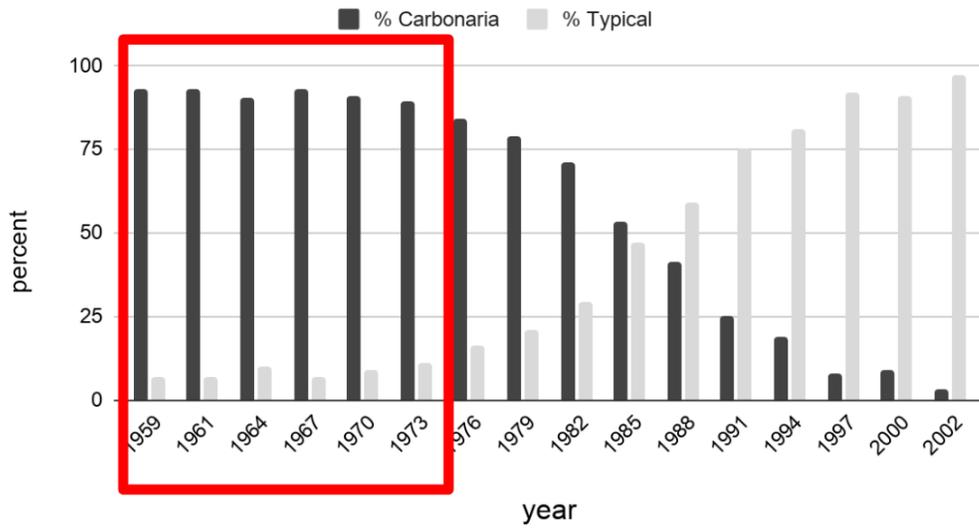


Peppered Moth Analysis

Analysis of Data Subset 1: Studies of the Population of Peppered Moths at the Beginning

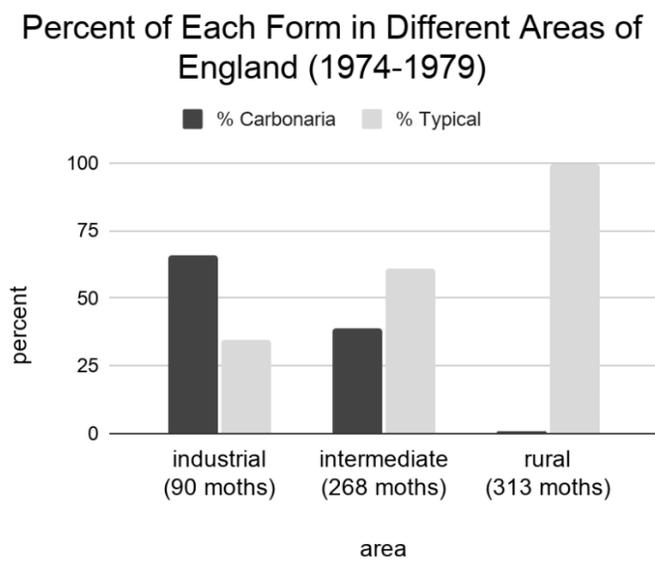
Percent of Each Form by Year



Numbers in different areas: Scientists had also noticed over many years that the carbonaria form seemed to be much more common in certain areas of England compared to others. They noticed that the areas where there seemed to be more carbonaria forms were usually areas where there was a lot of industry. They wanted to know if the industry or the level of pollution had anything to do with the forms that lived there. So they collected information on the proportion of carbonaria and typical forms in three different areas:

- a highly industrialized area
- an intermediate area where a lot of people lived and burned coal to heat their houses
- a rural area where few people lived

This is what they saw:



Consider the questions listed below in your analysis of the data and what they mean. Then write your summary in the box below.

<p>A. Identify: What do I see in the data?</p> <ul style="list-style-type: none">• What is the trait of interest in this study?• What are the variations for this trait in the population?• What is the proportion of those variations in the population in 1973?• What is the difference in proportions in different areas? <p>Your summary:</p>	<p>B. Interpret: What does this mean?</p> <ul style="list-style-type: none">• What do you think might be the effect of having a lighter, speckled color (typical) for moths in each area?• What do you think might be the effect of having a darker color (carbonaria) for moths in each area? <p>Your summary:</p>
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Data Subset 2: Environmental Studies

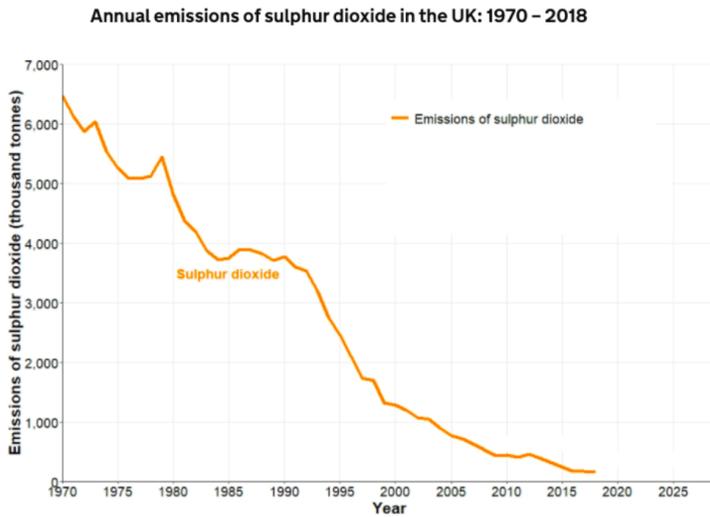
During the late 1950s and 1960s, people in England began to be concerned about the amount of pollution there was in the air in their cities. The industrial revolution had begun almost 100 years earlier. Since then, more and more industrial plants had been built throughout northern England. Large industrial plants had been creating a lot of air pollution in the form of smoke and sulfur dioxide that the manufacturing plants released into the air. In addition, many people were burning coal to heat their homes. Coal burning also releases smoke and sulfur dioxide into the air.



Air pollution in industrial England in 1954

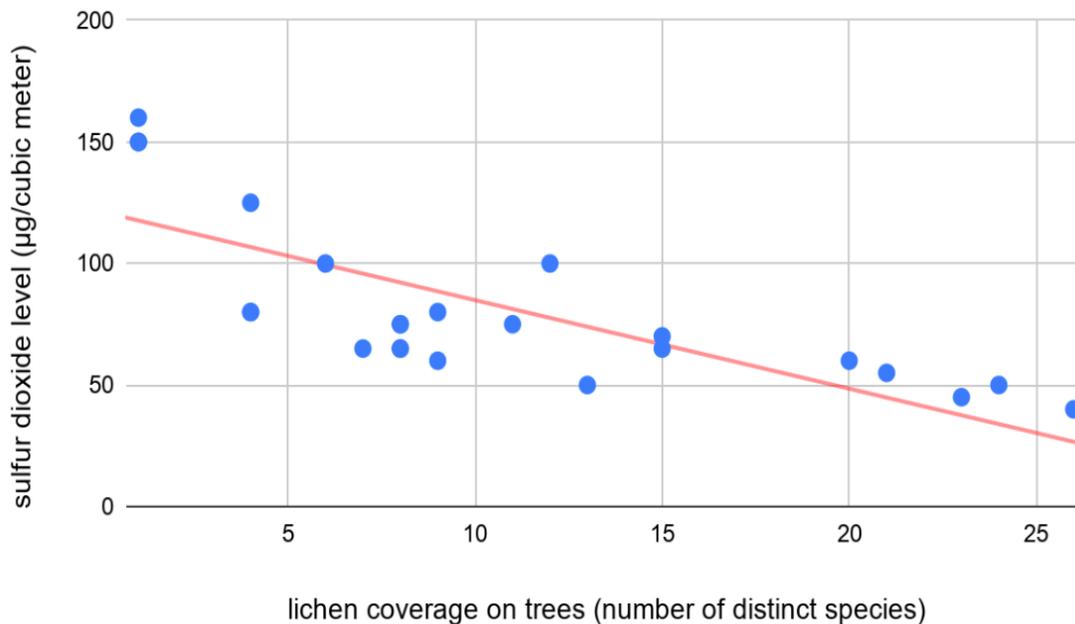
Scientists had seen that the different forms of peppered moth could camouflage on tree trunks based on their appearance. The typical forms were lighter in color and speckled, similar to the lichen coverage on trees. The carbonaria forms were darker in color, similar to tree bark without lichen coverage. They wanted to know whether the air pollution was affecting the way that lichen grew on trees and what effect that might have on the moths.

Pollution over time: During the time of the study, the government in the United Kingdom (UK) enacted clean air laws to limit the amount of air pollution. In order to see if the laws were working to reduce the amount of air pollution, the scientists collected information about how much sulfur dioxide air pollution was in the air in England. This is what they saw:



Pollution and lichen coverage: The scientists determined the amount and type of lichen that was growing on trees in many different locations throughout England. They checked whether the lichen coverage was affected by the amount of sulfur dioxide air pollution in the air in those locations. This is what they saw:

The Effect of Pollution levels on Lichen Coverage of Trees



Each point represents a different location in England. For each location, the point shows the amount of sulfur dioxide in the air and the amount of lichen coverage on the trees in that location. The line represents the line of best fit for the data.

Lichen coverage and moth forms: While scientists were measuring the amount and type of lichen that was growing on trees throughout England, they also collected, identified, and counted the forms of the peppered moths that they found on the trees. They observed that, in general, when trees had less lichen coverage, there were more carbonaria forms found on them. When there was more lichen, more of the moths on the tree were typical forms.

Consider the questions listed below in your analysis of the data and what they mean. Then write your summary in the box below.

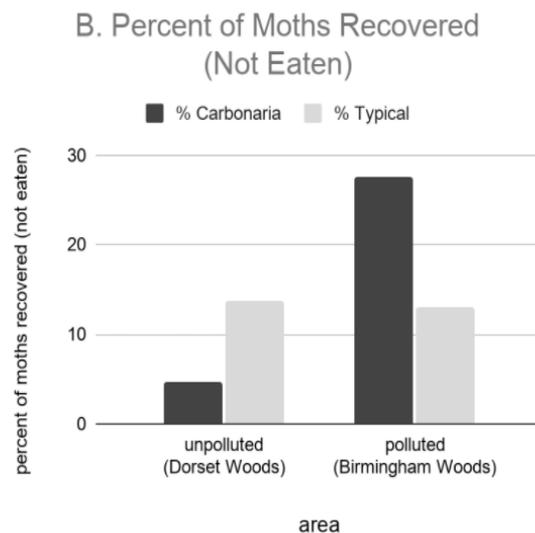
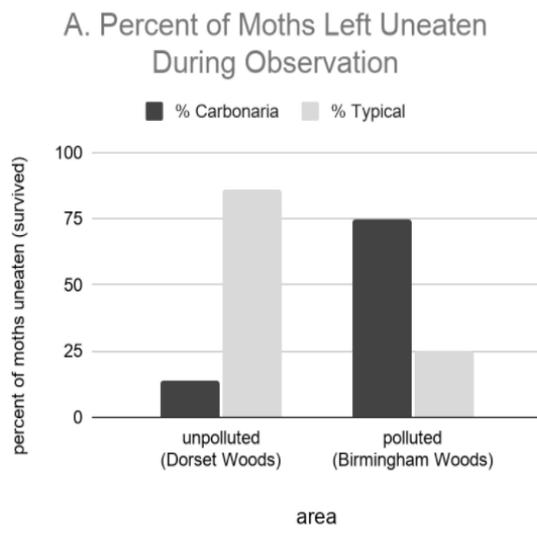
<p>A. Identify: What do I see in the data?</p> <ul style="list-style-type: none">• What patterns do you notice in air pollution over 1973-1997?• What pattern do you notice in lichen coverage on trees that relates to pollution levels? <p>Your summary:</p>	<p>B. Interpret: What does this mean?</p> <ul style="list-style-type: none">• How do you think any changes might have affected the peppered moths' survival?• How do you think any changes might have affected the peppered moths' ability to find mates and reproduce? <p>Your summary:</p>
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Data Subset 3: Survival and Reproduction Studies

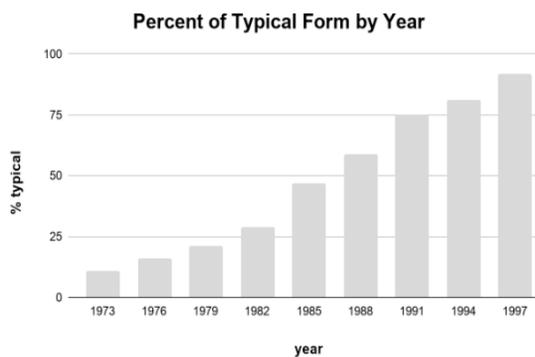
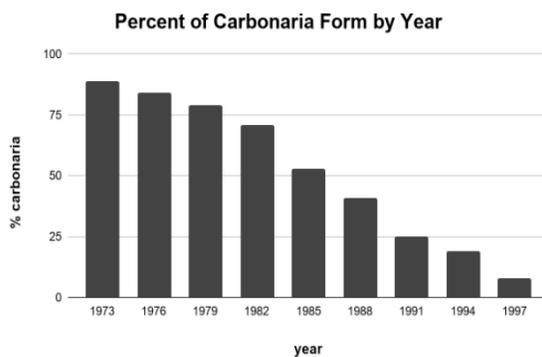
The peppered moths live in wooded areas all over England. They hide on tree branches and trunks during the day and fly around at night looking for food and mates. After mating, the females lay eggs that hatch in midsummer. The caterpillars grow by eating tree leaves throughout the summer. In the fall, the caterpillars become pupae and drop to the ground where they survive in the soil during the winter. The adult moths die during the winter. In the spring, mature moths emerge from the pupae hidden in the soil and begin the life cycle again.

While they are adults, the peppered moths become food for many different kinds of small birds. Since they had noticed more carbonaria moths in polluted areas, scientists were interested in finding out which forms of the moth were able to avoid being eaten by birds in polluted areas and unpolluted areas of England. They set up two different experiments to determine which forms were left uneaten by birds in the woods.

Survival: Scientists caught many hundreds of peppered moths of both forms. In experiment A, shown below, they released equal numbers of both forms of live moths onto trees in a polluted area in Birmingham. They did the same thing in an unpolluted area in Dorset. They filmed which moths were eaten by birds during the day and which moths were left uneaten. In experiment B, shown below, they marked the moths, then released equal numbers of each form early in the morning. In the evening they set out traps to capture the moths and then counted the number of marked moths that they recaptured. They assumed that most of the moths that were not recaptured had probably been eaten by birds. These are the results of both experiments:



Characteristics of offspring: During the time of the study, scientists were able to track the proportions of both forms of peppered moth that came from eggs laid each year in a population in a highly industrialized area of England. They did this by collecting and counting adult moths each year, since the adults of that year came from eggs laid the previous year. This is what they saw:



Consider the questions listed below in your analysis of the data and what they mean. Then write your summary in the box below.

<p>A. Identify: What do I see in the data?</p> <ul style="list-style-type: none">• What is the trend in the data for survival of each form of moth in different areas?• What is the trend in the data for the offspring?• What is the trend in the data for the forms of the moth over time? <p>Your summary:</p>	<p>B. Interpret: What does this mean?</p> <ul style="list-style-type: none">• What do you think might be the effect of coloration on survival in polluted areas?• What do you think might be the effect of coloration on survival in unpolluted areas?• What do you think might explain the change in reproduction of each form over time? <p>Your summary:</p>
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Data Subset 4: Offspring and Inheritance Studies

The peppered moths live in wooded areas all over England. They fly around at night looking for food and mates. They hide on tree branches and trunks during the day. The females lay eggs that hatch in midsummer. The caterpillars grow by eating tree leaves throughout the summer. In the fall, the caterpillars become pupae and drop to the ground where they survive in the soil during the winter. The adult moths die during the winter. In the spring, mature moths emerge from the pupae hidden in the soil and begin the life cycle again.

Scientists wanted to know whether the color pattern of the typical and carbonaria forms was an inherited trait or whether it was produced by something in their environment. However, they were unable to figure out which offspring were a result of which matings in the wild. So, over the years, many different scientists captured moths of different colors and did breeding experiments to determine whether the color pattern was inherited and to figure out if it might be due to a dominant or recessive allele of a gene. They knew that if one of the colors was due to a recessive allele, a cross between two parents of that color would not produce any offspring with the color of the other form.

This is an example of the kinds of results they got in their breeding experiments:

Parent crosses		# of carbonaria offspring	# of typical offspring
Parent #1	Parent #2		
carbonaria	carbonaria	405	110
carbonaria	typical	350	152
typical	typical	0	509

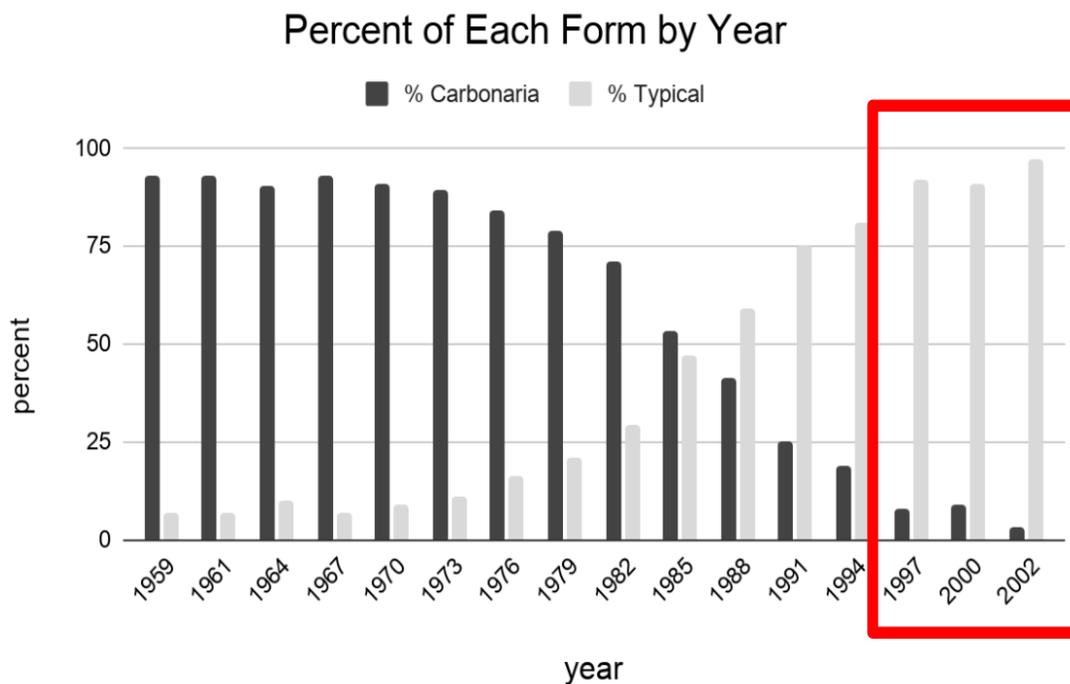
Consider the questions listed below in your analysis of the data and what they mean. Then write your summary in the box below.

<p>A. Identify: What do I see in the data?</p> <ul style="list-style-type: none">• Do the characteristics of offspring show evidence that the coloration is heritable in peppered moths? Explain.• What patterns provide evidence for your claim? <p>Your summary:</p>	<p>B. Interpret: What does this mean?</p> <ul style="list-style-type: none">• Would color be passed from parent to offspring?• Which color would be more likely to be passed down from parent to offspring?• Why would it matter if a trait is heritable or not if we are trying to understand what could cause changes in a whole population of descendants over several generations? <p>Your summary:</p>
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Data Subset 5: Studies of the Population of Peppered Moths at the End

People in England were concerned about the amount of pollution there was in the air in their cities. Large industrial plants had been creating a lot of air pollution. In addition, many people burned coal to heat their homes. The government in the United Kingdom enacted clean air laws in 1956 to limit the amount of air pollution. Since air pollution often darkened the trees they rested on, scientists had wondered for a long time about whether the color of peppered moths had anything to do with pollution as scientists in the 1800s had originally thought. So they studied the peppered moths as the clean air laws began to take effect and the amount of air pollution began to decrease.

Numbers over time: After the first clean air laws were passed, scientists began tracking the number of typical and carbonaria peppered moths that lived in a highly industrialized area called Caldy Common in West Kirby, England. They did this by trapping the moths at night, then counting them and releasing them the next day. The same group of scientists collected these data over the years from 1959 to 2002. In all, they collected, identified, and counted over 18,780 moths during the nearly 50 years of this study. This is what they saw. Focus on the data from the end of the study (1997 and after):

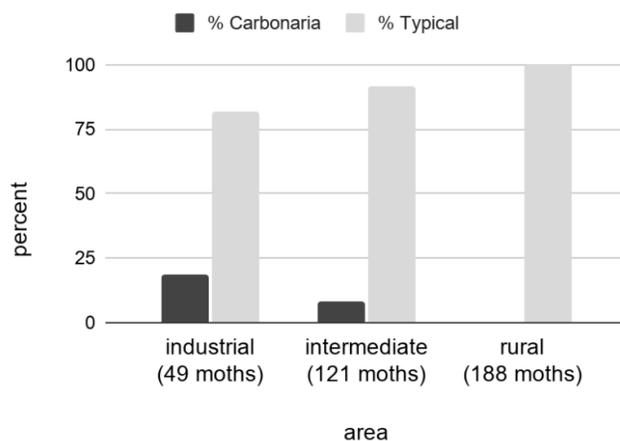


Numbers in different areas: Scientists had also noticed over many years that the carbonaria form seemed to be more common in certain areas of England. They noticed that the areas where there seemed to be more carbonaria forms were usually areas where there was a lot of industry. They wanted to know if the industry or the level of pollution had anything to do with the forms that lived there. So they collected information on the proportion of carbonaria and typical forms in three different areas:

- a highly industrialized area
- an intermediate area where a lot of people lived and burned coal to heat their houses
- a rural area where few people lived

This is what they saw:

Percent of Each Form in Different Areas of England (1995-1999)



Consider the questions listed below in your analysis of the data and what they mean. Then write your summary in the box below.

<p>A. Identify: What do I see in the data?</p> <ul style="list-style-type: none">• What is the trait of interest in this study?• What are the variations for this trait in the population?• What is the proportion of those variations in the population in 1997?• What is the difference in proportions of those variations in the population in different areas in 1997?• How does the proportion of those variations in the population shift over time? <p>Your summary:</p>	<p>B. Interpret: What does this mean?</p> <ul style="list-style-type: none">• What change occurred?• What do you think might be the effect of having a lighter, speckled color (typical) for moths in each area?• What do you think might be the effect of having a darker color (carbonaria) for moths in each area?• What do you think might be the effect of each color over time? <p>Your summary:</p>
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