Mustard Plant Data Packet

Overview: Mustard Plant Time to Flowering

The mustard plant is known as *Brassica rapa* by scientists.

Selective breeding of mustard plants over long periods of time has resulted in the production of vegetables as diverse as turnips, napa cabbage, and bok choy. The mustard plant is commonly used in genetic experiments in laboratories because it is easy to grow, grows quickly, and has many different traits that are easy to see and measure. However, mustard plants also grow in the wild throughout much of coastal California, where they are considered weeds. Wild mustard plants were probably introduced to California about 300 years ago from Asia or Europe, where the mustard plant also grows in the wild.

The wild mustard plants in California are an annual plant, meaning that they sprout--or germinate--from seeds, grow to full size, bloom, produce seeds, and die all in one year. The following year, the new seeds sprout and the cycle starts again. No individual plant grows for more than one year.

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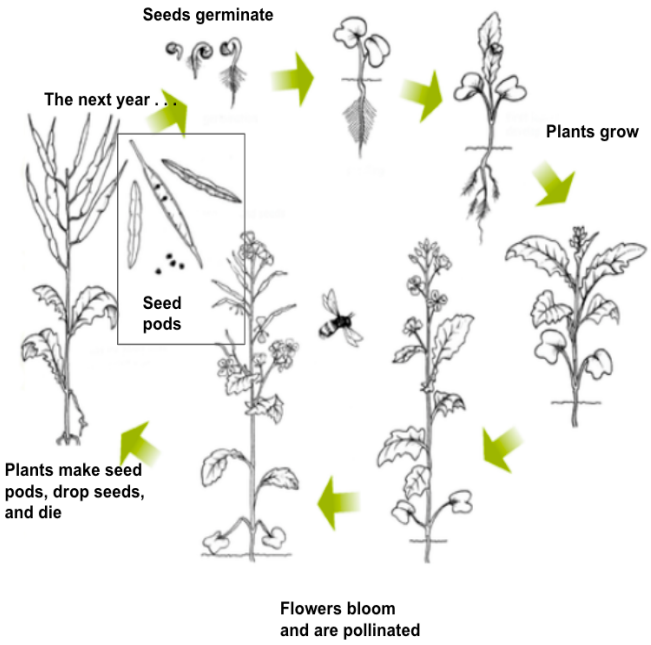
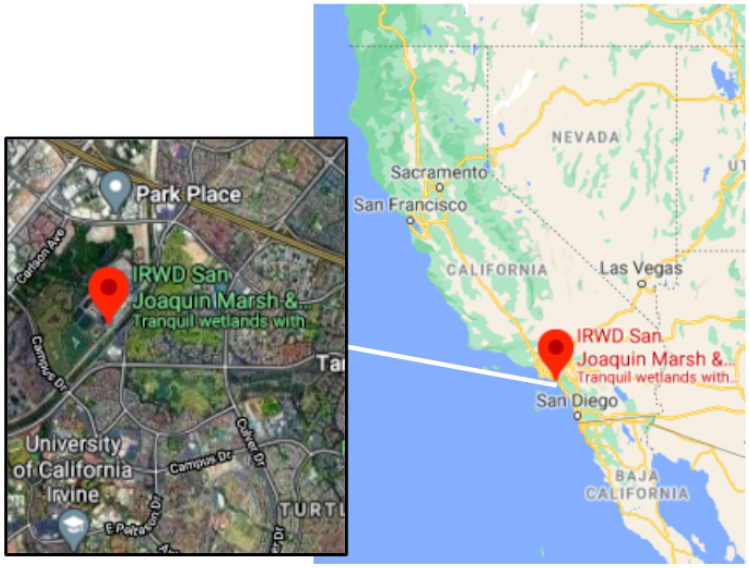


In California, wild mustard plants typically sprout and begin to grow sometime between October and January, right after the first rain of the season. They continue to grow as long as they have enough rain. When they are fully grown, they produce flowers, typically sometime between January and April. The flowers of one plant pollinate the flowers of neighboring plants, fertilizing them so that seeds are produced. Each fertilized flower produces several seeds in a pod which falls to the ground. These seeds will then sprout at the start of the next year's growing season and produce the next generation of plants. The length of time that it takes for a plant to become fully grown and produce its first flower is referred to as the "time to flowering" or "flowering time".

Scientists working in Southern California were interested in whether the wild mustard plants growing near them would show the same variety of different traits as the mustard plants they grew in the lab.

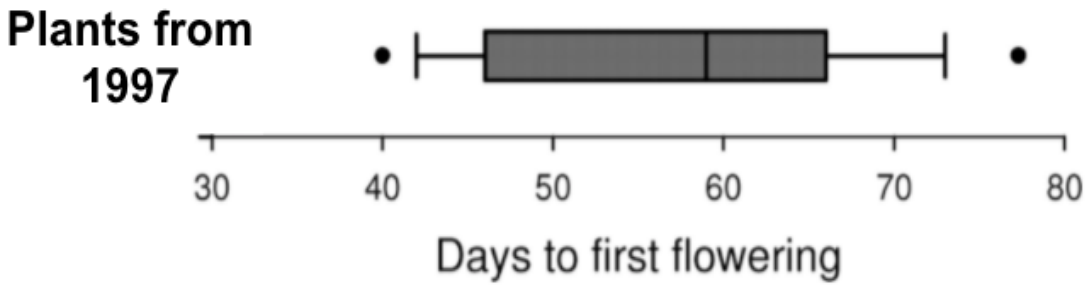


Wild mustard plants grew in several, different locations near the scientists. They had noticed that in some of those populations, the plants seemed to bloom earlier in the year than in others. Because the climate in Southern California is changing, they wanted to know what the effect of that might be on the wild mustard plants. They collected seeds from plants that grew in the same place in 1997 and in 2004 and made observations about how they grew. Between 1997 and 2004 they saw a change in the flowering time of the mustard plants.

Data Subset 1:
Studies of the Population of Mustard Plants at the Beginning

All the plants in a population of mustard plants need to bloom close to the same time so that pollen from a flower on one plant can fertilize a flower from a neighboring plant. Scientists wanted to see how long it took the plants in a population to grow to full size and produce flowers. They were interested in this because plants that do not get enough water can wilt and die before they have a chance to bloom. Since most of the rain usually falls close to the beginning of the growing season, plants that have a shorter time to flowering have a better chance to bloom and produce seeds each year. For this study, scientists gathered seeds from many hundreds of plants from a wet, marshy growing site in 1997. They brought the seeds into the laboratory and grew 100 plants under exactly the same conditions. For each plant they recorded the number of days it took for the plant to go from sprouting to producing its first flower (days to first flowering). This is what they saw:

Flowering Time in 1997 Plants



The center bar indicates the median time to flowering. The box shows the flowering time of the middle 50% of the population; the horizontal lines show the flowering time of the middle 80% of the population; and the dots indicate the times between which 90% of the plants flowered.

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

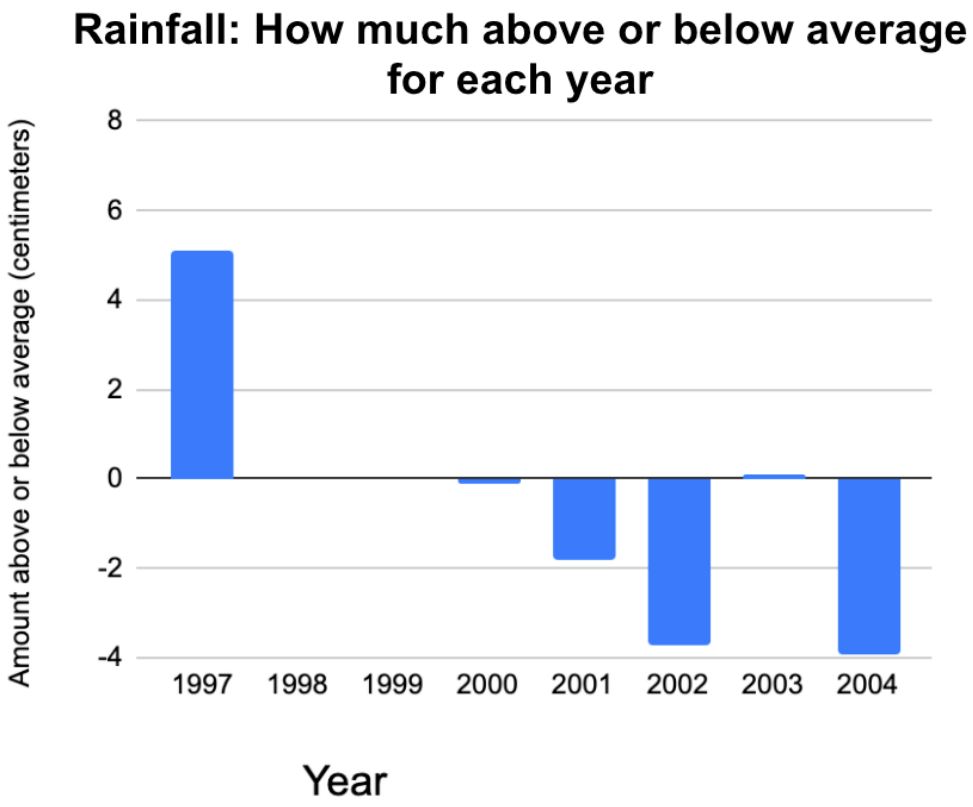
A. Identify: What do I see in the data?	**B. Interpret: What does this mean?**
• What is the trait of interest in this study? • What is the range of variations for this trait in the population? • What is the median value for this trait in the population?	• Is this a trait with many variations? • What do you think might be the effect of having a shorter time to flowering for mustard plants? • What do you think might be the effect of having a longer time to flowering for mustard plants?
Your summary:	**Your summary:**

Data Subset 2: Environmental Studies

In the area of Southern California where the mustard plants grow, it is usually warm and dry. The temperature does not vary much. The average monthly temperature varies by less than 20°F throughout the year. The average temperature in August (the warmest month) is 83°F. The average temperature in December (the coldest month) is 64°F.

Overall, not much rain falls each year in Southern California. The average amount of rainfall each year is only about 15 inches. However, the amount of rain varies substantially over the course of the year. Summer is the dry season, while the winter is usually the rainy season. Almost 95% of the rain each year falls between October and April, during the growing season for the mustard plants. The actual amount of rain that falls during the mustard plant's growing season usually varies a little bit each year.

Scientists studied and compared mustard plants that grew in 1997 and in 2004. They collected information about the rainfall during the growing season of the mustard plants throughout the time of their study. This is what they found:



Year

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

A. Identify: What do I see in the data? • What happened in the environment over the time of the studies on the mustard plants (1997-2004)? • What was the greatest difference between the mustard plants' environment in 1997 and in 2004? **Your summary:**	**B. Interpret: What does this mean?** • How do you think this might have affected the mustard plants' survival? • How do you think this might have affected the mustard plants' ability to produce seeds? **Your summary:**

Data Subset 3: Survival and Reproduction Studies

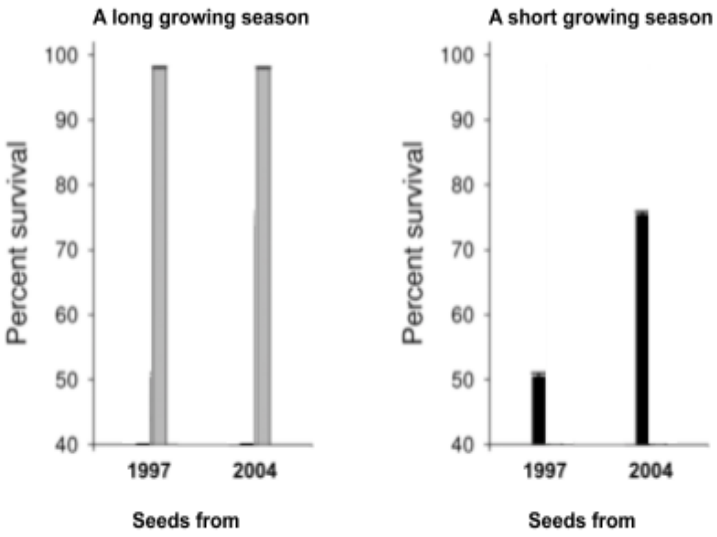
As described in the overview, mustard plants are annuals. Each plant lives only one year, during which it grows, blooms, and produces seeds after being pollinated (when male sex cells in the pollen in one plant's flower unite with female sex cells in the ovule of another plant's flower). Each fertilized ovule develops into a seed. The seeds from pollinated plants will fall to the ground and will germinate the following year. Plants must grow to full size before they can bloom. If plants do not get the amount of water that they need to grow during their growing season, they wilt and die before they can produce flowers. When this happens they will not produce seeds and will have no offspring (seeds) that sprout and grow during the following year. Because most of the rain usually falls close to the beginning of the growing season, plants that have a shorter time to flowering have a better chance to bloom and produce seeds each year.

Survival in a short growing season: Scientists wanted to know whether plants from seeds harvested at the end of 1997 and 2004 were different in terms of survival when they receive insufficient amounts of water. They grew 100 plants from seeds collected from a wet marsh in 1997 and compared them to 100 plants grown from seeds from that same location and population that were collected in 2004. They watered all the pots with the same amount of water each day. The plants all sprouted and began to grow.

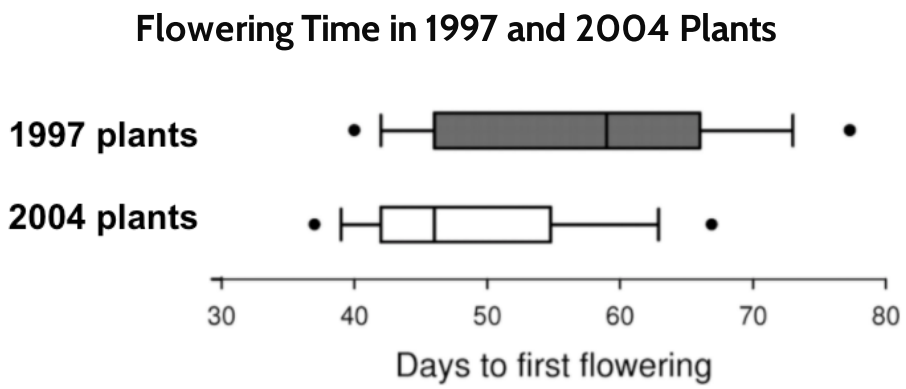
After 33 days they stopped watering half the plants to mimic the effect of a short growing season in which plants would have gotten water only at the start of the growing season.

They kept watering the other half for 81 days to mimic a longer growing season in which plants would continue to have enough water throughout the whole growing season. They determined the percent of plants that survived in each group (short growing season and long growing season). Their results are shown in the graph to the right.

Survival in Short and Long Growing Seasons



Reproduction: Scientists were also interested in whether there was a difference in how quickly these plants could reproduce. They planted seeds from both populations, watered them, and measured how many days it took them to begin to bloom after they began to grow (the days to first flowering). They measured 100 plants grown from 1997 seeds and 100 plants grown from 2004 seeds. In this experiment, they gave all the plants all the water they needed to grow and survive. This is what they saw:



The center bar indicates the median time to flowering. The boxes show the flowering time of the middle 50% of the population; the horizontal lines show the flowering time of the middle 80% of the population; and the dots indicate the times between which 90% of the plants flowered.

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

A. Identify: What do I see in the data?	B. Interpret: What does this mean?
• What is the difference in the survival of the mustard plants from the 1997 population compared to the 2004 population? • What is the difference in the ability of the mustard plants to reproduce in the 1997 population compared to the 2004 population?	• If water is available only for a short growing season, which flowers will be most likely to reproduce and make seeds for the following year? • If water is available for a long growing season, which flowers will be most likely to reproduce and make seeds for the following year?
Your summary:	**Your summary:**

Data Subset 4: Offspring and Inheritance Studies

Scientists wanted to know whether any differences they observed between the mustard plant population in 1997 and the population in 2004 were due to inherited traits. They knew that there were differences in the two populations both in how well they survived in a short growing season and in how long it took them to bloom after they sprouted (the flowering time). So they set up breeding experiments to test this question about inheritance.

Breeding experiments: They grew plants from the seeds they collected in 1997 (1997 population) and from the seeds they collected in 2004 (2004 population). They took pollen from the flowers of one parent population and used it to pollinate the flowers in another parent population. When flowers are pollinated, male sex cells in pollen from one plant's flower (male parent) unite with female sex cells in the ovule of another plant's flower (female parent). Pollinated flowers produce seeds in pods. The seeds are the offspring of the parent plants. The scientists collected all the seeds that were produced in these crosses. These are the crosses they did:

Male parent population (pollen)	Female parent population (ovule)	Offspring population (seeds)
1997	1997	purebred 1997
1997	2004	hybrid
2004	1997	
2004	2004	purebred 2004

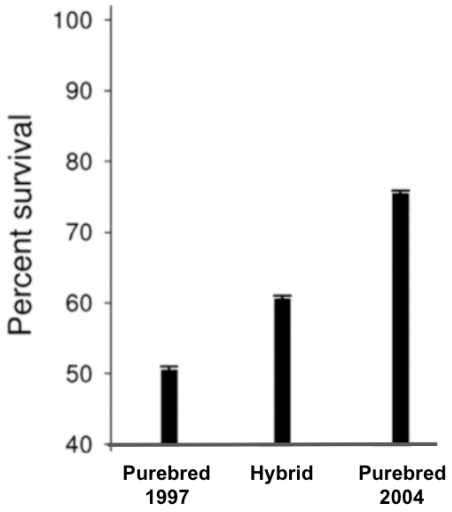
Then they tested the offspring populations by planting the seeds from each cross and determining

- how well they survived in a short growing season and
- how long it took them to bloom after they sprouted (flowering time).

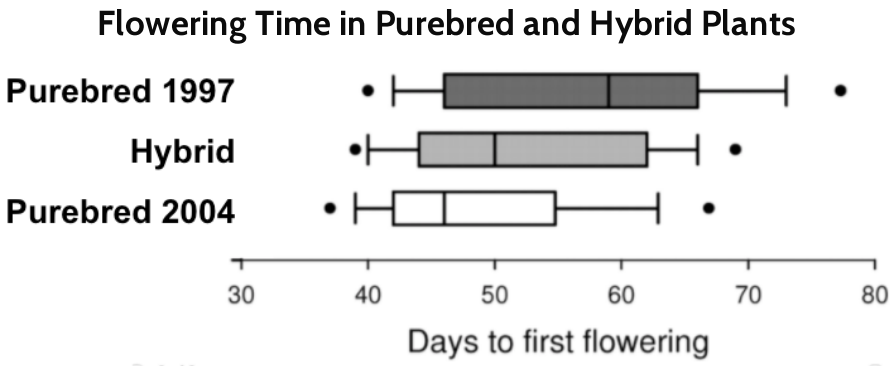
They knew that if the traits were inherited, hybrids between plants from the 1997 and the 2004 populations would be likely to have a variation in survival or in flowering time that was midway between the survival or flowering time of the purebred populations.

Survival in a short growing season: To test for survival in a short growing season, they planted 100 seeds from each offspring population and watered all the pots with the same amount of water each day. The plants all sprouted and began to grow. After 33 days they stopped watering the plants to mimic the effect of a short growing season in which plants would not get enough water over time. They determined the percent of plants that survived in each offspring population. The data they collected is shown in the graph to the right.

Survival of Purebred and Hybrid Plants in a Short Growing Season



Flowering time: Scientists were also interested in whether there was a difference in the offsprings' flowering times, so they measured how many days it took for each offspring population's plants to begin to bloom after they began to grow (the days to first flowering). In this experiment, they planted 100 seeds of each offspring population and gave all the plants all the water they needed to grow and survive. This is what they saw:



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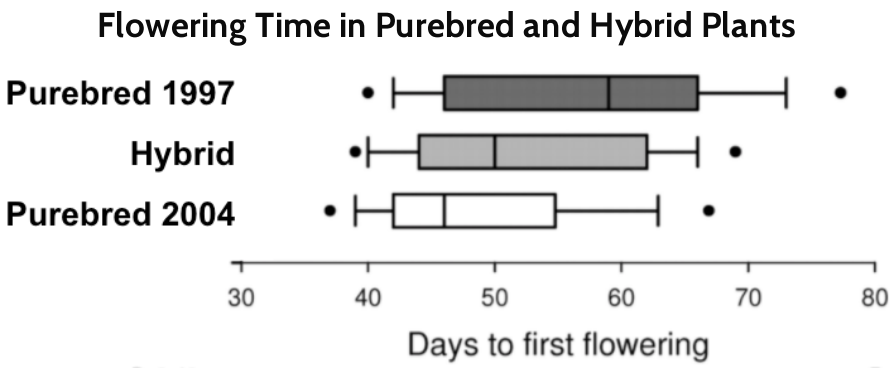
Structural differences: A second group of scientists investigated whether any structures of the mustard plants were different between the 1997 population and the 2004 population. They found that many of the proteins involved in signalling the plant to start to grow or to start to produce flowers were structurally different between the two populations.

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

A. Identify: What do I see in the data?	B. Interpret: What does this mean?
• What is the pattern of survival in a short growing season for the three offspring populations? • Do the characteristics of the three offspring populations show evidence that the ability to survive in a short growing season is heritable in mustard plants? Explain. **Your summary:**	• Are there structural differences among the populations? • If a trait is heritable, how does that affect the traits of the offspring in the next generation? • 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? **Your summary:**

Data Subset 5: Studies of the Population of Mustard Plants at the End

All the plants in a population of mustard plants need to bloom close to the same time so that pollen from a flower on one plant can fertilize a flower from a neighboring plant. Scientists wanted to see how long it took the plants in a population to grow to full size and produce flowers. They were interested in this because plants that do not get enough water can wilt and die before they have a chance to bloom. Since most of the rain usually falls close to the beginning of the growing season, plants that have a shorter time to flowering have a better chance to bloom and produce seeds each year. For this study, scientists gathered seeds from many hundreds of plants from a wet, marshy growing site in 1997 and again from the same location and population of plants in 2004. They brought the seeds from the 1997 plants and the 2004 plants into the laboratory and grew 100 plants of each group under exactly the same conditions. This is what they saw:



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

A. Identify: What do I see in the data?	B. Interpret: What does this mean?
• What is the trait of interest in this study? • What is the range of variations in the 1997 plants? What is the range in the 2004 plants? • What is the median value for this trait in the 2004 plants?	• What change occured? • What do you think might be the effect of having a shorter time to flowering for mustard plants? • What do you think might be the effect of having a longer time to flowering for mustard plants?
Your summary:	**Your summary:**