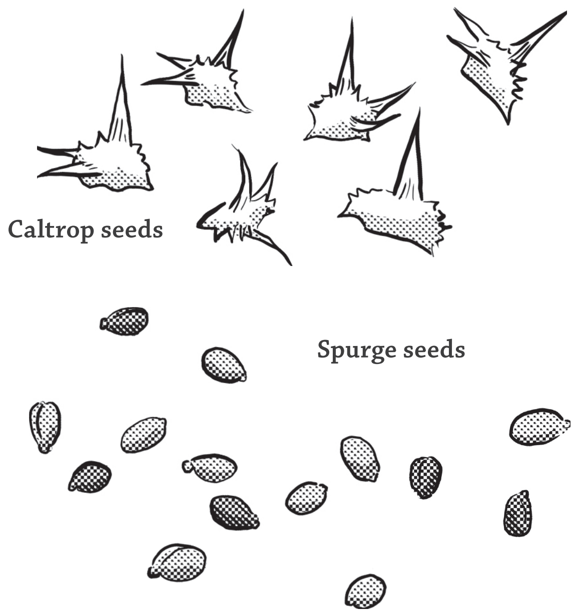
Is it Natural Selection?

Darwin's Finches

Background

The Galapagos Islands are a group of small volcanic islands located near the Equator in the Pacific Ocean. The islands are home to several finch species, together know as Darwin's Finches. The finches on the island Daphne Major caught the interest of two scientists, Peter and Rosemary Grant, who studied the population for twenty years.

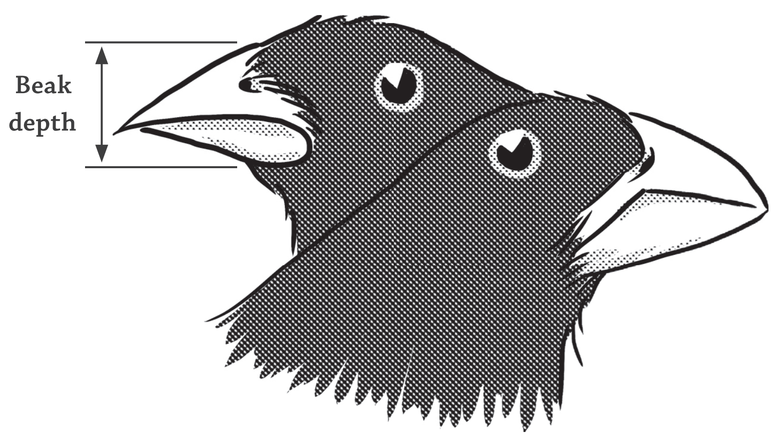




Daphne Major is a very small island with no trees and very few plant species. The scientists were able to follow all the finches on the island and record their individual feeding habits. In the dry season, the finches ate the hard woody seeds of caltrop plants and the smaller seeds of spurge plants. The scientists noticed that finches with smaller beaks struggled to crack open the hard caltrop seeds and often gave up. Beak depth was an important trait for getting food.

Experiment 1

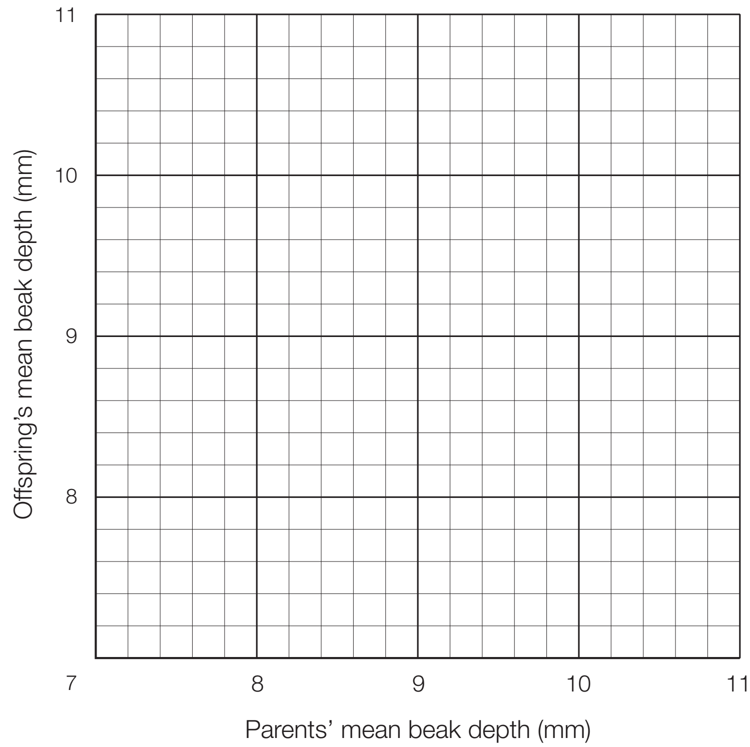
Scientists wondered if beak depth was a heritable trait. To find out, they measured beak depths of parents and their offspring. The data are in the table on the next page.



NAME ______________________________ DATE _______________

Beak depth in finch parents and their offspring

Mean beak depth (mm)	
Parents (**x**)	Offspring (**y**)
9.3	9.1
10.3	9.5
9.7	8.9
8.1	7.7
9.9	9.5
8.4	8.8
10.2	9.8
8.4	8.3
8.8	8.6
10.0	10.2



1. Use the data in the table to make a scatterplot.

2. Is there a relationship in beak depth between parents and offspring? If so, draw a trend line on your scatterplot that shows this relationship.

3. Do the data provide evidence that beak depth is heritable? Why or why not?

Experiment 2

In 1977, after the Grants had been studying the finches for several years, a major drought killed most of the spurge plants on the island. Many finches died because they could not crack open the caltrops seeds.

Before the drought, beak depths in the population ranged from 8 to 11 mm with a mean of 9.2 mm. In 1978, the first generation of finches born after the drought had a mean beak depth of 9.7 mm.

4. Is it likely that their beak depth gave some finches a reproductive advantage? Explain.

Question

Did natural selection act on beak depth in the finch population between 1977 and 1978?

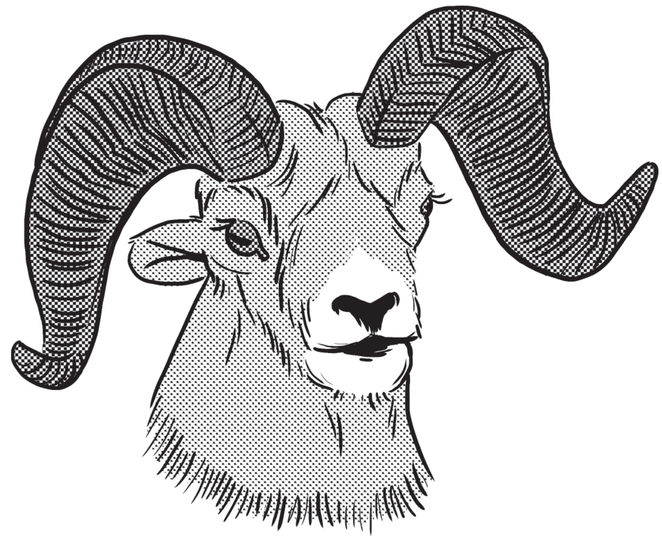
Is it Natural Selection?

Bighorn Sheep

Background

The world's largest bighorn sheep live in the Canadian Rocky Mountains. The horns of bighorn sheep grow throughout their lives, but most of the growth occurs before age 5. Male bighorn sheep (rams) reach reproductive age when they are about 2-3 years old, and they live for an average of about 11 years.

Bighorn sheep attract many big-game hunters, who like to harvest the rams with the biggest horns. Since the 1970s, scientists have studied the effect of hunting on the bighorn sheep population of Ram Mountain.



Experiment 1

When researchers measured the lengths of the horns of rams and their sons, they saw a correlation: Rams with longer horns had offspring with longer horns, while rams with smaller horns had offspring with smaller horns.

Experiment 2

When researchers looked at the mean horn lengths each year between 1972 and 2002, they noticed that the population's mean horn length steadily decreased over time. In those 30 years, mean horn length decreased by 20 cm.

Experiment 3

Researchers wondered if hunting was influencing the horn length of the rams in the population of bighorn sheep on Ram Mountain. The data table on the next page shows the horn lengths of 5-year-old rams. After measuring the rams' horns in 1989, researchers continued to track them for several more years. They recorded whether or not each ram was eventually harvested by hunters; this information is also in the table.

NAME ______________________ DATE ____________

1. Calculate the mean horn length for all of the rams:

$$\frac{\text{total horn length}}{\text{number of rams}} =$$

2. Calculate the mean horn length for the rams that were harvested:

$$\frac{\text{total horn length}}{\text{number of rams}} =$$

3. Is there evidence that their horn length gave some rams a reproductive advantage? Explain.

Horn lengths of 5-year-old rams in 1989 and if they were eventually harvested

Horn length (cm)	Harvested?
53	no
58	no
61	no
61	no
62	no
64	no
65	no
67	**yes**
73	no
77	**yes**
80	no
81	**yes**
82	**yes**
84	no

Question

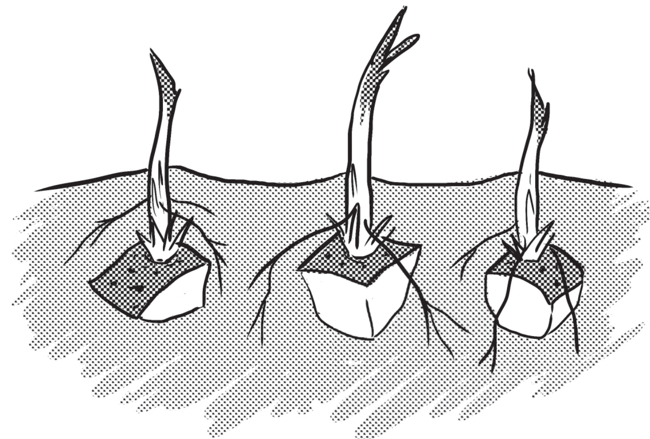
Did hunting influence the horn length in the Ram Mountain bighorn sheep population?

Is it Natural Selection?

Irish Lumper Potatoes

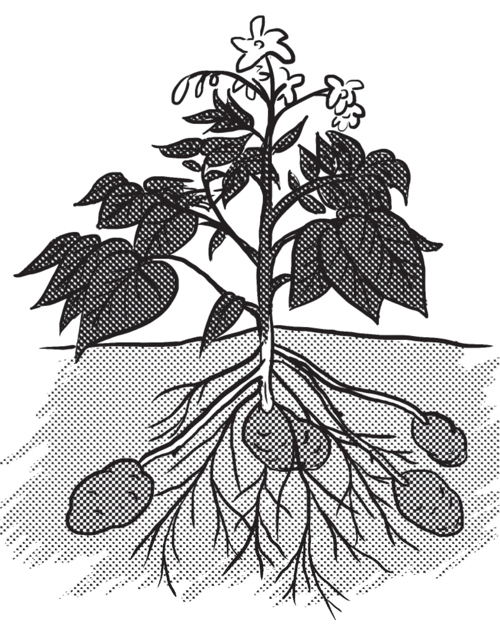
Background

The part of the potato plant that we eat is called the tuber. Each tuber has several eyes, or nodes. By cutting a potato tuber into small pieces, you can grow several new potato plants, one from each eye. This method makes potatoes a cheap and easy crop to grow—but it results in potatoes that are all identical genetic clones.



Potatoes have a gene called R1, which has two possible alleles. One allele gives the potato resistance to infection by a mold called *P. infestans*. When the mold infects a potato plant that does not have a copy of this allele, it leaves the tubers mushy, rotten, and inedible. Potatoes need to inherit only one copy of the mold-resistance allele of R1 to avoid infection.

In the 1800s, a variety of potato called the Irish Lumper had become a primary food source in Ireland, especially among the poor. The Irish Lumper was farmed year after year as identical genetic clones that did not have a mold-resistance allele of the R1 gene.



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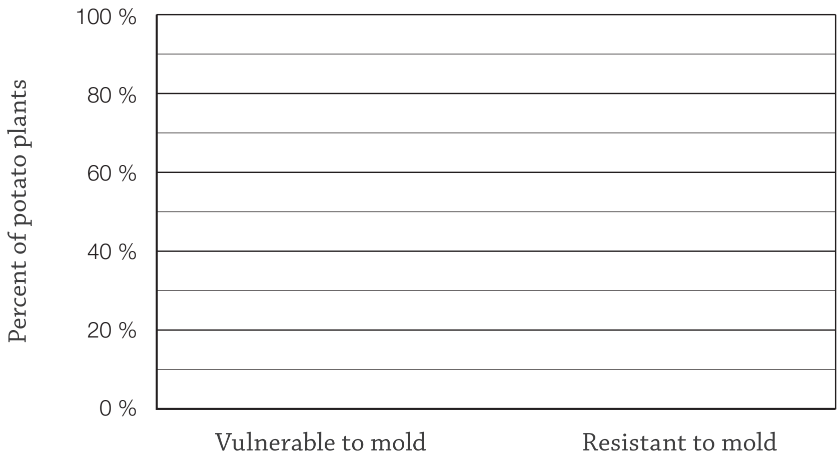


1. Use the information in the Background section to fill in the bar graph above, showing the percentage of Irish Lumpers that were vulnerable and resistant to the mold.

2. Do the data provide evidence that mold resistance in the Irish Lumper was variable? Explain.

The Great Irish Potato Famine

In 1845, the *P. infestans* mold was accidentally brought from North America to Ireland. Over several years, the mold destroyed entire crops of Irish Lumper potatoes all across Ireland. Loss of such an important food source led to the Great Irish Potato Famine, during which 1 million people died of starvation.

Now Irish Lumper potatoes are very rare, and hardly anyone tries to grow them. Instead, the popular potato varieties of today have been bred to have a mold-resistance allele of R1.

3. Is there evidence that their mold resistance status gave some Irish Lumper potatoes a reproductive advantage? Explain.

Question

Did natural selection act on mold resistance in Irish Lumper potatoes during the Great Irish Potato Famine?

Is it Natural Selection?

Freshwater Snails

Background

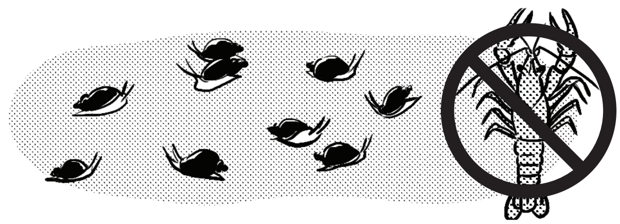
The small freshwater snail, *Physella virgata*, lives in streams. Crayfish live in some of these streams, and they eat the snails. Most of the time, crayfish eat the smaller snails.

Experiment 1

Scientists measured the shells of snails living in streams with and without crayfish. They found that the snails were larger in the streams with crayfish.

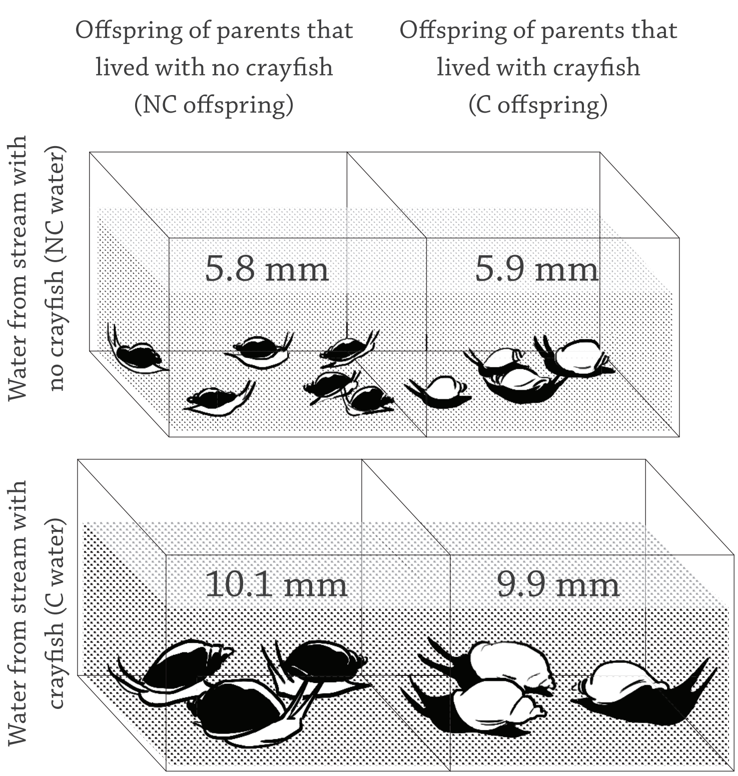
They wondered whether natural selection was causing the differences in shell length.

Snails living in streams without crayfish are smaller than snails living in streams with crayfish.



No Crayfish (NC): Mean shell length = 5.6 mm

Crayfish (C): Mean shell length = 9.8 mm



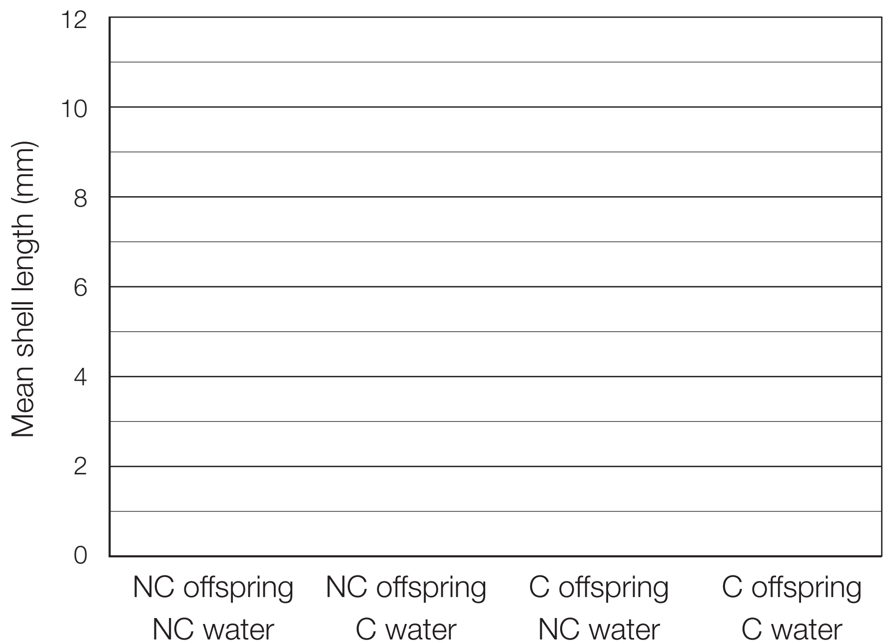
Experiment 2

To test whether shell length is heritable, scientists collected snails from two streams: one with crayfish and one without crayfish. Keeping the snail populations separate, they brought them to the lab, let them mate, and then raised their offspring in 2 different types of water:

- Half of the offspring from each group were grown in water from a stream that had no crayfish.
- The other half were grown in water from a stream that had crayfish.

After the offspring grew to adulthood, the researchers measured their shell lengths and calculated the mean for each group.

NAME ______________________ DATE ____________



1. Use the data from Experiment 2 to fill in the bar graph above.

2. Do the data provide evidence that shell length is heritable? Explain.

3. For streams without crayfish, is there evidence that snails' shell length gives some individuals a reproductive advantage? How about in streams with crayfish? Explain.

Question

Did natural selection act on shell length in snail populations with or without crayfish?

Is it Natural Selection?

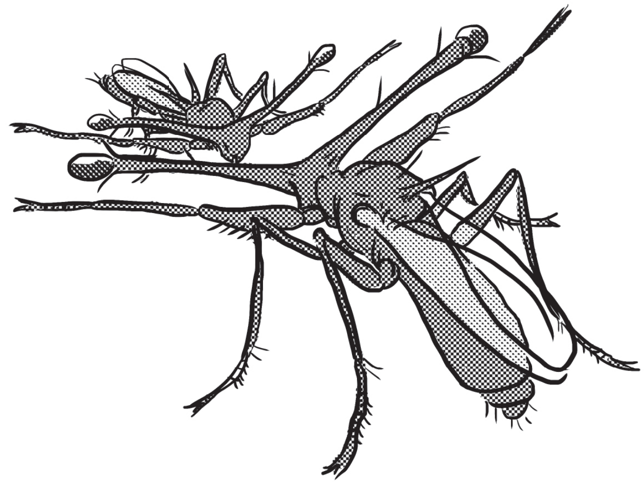
Stalk-eyed Flies

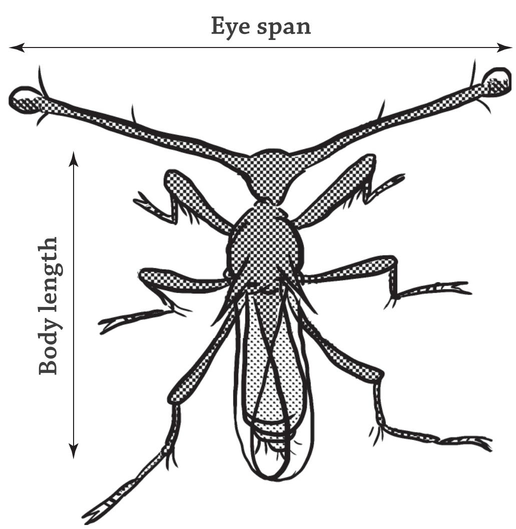
Background

Stalk-eyed flies have eyes on long stalks that stick out from the sides of their heads. Females prefer to mate with males with wide eye spans.

Males fight for a chance to mate with females. Experiments have shown that most of the time, the male with the greatest eye span wins.

In fossils of stalk-eyed flies preserved in amber, the eye spans are much smaller than those of living flies. Scientists wondered if eye span in stalk-eyed flies was influenced by natural selection.





Experiment

To find out whether eye span is a heritable characteristic, scientists measured the relative eye spans of male stalk-eyed flies and their sons.

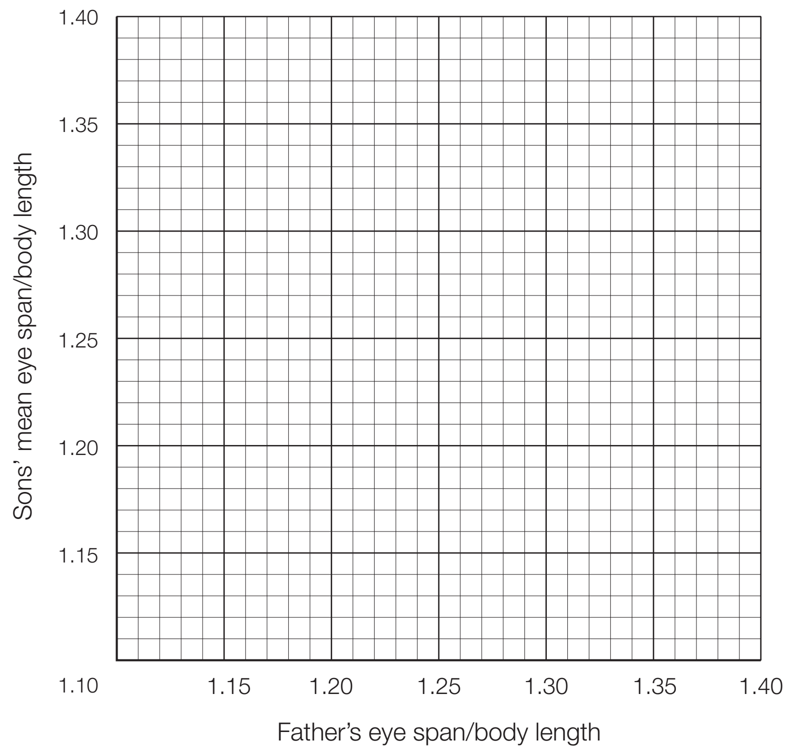
Since flies may be slightly different sizes, scientists measured eye span relative to body length (eye span/body length). Male eye span is often greater than the length of the body (eye span/ body length > 1).

The data from this experiment are in the table on the next page.

NAME ______________________________ DATE ________________

Relative eye span of stalk-eyed fly fathers and sons

Fathers (**x**) eye span / body length	Sons (**y**) mean eye span / body length
1.16	1.16
1.16	1.18
1.19	1.22
1.22	1.22
1.24	1.25
1.25	1.26
1.29	1.29
1.33	1.30
1.33	1.33



1. Use the information in the table to fill in the scatterplot above.
2. Is there a relationship in relative eye span between fathers and sons? If so, draw a trend line on your scatterplot that shows the relationship.
3. Do the data provide evidence that relative eye span in stalk-eyed flies is heritable? Explain.

4. Is there evidence that their eye span gives some stalk-eyed flies a reproductive advantage? Explain.

Question

Did natural selection act on eye span in stalk-eyed flies?

Is it Natural Selection?

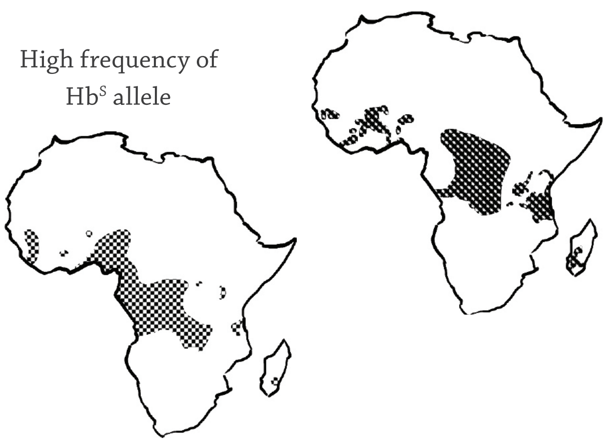
Malaria Resistance

Background

Hemoglobin, the oxygen-carrying protein in red blood cells, is coded for by the *Hb* gene. In the early 1900s an allele of *Hb* was discovered, called Hb^S, which codes for a hemoglobin protein with an altered shape.

People with one copy of the Hb^S allele are healthy. But people with two copies suffer from sickle cell disease. Their hemoglobin proteins stick together, forming long fibers that force the blood cells into a stiff, sharp "sickle" shape. The pointy cells get stuck in capillaries and block blood flow, causing pain and damage to organs and muscles.

Red blood cells



Researchers noticed that the Hb^S allele—and sickle cell disease—is rare to absent in populations from most places in the world. But it is much more common in populations of people living in sub-Saharan Africa.

The same areas also have high rates of malaria—an illness caused by a parasite that infects red blood cells. Symptoms of infection include fever, headache, and body aches. Each year, malaria kills 1.1 million sub-Saharan people, mostly children.

NAME ______________________ DATE ____________

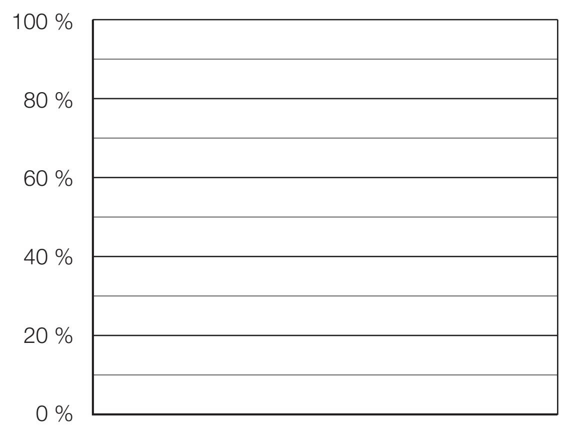
Experiment

Researchers wondered if the reason the Hb^S allele is more common in sub-Saharan populations is because it also protects against malaria infection.

To look for a link between the Hb^S allele and malaria resistance, a researcher tested a group of children from Uganda to find out if they carried an Hb^S allele and if they were infected with the malaria parasite. The data are summarized in the table below.

Alleles	Children with malaria	Children without malaria	Total number of children	% of children with malaria
Hb/Hb (non-carrier)	113	134		
Hb/Hb^S (carrier)	12	31		
TOTAL	**125**	**165**		---

1. Fill in the last two columns of the table above.
2. Fill in the bar graph to the right to show the percentages of Hb/Hb children and Hb^S carriers who were infected with malaria.



Over the past 60 years, scientists have continued studying malaria and the Hb^S allele. Although the Hb^S allele causes sickle cell disease, scientists have collected many pieces of evidence that together suggest that carriers with only a single copy of Hb^S are less likely to get malaria. Those who do get malaria suffer a less severe version of the disease, and they are more likely to survive infection.

3. Malaria is a deadly disease that often kills young children before they can grow up to have children of their own. Do the data provide evidence that malaria resistance gives some people a reproductive advantage? Explain.

Question

Did natural selection act on malaria resistance in the population of people living in Uganda?

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Is it Natural Selection?

Color Blindness

Background

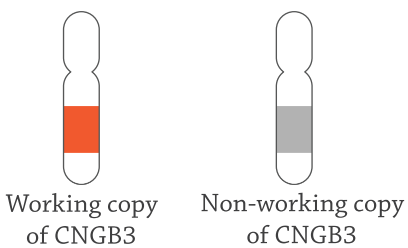
Pingelap, a tiny island in the Pacific Ocean, is home to the Pingelapese people. Because of the island's remote location, the Pingelapese population has been fairly isolated.

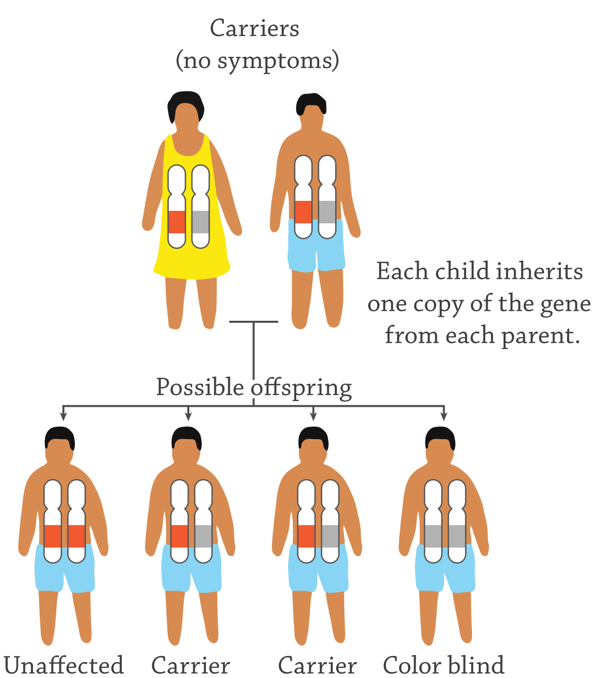
In 1775, a typhoon struck the island, reducing the population of 200 to just 20 people.

Today, the population has grown to 3,000 people living on Pingelap and neighboring islands. In this population, 5% of the people are severely color blind: they have poor vision, and they cannot see color at all. Before the typhoon, no one was color blind.


Normal vision


Color blind





Experiment 1

After studying the population of Pingelap, researchers discovered that the color blindness is caused by a variation in the *CNGB3* gene.

When it's working properly, the *CNGB3* gene codes for a protein in the eye that is necessary for color vision. But people with two copies of a non-working allele of *CNGB3* are color blind. People with one copy of the non-working *CNGB3* allele have normal vision—but they are called "carriers" because they may pass the allele to their children.

Today, 30% of the population are carriers. All of the color blind people and the carriers can trace their ancestry back to the ruler at the time of the 1775 typhoon, who was one of the 20 survivors. He must have been a carrier.

NAME ______________________ DATE ____________

1. Fill in the data table:

Time	Color blind	Carrier	Unaffected	Total
Immediately after the 1775 typhoon	%	%	%	100%
Today	%	%	%	100%

2. Use the data above to fill in the bar graphs, showing the frequency of color blindness immediately after the typhoon and today:

3. Do the data provide evidence that the proportion of individuals in the population with a non-working copy of the CNGB3 gene has changed over time? Explain.

4. Is there evidence that color blindness gives some people a reproductive advantage? Explain.

Question

Did natural selection act on color blindness in the Pingelapese population?

NAME ______________________ DATE ____________

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