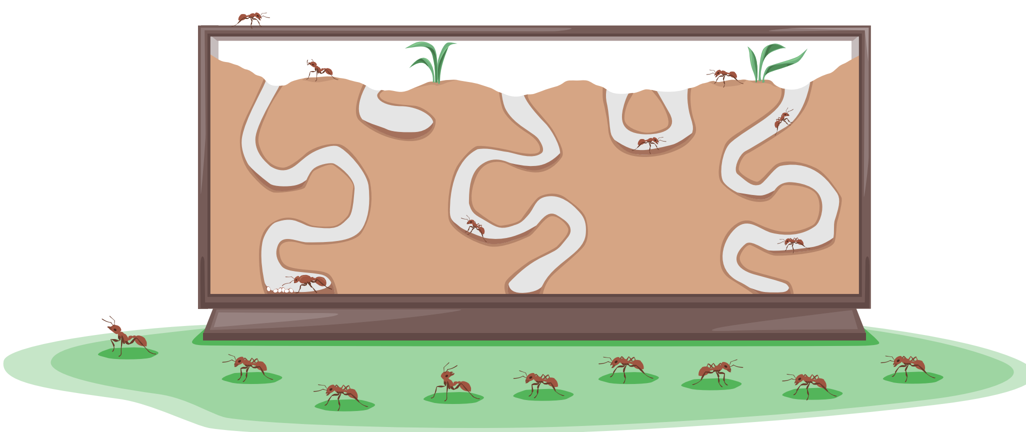
Ant Farm

Ask A Biologist activity for the classroom and home

By Rebecca Clark and Tate Holbrook



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Secrets of a Superorganism
http://askabiologist.asu.edu/explore/secrets-superorganism

Credits

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Ants

A brief background

Ants are everywhere - they thrive in forests, fields, deserts, and cities all over earth. But what is the secret behind their success? Like humans, ants are social. They live and work together in highly organized societies called colonies. In fact, most ant colonies are so united toward the common purposes of survival, growth, and reproduction that they behave like a single organism, or a "superorganism." The smallest ant colonies contain a queen and just a few workers. The largest have many millions of workers, more populous than any human city!

Ant nest in a piece of wood

One ant by itself cannot do much harm to many larger animals. But, an ant colony is a major force to be reckoned with. Hunting in groups allows ants to overcome much bigger and stronger prey. By teaming up, ants can even defend their colony against mammals. You may have been unlucky to experience such an attack first-hand!

Ants build their homes in all sorts of places. Many species dig underground nests and/or build mounds of soil. Others live in leaf litter, acorns, or rotting wood on the forest floor. Some ants prefer to take cover underneath rocks, which can also provide warmth. There are even ants that nest only in trees. Ants are excellent architects - their nests are designed to provide just the right environment for larvae to grow. Some nests even have a built-in ventilation system to circulate fresh air.

Ant Facts

How much weight can an ant carry?

According to different estimates, ants can carry 10 - 50 times their body weight! How? Because ants are so small, their muscles have a greater cross-sectional area (they are thicker) relative to their body size than in larger animals. Thus, they can produce more force pound-for-pound (or in the case of an ant, milligram-for-milligram).

How many ants are there in the world?

Scientists have described over 12,000 ant species. Many more have yet to be discovered, especially in the tropics. The total weight of all ants on Earth is close to that of humans. That's pretty impressive considering the average ant is about one-millionth the size of a human being!

Does the queen control the colony?

No. Despite her size and royal title, the queen doesn't boss the workers around. Instead, workers decide which tasks to perform based on personal preferences, interactions with nestmates, and cues from the environment. The colony exhibits a division of labor where different individuals specialize on different jobs. Younger ants often work inside the nest, taking care of the queen and her brood. Older workers are more likely to go outside to gather food or defend the nest against enemies.

Are all ants pests?

No. Ants serve many roles in nature, some of which are beneficial to humans. They eat other insects, pollinate plants, disperse seeds, move soil, and circulate nutrients. Because ants perform all these functions, they are a key component of many ecosystems.

Which hurts worse, an ant's bite or its sting?

Usually its sting. The bite of most ants (except for really big ones) feels like a weak pinch. But even tiny ants can deliver venom through their stings, resulting in burning, itching, and/or swelling. Hence, names like fire ant and bullet ant. Remember though that many ants don't have stingers and are more or less harmless to humans.

Ant Anatomy

Imagine being the size of an ant. Be careful - a face-to-face encounter with an ant would be scary and potentially life-threatening! But, if you avoided being eaten, you could learn a lot about ant anatomy from a close-up view. Ants have many body parts that are normally hard to see without a magnifying glass or microscope. Each structure has its own special function.

When you come across an ant on the ground, it's almost always a worker ant. Workers are adult females that don't reproduce, but perform all the other jobs needed to keep an ant colony alive and healthy. In case you are wondering, there are no male workers in ant colonies. What do these female worker ants look like? Let's take a closer look.

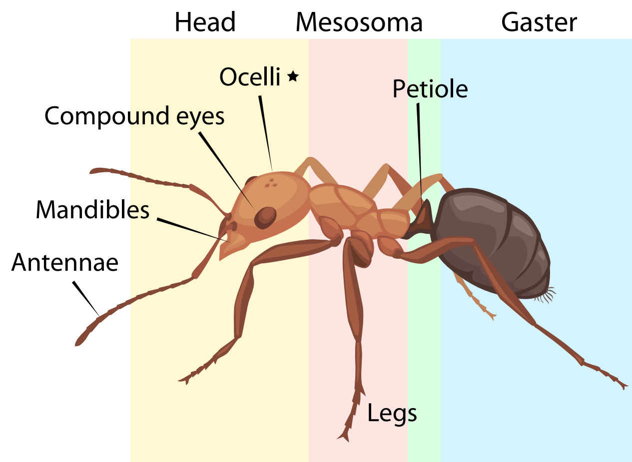
Like other insects, ants do have a head, thorax, and abdomen, but the thorax and abdomen are not obvious... The ant's mesosoma includes the thorax plus the front of the abdomen – they are fused together. The rest of the abdomen is divided into the petiole, post-petiole (when present), and gaster.

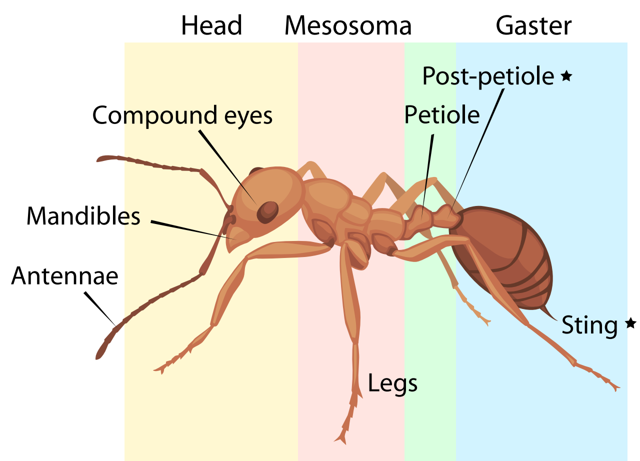
The ant's second body segment, the **mesosoma**, is packed full with muscles that power its three pairs of legs. The legs are designed for running – ants can run very fast for their size. At the end of each leg is a hooked claw that is used to climb and hang on to things.

The **gaster** contains the ant's heart, digestive system, and chemical weaponry. Some ants have a sting, which is used to inject venom into enemies. Others have a tiny opening at the tip of their gaster through which they spray acid to stun prey or defend themselves.

In between the mesosoma and the gaster is the **petiole** (and in some ants, the post-petiole). This is one body part that distinguishes ants from other insects. The petiole (and post-petiole, when present) provides a flexible junction, allowing the ant to bend its gaster forward to sting or spray.

Finally, the entire body of an ant is covered by a hard **exoskeleton** that provides support, protection, and a barrier against water loss.

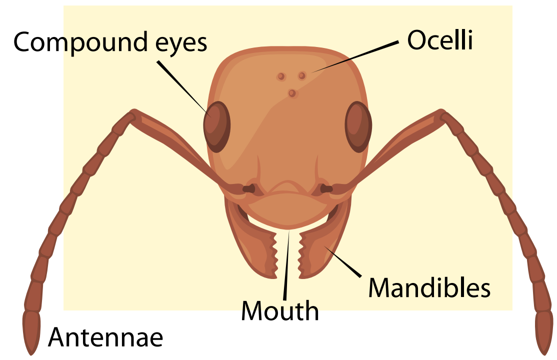




All ants may look the same to you, but if you look closely at workers from different ant species, you may see some differences. We have pointed a few of them out using an asterisk (*) symbol.

Ant Heads

Like you and me, ants use their heads to sense information about the world around them. This is very important for their survival and the life of the colony. If you watch an ant's head, the antennae are always moving back and forth, touching, tasting, and smelling everything within reach. Each antenna is bent in the middle like the elbow of a human arm – this is another unique feature of ants.



Ants communicate mainly using chemicals, which they sense with their antennae. They release pheromones with specific messages, such as "Follow me to food!" or "Attack the intruder!". In addition, nestmates recognize one another by chemicals on their bodies. The queen is coated with a unique blend of chemicals that advertises her presence. Ants can also use touch and vibration to communicate.

Their **compound eyes**, like the eyes of most insects, can contain hundreds of lenses that combine to form a single image in the ant's brain. Ants that use vision to hunt for prey have big compound eyes. Other ants that live in dark places have reduced eyes and may even be blind. Some ants also have three simple eyes called **ocelli** that detect light.

The **mandibles** are an ant's most important tool. Ants don't have grasping forelegs, so they use their mandibles like human hands to hold and carry things. Mandibles can also be used for biting, crushing, cutting, digging, fighting, and hunting. Hidden by the mandibles is the mouth, which ants use not only to eat, but also to clean themselves and nestmates.

Cephalotes atratus

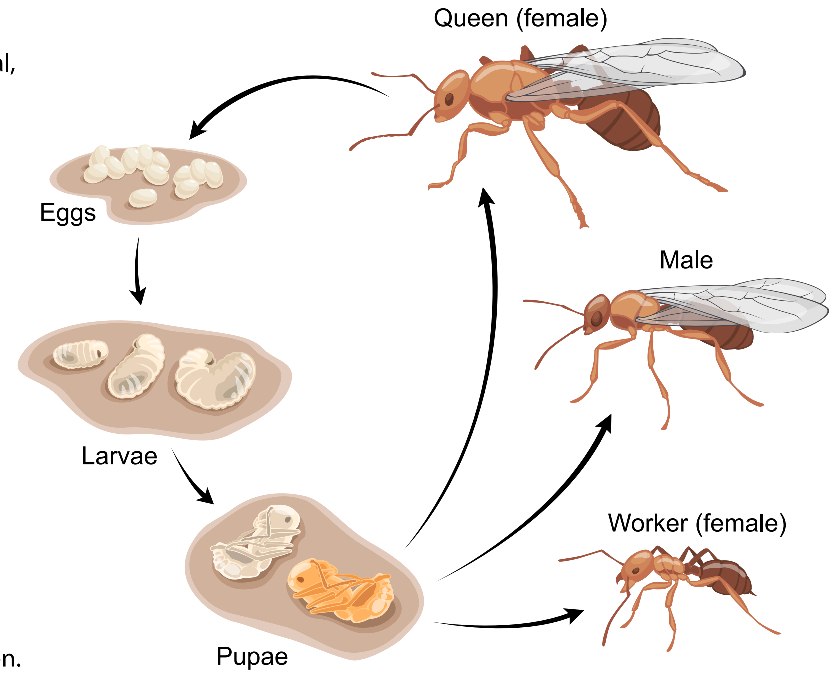
The Many Faces of Ants

Ant heads, especially the eyes and mandibles, come in all shapes and sizes and provide clues to the kinds of food ants eat and the different lifestyles they live. The structure of an ant's head corresponds to its function, so you can tell a lot about an ant from its face. The shape of the head and mandibles and size of the eyes can reveal the diet and lifestyle of an ant species. The ant on the left, photographed by Alex Wild, has generalized mandibles used for biting, carrying, etc.

To learn more about the forms and functions of ant head types and to try our ant heads matching game, visit us online: askabiologist.asu.edu/research/ant_anatomy/ant_heads.html

Individual Life Cycle

Ants undergo complete metamorphosis, a dramatic change in body form, passing through a sequence of four stages: egg, larva, pupa, and adult.



Egg

An ant's life begins as an egg. Ant eggs are soft, oval, and tiny – about the size of a period at the end of a sentence. Not all eggs are destined to become adults – some are eaten by nestmates for extra nourishment.

Larvae

An egg hatches into a worm-shaped larva with no eyes or legs. Larvae are eating machines that rely on adults to provide a constant supply of food. As a result, they grow rapidly, molting (shedding their skin) between sizes.

Pupa

When a larva is large enough, it metamorphoses into a pupa. This is a stage of rest and reorganization. Pupae look more like adults, but their legs and antennae are folded against their bodies. They start out whitish and gradually become darker. The pupae of some species spin a cocoon for protection, while others remain uncovered, or naked.

Adult

Finally, the pupa emerges as an adult. Young adults are often lighter in color, but darken as they age. The process of development from egg to adult can take from several weeks to months, depending on the species and the environment. Like all insects, ants are full-grown when they become adults. Their exoskeletons prevent them from getting any larger. Adult ants belong to one of three classes known as castes: queen, worker, or male.

Males

Males have wings and fly to mate with queens. They live for only a few weeks and never help with the chores of the colony. The only time you'll encounter a male ant is during mating, because they die shortly afterward. Like queens, males have wings and muscular mesosomas for flying. But males are typically not as large as queens and have smaller heads with bigger eyes and straighter antennae.

Workers

Workers are females that were fed less as larvae. They do not reproduce, but perform other jobs, such as taking care of the brood, building and cleaning the nest, and gathering food. Workers are wingless and typically survive for several months. In most species, all workers are roughly the same size, but some ants have different sizes of workers that serve different roles. Minor workers are smaller and perform general labor such as taking care of the young, building and cleaning the nest, and gathering food. Major workers are larger and specialized to perform certain tasks. For example, major workers called soldiers have large heads and powerful mandibles used to guard and defend the colony.

Queens

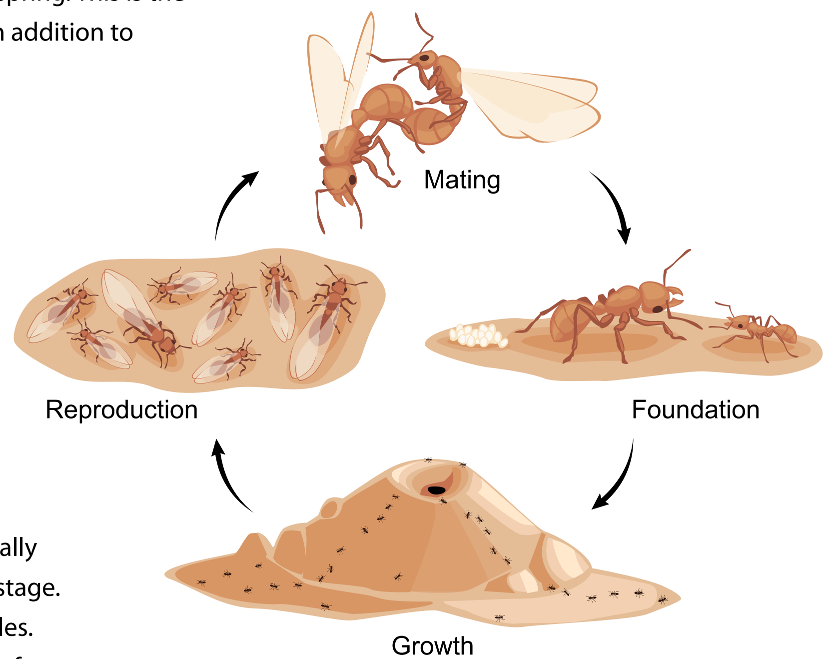
Queens are females that were fed more as larvae. They are larger than workers and lay all the eggs in a colony – up to millions in some species! Queens initially have wings and fly to find a mate(s), but they tear them off before starting a new colony. A queen can live for decades under the right conditions.

Colony Life Cycle

Like individual ants, ant colonies also undergo a sequences of changes known as the colony life cycle.

Founding

An ant colony begins in the founding stage. After mating, the queen(s) starts a new nest and raises her first worker offspring. This is the only time in a queen's life that she does work in addition to laying eggs.



Growth

During the growth stage, the colony grows larger by producing more workers. The workers now perform all the colony's jobs except laying eggs. This period may last for several years.

Reproduction

When the colony grows large enough (this usually takes several years), it enters the reproductive stage. Now the colony produces new queens and males. These winged adults fly away to mate with ants from other colonies. The queens then start the next generation of colonies. Colonies may reproduce year after year until their queen(s) dies.

Collecting Ants

While it can be fun to watch ants outside, or perplexing to find them in your house, one of the most exciting ways to study ants is to keep them in an ant farm so you can see all of the action that goes on underground. But before you can keep them in an ant farm, you have to collect them first!

There are several different ways to get ants for an ant farm, depending on when you would like to start the farm and how long you would like for your ant farm to last.

Option 1

If you want to start an ant farm fast and you want one that will only last for a few weeks or months, all that you will need to do is to **collect worker ants**, without a queen. The only trouble is, when there isn't a queen around, worker ants don't have much to do because they cannot lay any eggs. But sometimes that is the easiest and fastest option.

Option 2

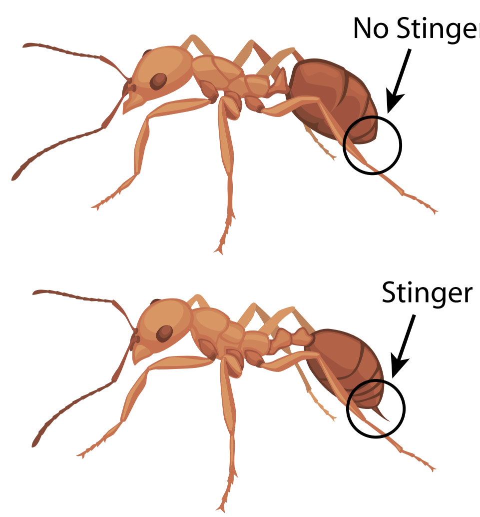
If you are very patient and are willing to wait until just the right time of year, you might be able to use your knowledge of the ant colony life cycle to **collect ant queens** and start a brand-new colony.

Collecting Worker Ants

Although there are some companies that will sell worker ants for your farm, it's even more fun to collect them yourself from the different kinds of places where ants like to build their homes.

There are a few key ideas to keep in mind when you go ant-hunting. Some kinds of ants, but not all of them, will sting to defend their colonies from you, so it's probably best to leave these ants alone. But there are many other kinds of ants that can't sting at all, which are more pleasant to have around. But you will have to spend some time carefully figuring out what kind of ant you're watching to see if it's a stinger or not.

Next, one of the most important tricks for collecting your own ants is to collect at the right time of year. In the winter, when it is cold, you probably won't be able to find very many ants. Why not? Well, probably because ants can't move very fast in the cold. In the spring and summer, however, ants are usually much more active and will be easier to find. Often, if you give them the right motivation, they might find you before you find them!



Depending on where you live, you might have to do some detective work to locate an ant colony, and keep in mind that different types of ants like to live in different types of homes: in the soil or in mounds, underneath rocks, or in acorns or pieces of wood. The kinds that are the simplest to find and collect are the ants that are found in the ground.

If you live in an area where ants live in the soil or where ants build mounds, you have a pretty easy job. To find them, just walk around slowly and look for the entrance to a nest. Spend some time trying to find a couple of nests to get an idea of how many different kinds of ants you can choose among. Usually, if you find the entrance and dig up about six inches of soil, you'll be able to find a lot of worker ants.

If you decide to look for ant nests underneath rocks, all you need to do is carefully flip over a rock that is around the size of a loaf of bread, and check underneath. This method of ant-hunting is kind of like a game of hide-and-go-seek: you won't find ants underneath every single rock, but it's really exciting when you do find them. If you look for ants under rocks, please be careful to put the rocks back when you are finished checking for ants. That way, other animals that like to hide out can still use the rocks as a nice hiding place.

Once you have found an ant colony, you can then scoop up some ants with a hand shovel and put them into a clear plastic tupperware container or glass jar to bring them back with you. The number of ants that you can bring back will depend on how big the colony is and how many you want to collect.

Ants are usually pretty good at climbing, so make sure that your container closes tightly! If you need to transfer them to a new container at any point, it's okay to knock the container to shake all of the ants to the bottom. They are pretty sturdy and can usually recover quickly.

Collecting Queen Ants

One of the most exciting ways to get an ant farm underway is to start with a colony at the very beginning of the ant colony life cycle, when the colony contains just one kind of ant, the queen. New colonies get their start when winged queen and male ants fly out of mature colonies and mate. The image on the left, taken by Alex Wild, shows queens in flight.

But how do these winged ants know when to fly out of the nest to find a new mate? Depending on where they are found, they can rely on different kinds of information, including the day length, temperature, and rainfall. So the biggest trick is usually to have a good idea of when-what time of year and what time of the day-to look for them. Also keep in mind that you're most likely to find them in an area that already has a lot of ant colonies present.

In places like Arizona, some ants will start new nests in the springtime, sometime between March and May, depending on the ant species and the temperature. Other ants will wait until the summer monsoon rains have rained enough to drench the soil and make it easier to dig a new nest. So getting the timing just right to find queens that are starting new nests can be kind of like winning the lottery-you have to be patient and persistent and willing to wait until conditions are just right.

A good way to know if your chances of finding a queen are good is to go over and take a look at what's going on in some big, mature colonies. Before the queens and males leave the nest to mate, they will usually hang out around the entrance of their parent colony for a little while, deciding if the weather is just right for some flying. If you see winged queens and males in a colony about to take off from the nest, you will probably start to see mated and now wingless queens running around sometime shortly after that.

Queens that have just mated and are looking for a place to start a new nest resemble tourists that are lost in a big city, running around, taking wrong turns, getting into arguments, and poking their heads into cracks in the ground as they look for just the right spot to dig their new home. Some newly mated queens will still have their wings attached, but most will tear them off pretty quickly as they start to look around because wings make the queens an easy target for predators to find.

In contrast to the queens, worker ants look more like people on their way to work and school, traveling along straight trails in a purposeful fashion as they go about their regular business of collecting food for their colonies.

While a queen is busy looking around, it's pretty easy to reach down and pick her up gently between your fingers, being careful to hold her firmly but not crush her. With a little bit of practice, you can even get good at just grasping her by the legs. If you are lucky enough to spot more than one queen, pick up as many as you can collect, because not every queen will be able to get a new nest started.

The image on the right shows a queen and worker side by side. Queens are typically much larger than worker ants.

Queens can be kept in a small container such as a film canister for a little while. Just make sure they have plenty of water, which you can provide by giving them a soaked cotton ball. They will be hard to watch, though, so you could also build an ant farm to be able to see what's going on. Just be sure to collect up several cups of the soil from the place where you collected the queens.

If you're just a little bit too late to collect queens while they're still running around, it is still possible to collect them as they start to dig a new nest because they won't be very deep underground. Start out by looking around for a small hole in the ground that is surrounded by a little heap of fresh dirt.

Use a hand shovel to dig up the dirt around the hole, and use your hand to fan it out across the surface of the ground. If the hole contained a queen, she will usually try to scramble free of the dirt to escape. Not every hole will contain a queen, so keep trying if you don't succeed at first. Besides, you might find some other cool surprises as you dig! Just be careful to fill in the holes that you have dug when you are finished.

Building an Ant Farm

a step by step tutorial on how to build an ant farm

Also available, a video of how to build an ant farm
http://www.askabiologist.asu.edu/video/

Materials

1. Two clear plastic CD cases, standard width
2. Sieve for soil
3. Dry soil, ideally from place where ants were collected (approximately 3 cups before sifting)
4. Container for sifted soil (approximately ½ cup after sifting)
5. Utility knife or other sharp knife that can cut plastic
6. Clear packing tape
7. Spoon
8. Shovel
9. Eyedropper (for watering soil)
10. Straightedge for scoring and cutting plastic
11. Marker to note exit/entry point location
12. Two pieces of dark construction paper, or aluminum foil to cover sides of farm

Fully assembled and farm with water added

Methods

1. Empty CD cases

Remove interior plastic pieces from both CD cases. One interior plastic piece will serve as the farm's base, while only part of the other piece is needed to seal the top of the farm. Set aside both pieces for the moment.

2. Cut holes for passage between top and bottom case

Position the two empty CD cases so that the case that will form the upper part of the ant farm is sitting flat on top of and perpendicular to the CD case that will hold the lower dirt portion of the farm, with the front side of the top case facing upwards so that it is easy to open and close.

The top and bottom edges of CD cases contain two small openings each, and you will use one of those slits on top of the lower dirt CD to make an exit/entry point for the ants.

Enlarge one of the slits on the lower dirt CD case: score the edges of the slit on both sides of the case.

Once you've scored the edges, you will be able to snap off enough plastic to create a square hole.   The final hole should be as wide as the edge of the CD case.

Mark the corresponding location on the underside of the upper CD case, where you will carve a small, circular hole using a utility knife or other sharp blade.The plastic may crack if you carve too quickly, so work gradually and avoid applying too much pressure.

3. Construct a cover

Ants tend to prefer dark locations. Tape together two pieces of construction paper lengthwise or use a sheet of aluminum foil to create a long rectangle that is the same height as one CD case and that is long enough to wrap around the entire lower case with several inches of overlap.

4. Seal holes and fill lower CD case with soil

To fill the lower CD case with soil, all small holes must first be sealed with tape. Use long strips of packing tape to close and seal the bottom edge and the side opposite the hinge, but leave the half-inch gap along the case's spine open so you can add soil through the gap. Place a small piece of temporary tape over the top edge to cover the entry/exit hole.

Before adding soil to the farm, sift dried soil to remove clumps and debris. You will need approximately ½ cup of sifted soil.

Use a spoon to add soil into the CD case through the half-inch gap along the case's spine, periodically pausing to tap the CD case to get soil to settle and compact. Try to fill the case with as much soil as possible.

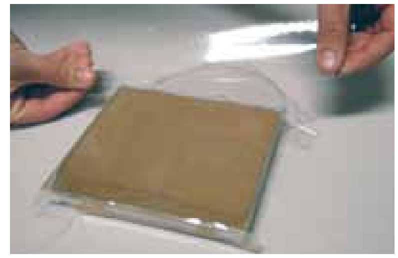
Clean off any dust that is on the outside of the case.

Use a long strip of packing tape to seal the open edge along the spine.

5. Assemble the farm

Attach CD case filled with soil to base: Locate one of the square pieces of plastic that came from the interior of one of the CD cases. Use a strip of packing tape along one bottom edge of the CD case filled with soil to attach it to the base piece. Make sure that the top edge with the entry/exit hole faces upwards.

A careful taping job will ensure that the ant farm will remain upright. Lay the CD case filled with soil flat on its side to attach a second strip of packing tape along the second side of the bottom edge of the CD case.



Once the second side is attached, the CD case filled with soil should be able to remain upright on its own. Remove the temporary piece of tape that is covering the entry hole.

Attach the upper CD case to the lower CD case filled with soil. First, apply a strip of tape along the length of one of the sides of the CD filled with soil, leaving about half of the tape sticking up above the top of the CD.

Fold the tape down, and reposition the upper CD case so its entry/exit hole lines up with the hole in the lower CD case. Once the CD cases are properly lined, up, let the tape adhere to the upper CD case.

Then, tilt back the upper CD case, and apply a second piece of tape to the other side of the lower CD case, and tape the upper CD case securely in place

Check to make sure that the hole in the upper CD case lines up with the hole in the lower CD case.

6. Seal all holes on the upper CD case

Locate the second plastic piece that formed the interior of the CD case. This piece will seal the half-inch hole along the spine on the top of the farm. Cut the interior plastic piece parallel to and 1.5 inches from the edge that is usually located next to the hinge of the CD case.

Snap this interior plastic piece into two pieces.

Fit the side that contains part of the CD case's spine back into the CD case to seal the edge.

Use several small pieces of tape to cover the small holes on the edges of the top CD case.

7. Add water and ants

Use an eyedropper or similar device to add approximately 2 tablespoons of water to the ant farm through the farm's entry hole. This water will soak down through the rest of the ant farm to provide enough moisture for the ants.

Add ants into the top CD case, and close the lid, being careful to avoid crushing the ants. It may take the ants a little while to find the entry hole. Wrap the construction paper or aluminum foil cover around the soil portion of the ant farm when you are not trying to view the ants.

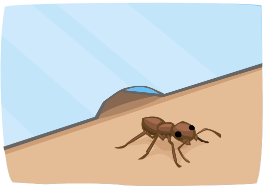
To feed the ants, open the top CD case and place food on the surface inside. If there are a lot of ants that could attempt to escape, place the ant farm in the refrigerator for 5 minutes to slow them down before opening the case to feed them.

E. Keep your ant farm somewhere moderately warm, but out of direct sunlight (e.g. on top of refrigerator, on desk under a warm lamp).

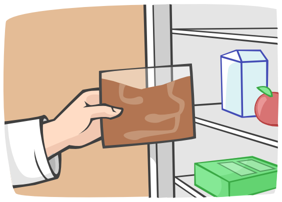
Tips and Tricks

how to handle your ants

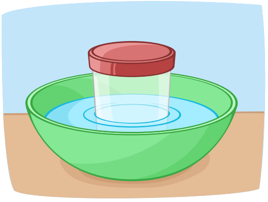
One of the trickiest parts of working with ants is getting them to stay where you want them, or moving them somewhere else without ants going everywhere. Here are a couple of tricks to keep ants where you'd like them to be.



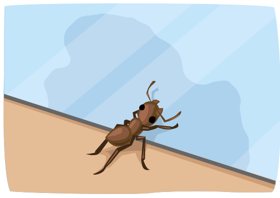
Check containers carefully for holes: Ants are very good at finding even tiny holes and will use them to their advantage!



Chill out: If you need to move ants from one container to another, you can put an ant colony in the refrigerator for a minute or two to slow the ants down. Be careful not to leave them in the refrigerator for too long, though, or they might not survive! Sometimes, cold ants can look like they have died even though they are still alive, so don't be alarmed if they suddenly come back to life.



Put a moat around the castle: Most ants are pretty terrible at swimming, so you can use a big dish as a moat to keep ants in a container, or you can create a moat around a container to keep the ants out if they're really interested in it.



Slippery slopes: For some types of ants, you can use a very thin layer of oil, such as mineral oil, to keep ants from climbing up the sides of a container. You will have to keep a careful eye on it, though, because eventually the ants will wear it down until they are able to get across!

Experiments

A great way to come up with science experiments on ants is to start out by watching what they do. Before you collect some from their nest to put in an ant farm, watch how they behave outside. Is there anything puzzling about their behavior that makes you really curious, and makes you want to ask a question, or maybe a hundred questions? Aha! A question is a great way to get started with a science experiment!

We have been watching ants for a long time, and have come up with a few questions of our own, too. We have also come up with some (but not all!) possible answers to our questions and some experiments that you can do to find out if our possible answers seem right. But we don't know how the experiment will turn out, so it's up to you to make a prediction about the experiment and then go and find out what happens.

What do ants like to eat?

Have you ever discovered ants in your kitchen and wondered what they are doing there? Maybe they're hungry and looking for something to eat! But what kinds of foods do ants like to eat? We came up with the idea that ants like to eat sweet things because they contain sugar, which is a form of energy. Here are three kinds of sweet things the ants might like to eat: skittles candies, life savers, and honey cereal. If you give all three things to some ants, which one would you predict that the most ants will visit? What else might ants like to eat?

When are ants most active?

What time of day are ants most active in the farm? Just like humans sleep at night and go to work and school at certain times, ants might rest and work at different times of the day. Count the number of ants out in the top of the case during different times of the day for least a week then average the results to find the answer.

How do ants "talk" to each other?

If you watch ants for a while, you will notice that they interact with each other a lot. But how are they "talking" to each other? Just as humans have different senses like sight, hearing, touch, and smell, ants could have several different senses, too, which they use to communicate. Here are some ways you could check to see which senses ants use the most. Try each one out, and make observations about how the ants react.

Hearing: Clap your hands.
Touch: Tap the ground close to the ants.
Smell: Blow very gently on the ants.
Sight: Wave something small, like the end of a pencil, close to the ants.

How do ants build their nest?

If you have ants in an ant farm, you will have a chance to see something really neat: ants at work, digging a nest! But just like there could be a lot of different ways to draw a picture, there could also be a lot of different ways to dig an ant nest! For example, what shape will it be? Will it be one giant hole, or a lot of small tunnels? Will the ants dig straight down, or will they dig sideways first? Will all of the ants dig at the same time, or will they take turns?

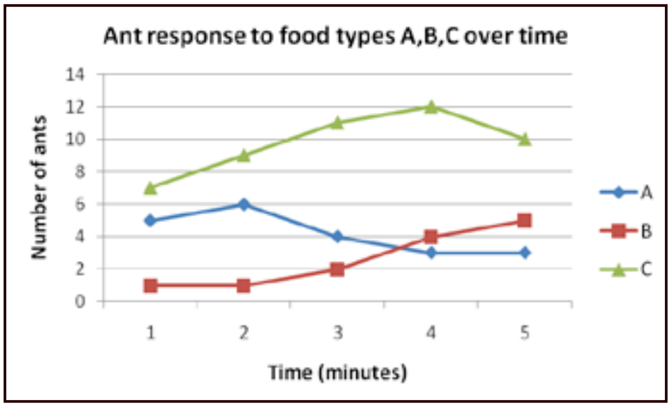
A neat way to answer some of these questions is by using time-lapse photography. What this means is to take a series of photographs of something over time. When you look at all of the photographs together, one after another, you will be able to see how the nest changes over time. You could almost think of a movie as a type of time-lapse photography, where the time between each picture is incredibly short! For the best time-lapse photography, find a place where you can arrange the nest and the camera in the exact same place to take one picture every day. If you take one picture every day for one week, you should be able to start to see how the ants have been digging their nest!

Analyzing

The best way to see the results of an experiment is to make a graph. The kind of graph you make depends on the question you want to answer and what kind of information you have gathered on your results. To find out what kind of food ants like best, for example, we would have to compare the data from two or more kinds of food. Suppose we performed the experiment described in the lesson plan below, and gathered the following data.

Type of Food	Number of ants				
	Time 1	Time 2	Time 3	Time 4	Time 5
A	5	6	4	3	3
B	1	1	2	4	5
C	7	9	11	12	10

We can now make many different kinds of graphs. A line graph (shown below) is good for looking at trends over time. While this might help us answer the question of when ants are most active in foraging, it is not the best type of graph to use to answer the question of what kind of foods ants like most.



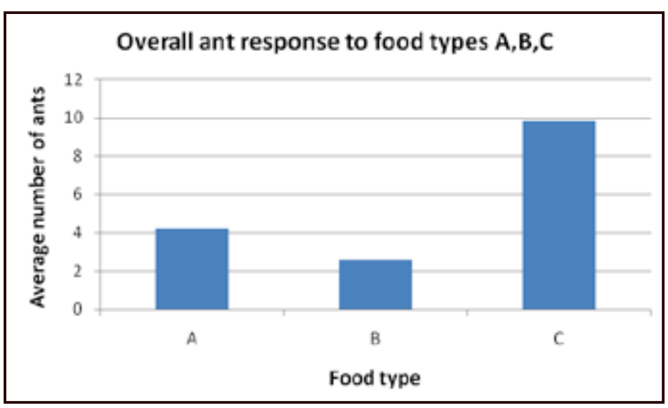
To answer our question and make quick comparisons between the results of each food type, the best sort of graph to use would be a bar graph. To create a bar graph, we must first find the average for each food type. Averages can be used by scientists to see trends when multiple values are collected. In our example, we counted the number of ants present at different times for each of the three types of food. To get the average number of ants present for each food type, we would do the following..

First, add the values of all times together for each food type (food type A shown here)
5 + 6 + 4 + 3 + 3 = 21

Next, divide the result by the total number of values collected for that food type
21 / 5 = 4.2

4.2 is our average for food type A

Once we have the averages for all three food types, we can make a bar graph. By looking at the height of the bars, we can quickly see that ants like food type C best.



As you can see from these graphs, you need to use the right graph and analysis tools to write and publish sound scientific results. If you have access to a computer with Microsoft Office, you can download a free Excel spreadsheet where students can enter data which is automatically averaged and graphed.

Lesson Plan Example

What types of food do ants prefer?

Background

Ants need food for energy and growth. Different species may have different food preferences, depending on their habitats and lifestyles. Foraging behavior is easy to observe and can be studied in the field, lab, or classroom.

Hypothesis

Based on your knowledge of the ants you are studying, hypothesize what types of food you think they prefer. Explain why. For example, you could hypothesize whether they prefer sugary foods (e.g., sugar, honey water) or protein-rich foods (e.g., tuna, dog food). Or you could consider their preferences for sugar vs. artificial sweeteners. If you are working with seed-harvester ants, you could test their preferences for different types of seeds. The possibilities are endless.

Methods

1. Measure out a set amount of each food type.
2. Place each food onto a piece of paper (index cards work well) labeled with the type. If using liquid foods, small containers can be used instead of, or in addition to, paper.
3. Arrange the pieces of paper inside the foraging space of your ant farm, or, if conducting a field experiment, a set distance (e.g., 25 cm) from the nest entrance.
4. Count the number of ants on each piece of paper every minute for 15 minutes (or every 5 min for 30 min if ants are slow to respond). Record your data into a table such as the one below.
5. Depending on the food type and what equipment you have access to, you may also be able to measure the amount of food collected (e.g., change in weight or volume).
6. Repeat the procedure multiple times using the same colony, or using different colonies.

Type of Food	Number of ants					
	Time 1	Time 2	Time 3	Time 4	Time 5	Average
A						
B						
C						

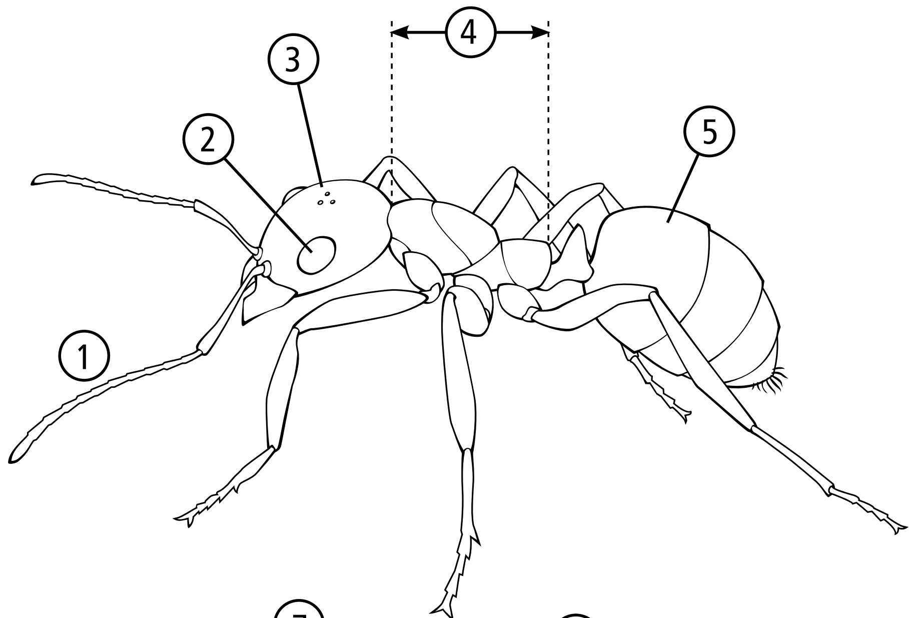
Results and Conclusions

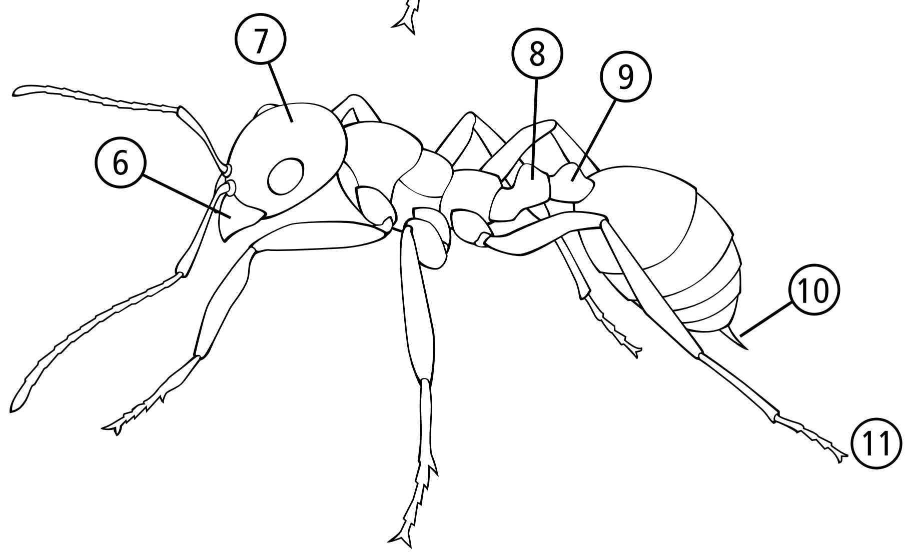
Plot your data onto a graph (see examples in Analyzing section above). If you conducted multiple trials or used multiple colonies, you may want to calculate and graph the averages for each time record and/or the overall average for each food type. Compare the results. Did the ants prefer a particular food source? Do the results match your prediction? Is your hypothesis supported? Can you explain any other patterns in the data?

Ant Activities

Ant Anatomy Worksheet

The parts of each ant type have been labeled. Your challenge is to write the correct name for each part. If you need some help, visit the web article listed below.



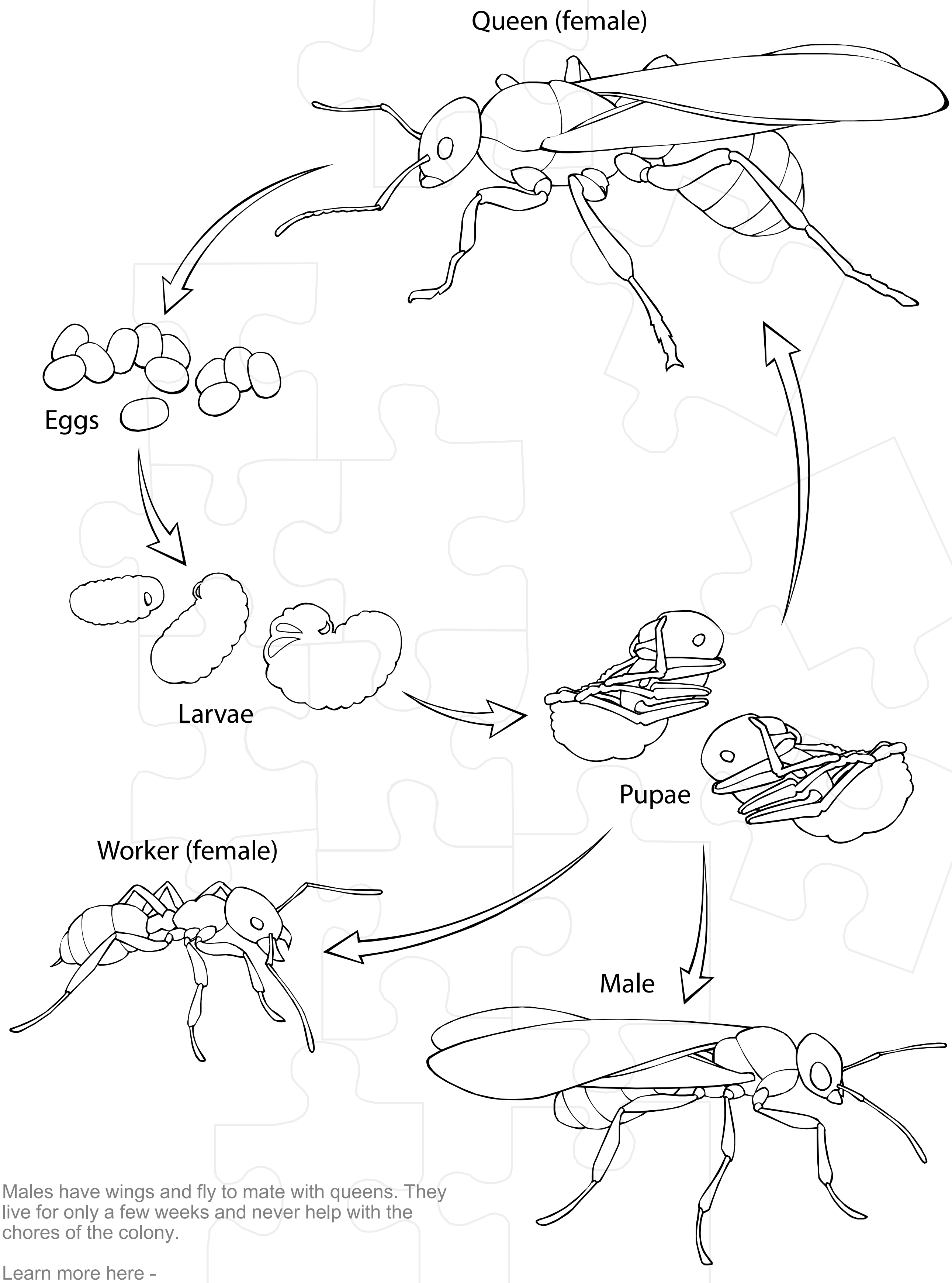


1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________

Ant Anatomy Activity

Answer Key

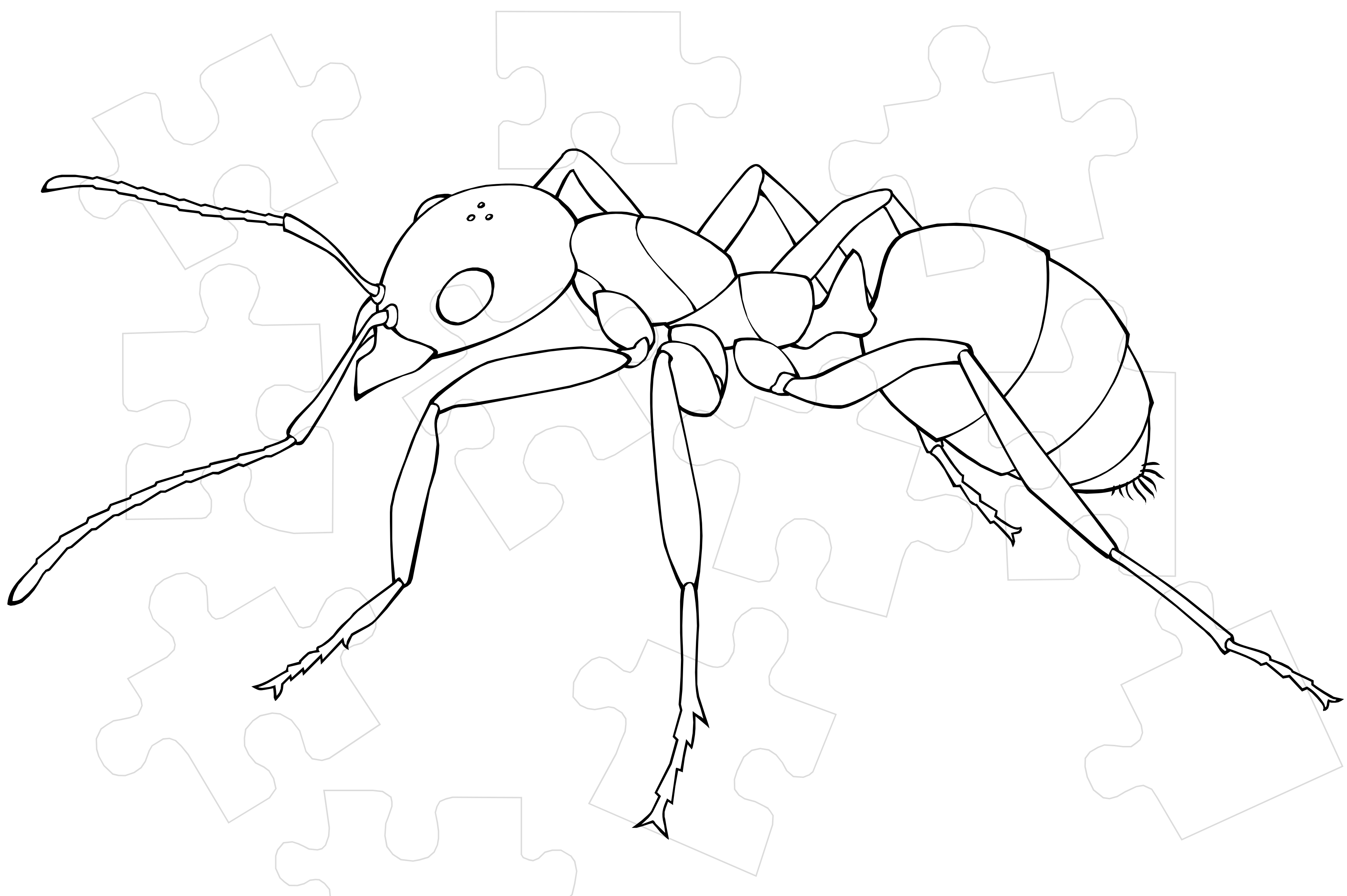
1. Antennae
2. Compound Eyes
3. Ocelli
4. Mesosoma
5. Gaster
6. Mandibles
7. Head
8. Petiole
9. Post-petiole
10. Sting
11. Leg



Males have wings and fly to mate with queens. They live for only a few weeks and never help with the chores of the colony.

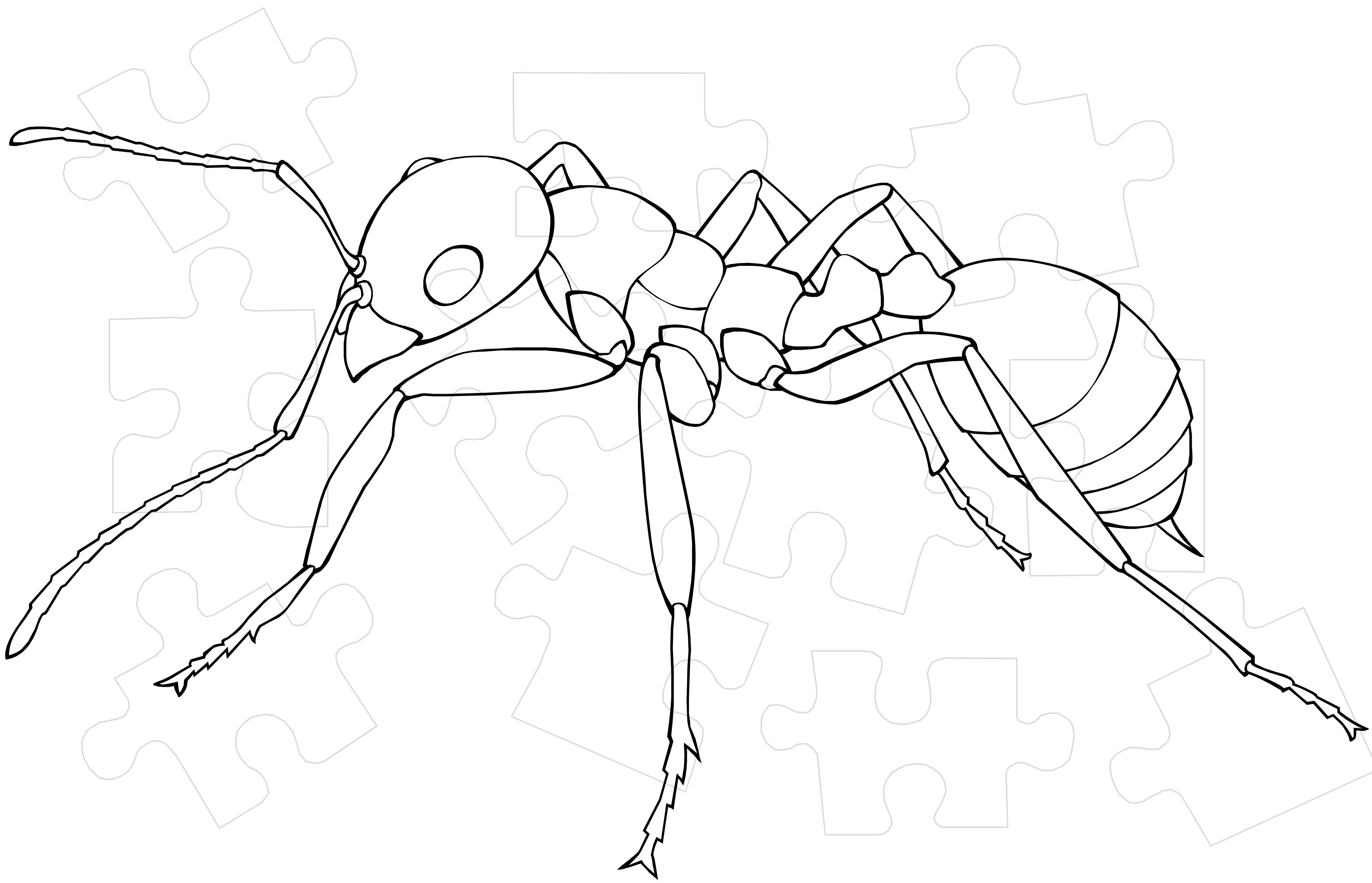
Learn more here - http://askabiologist.asu.edu/individual-life-cycle

Illustration by Sabine Deviche



Worker Ant
Did you know that all worker ants are girls? There are no boy worker ants.
Learn more about ants - http://askabiologist.asu.edu/explore/ant-anatomy

Illustration by Sabine Deviche



Worker Ant with Stinger
Did you know that not all ants have stingers? Watch out this one does.
Learn more about ants -
http://askabiologist.asu.edu/explore/ant-anatomy

Illustration by Sabine Deviche

Objectives

For the educator

1. Students will be familiar with the anatomy of an ant
2. Students will recognize the different stages of an ant's individual life cycle
3. Students will be able to explain the roles of different castes in a colony (males, female workers, queen)
4. Students will understand the ant colony life cycle

Readiness

Perform simple measurements and comparisons
Observe and describe changes in a simple system
Describe the basic needs of living organisms

Foundations

Identify and record changes and patterns of changes in a familiar system
Identify the basic anatomy of an ant
Describe and explain cause-and-effect relationships in living systems
Recognize that different species of ants have similarities and differences

Essentials

Organize and present data gathered from their own experiences, using appropriate mathematical analyses and graphical representations

For the student experimenter

1. To observe the effect of the environment on ant behavior
2. To practice the scientific method

Readiness

Collect, organize and describe simple data
Construct concrete displays of data; read and interpret elementary tables, graphs and charts

Foundations

Collect and analyze data using the concepts of largest, smallest, most often, least often and middle
Construct, read and interpret displays of data to make valid decisions, inferences and predictions
Demonstrate that a single object has different attributes that can be measured in different ways (e.g. Length, mass/weight, time, temperature, area and volume)
Explain the concepts related to units of measure and demonstrate the process of measurement with non-standard (e.g., using paper clip lengths), U.S. customary and metric units

Essentials

Construct, read, analyze and interpret tables, charts, graphs and data plots (e.g., box-and-whisker, stem-and-leaf, and scatter plots)

Display and use measures of range and central tendency (i.e., mean, median and mode)

Estimate, make and use measurements (U.S. customary and metric) to describe and make comparisons

Develop and use formulas and procedures to solve problems involving measurements

Proficiency

Construct and draw inferences including measures of central tendency, from charts, tables, graphs and data plots that summarize data from real-world situations.

Standards

National Science Education Standards

Unifying Content Standard: K-12

As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

• Constancy, change, and measurement

CONTENT STANDARD C: K-4

As a result of activities in grades K-4, all students should develop understanding of:

• The characteristics of organisms
• Life cycles of organisms
• Organisms and environments

CONTENT STANDARD C: 5-8

As a result of their activities in grades 5-8, all students should develop understanding of:

• Structure and function in living systems

National Math Standards

Instructional programs from prekindergarten through grade 12 should enable all students to:

• Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
• Develop and evaluate inferences and predictions that are based on data
• Select and use appropriate statistical methods to analyze data
• Understand measurable attributes of objects and the units, systems, and processes of measurement
• Apply appropriate techniques, tools, and formulas to determine measurements

Arizona Science Standards

Kinder - 4th grade

SC00-S1C1-02 SC01-S1C1-01 SC01-S1C1-02 SC02-S1C1-02 SC03-S1C1-01 SC04-S1C1-02	Ask questions based on experiences with objects, organisms and events in the environment (see M01-S2C1-01) Compare common objects using multiple senses Ask questions based on experiences with objects, organisms and events in the environment (see M01-S2C1-01) Predict the results of an investigation Formulate relevant questions about the properties of objects, organisms, and events of the environment using observations and prior knowledge Formulate a relevant question through observation that can be tested by an investigation (see M04-S2C1-01)
SC00-S1C2-01 SC00-S1C2-02 SC00-S1C2-03 SC01-S1C2-02 SC01-S1C2-03 SC01-S1C2-04 SC02-S1C2-02 SC02-S1C2-03 SC02-S1C2-04 SC03-S1C2-03 SC03-S1C2-04 SC03-S1C2-05 SC04-S1C2-04 SC04-S1C2-05	Demonstrate safe behavior and appropriate procedures Participate in guided investigations in life, physical, and earth and space sciences Perform simple measurements using non-standard units of measure to collect data. Participate in guided investigations in life, physical, and earth and space sciences Use simple tools such as rulers, thermometers, magnifiers, and balances to collect data (US customary units) Record data from guided investigations in an appropriate format (e.g., lab book, log, notebook, chart paper). Participate in guided investigations in life, physical, and earth and space sciences Use simple tools such as rulers, thermometers, magnifiers, and balances to collect data (US customary units) Record data from guided investigations in an appropriate format (e.g., lab book, log, notebook, chart paper). Conduct simple investigations in life, physical and Earth and space science Use metric and U.S. customary units to measure objects Record data in an organized and appropriate format (e.g., t-charts, table, list, written log). (See W03-S3C2-01 and W03-S3C3-01) Measure using appropriate tools (e.g., ruler, scale, balance) and units of measure (i.e., metric, U.S. customary). Record data in an organized and appropriate format (e.g., t-charts, table, list, written log). (See W04-S3C2-01 and W04-S3C3-01)
SC00-S1C3-02 SC01-S1C3-02 SC02-S1C3-01 SC02-S1C3-02 SC02-S1C3-04 SC03-S1C3-01 SC03-S1C3-04 SC04-S1C3-01	Compare objects according to their measurable characteristics (e.g., longer/shorter, lighter/heavier) Compare the results of the investigation to the predictions made prior to the investigation Organize data using graphs, tables and journals Construct reasonable explanations of observations on the basis of data obtained Generate questions for possible future investigations based on the conclusions of an investigation Organize data using the following methods with appropriate labels: bar charts, tally charts. Generate questions for possible future investigations based on the conclusions of the investigation Analyze data obtained in an investigation to identify trends
SC00-S1C4-01 SC02-S1C4-02 SC04-S1C4-02	Communicate observations with pictographs, pictures, models and/or words Communicate with other groups to describe the results of an investigation Choose an appropriate graphic representation for collected data
SC01-S4C1-01 SC02-S4C1-01	Identify the following as characteristics of living things: growth and development, reproduction, response to stimulus Identify animal structures that serve different functions
SC02-S4C2-01	Describe the life cycle of various insects

SC00-S4C3-03 SC03-S4C3-01	Describe changes observed in a small system (e.g., ant farm, plant terrarium, aquarium). Identify the living and non-living components of an ecosystem

5th-8th grade

SC05-S1C1-02 SC06-S1C1-02	Formulate predictions in the realm of science based on observed cause and effect relationships Formulate questions based on obserbvations that led to the development of a hypothesis (See M06-S2C1-01)
SC05-S1C2-04 SC05-S1C2-05 SC06-S1C2-05 SC07-S1C2-05 SC08-S1C2-05	Measure using appropriate tools (e.g., ruler, scale, balance) and units of measure (i.e., metric, Us.S. customary). (See M05-S4C4-01) Record data in an organized and appropriate format (e.g., t-chart, table, list, written log). (See W05-S3C2-01 and W05-S3C3-01). Keep a record of observations, notes, sketches, questions, and ideas using such tools as written and/or computer logs. (See W06-S3C2-01 and W06-S3C3-01) Keep a record of observations, notes, sketches, questions, and ideas using such tools as written and/or computer logs. (See W07-S3C2-01 and W07-S3C3-01) Keep a record of observations, notes, sketches, questions, and ideas using such tools as written and/or computer logs. (See W08-S3C2-01 and W08-S3C3-01)
SC05-S1C3-01 SC06-S1C3-01 SC07-S1C3-01 SC08-S1C3-01	Analyze data obtained in a scientific investigation to identify trends and form conclustions (See M05-S2C1-03) Analyze data obtained in a scientific investigation to identify trends (See M06-S2C1-03) Analyze data obtained in a scientific investigation to identify trends (See M07-S2C1-03 and M07-S2C1-08) Analyze data obtained in a scientific investigation to identify trends (See M08-S2C1-08)
SC05-S1C4-02 SC06-S1C4-01 SC06-S1C4-02 SC07-S1C4-01 SC07-S1C4-02 SC08-S1C4-02	Choose an appropriate graphic representation for collected data: bar raph, line graph, Venn diagram, model. (See M05-S2C1-02) Choose an appropriate graphic representation for collected data: line graph, double bar graph, stem and leaf plot, histogram. (See M06-S2C1-02) Display Data collected from a controlled investigation (See M06-S2C1-02) Choose an appropriate graphic representation for collected data: line graph, double bar graph, stem and leaf plot, histogram. (See M07-S2C1-03) Display Data collected from a controlled investigation (See M07-S2C1-03) Choose an appropriate graphic representation for collected data: line graph, double bar graph, stem and leaf plot, histogram. (See M08-S2C1-03)
SC06-S4C1-06	Relate the structures to their functions

High school

SCHS-S1C1-02	Develop questions from observations that transition into testable hypotheses
SCHS-S1C2-05	Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs and computers
SCHS-S1C3-06 SCHS-S1C3-07	Use descriptive statistics to analyze data, including: mean, frequency, range Propose further investigations based on the findings of a conducted investigation
SCHS-S1C4-02	Produce graphs that communicate data
SCHS-S4C3-02	Describe how organisms are influenced by a particular combination of biotic (living) and abiotic (nonliving) factors in the environment

Arizona Math Standards

Kinder - 4th grade

M00-S2C1-01	Formulate questions to collect data in a contextual situation
M01-S2C1-01	Formulate questions to collect data in a contextual situation
M01-S2C1-02	Make a simple pictograph or tally chart with appropriate labels from organized data
M02-S2C1-01	Formulate questions to collect data in a contextual situation
M03-S2C1-01	Formulate questions to collect data in a contextual situation
M03-S2C1-02	Construct horizontal bar, vertical bar, pictograph or tally chart with appropriate labels and title from organized data
M04-S2C1-01	Formulate questions to collect data in a contextual situation
M04-S2C1-02	Construct a single-bar graph, line graph or two set Venn diagram with appropriate labels and title from organized data
M01-S3C4-01	Identify the change in a variable over time (e.g., object gets taller, colder, heavier, etc.)
M02-S3C4-01	Identify the change in a variable over time (e.g., object gets taller, colder, heavier, etc.)
M04-S3C4-01	Identify the change in a variable over time (e.g., object gets taller, colder, heavier, etc.)
M00-S4C4-01	Verbally compare objects according to observable and measurable attributes
M00-S4C4-02	Communicate orally how different attributes of an object can be measured
M01-S4C4-01	Compare the measurable characteristics of two objects (e.g., length, weight, and size)
M01-S4C4-07	Measure a given object using appropriate unit of measure
M02-S4C4-06	Measure a given object using appropriate unit of measure
M03-S4C4-08	Compare the length of two objects using u.s. customary or metric units
M04-S4C4-03	Select an appropriate tool to use in a particular measurement situation

5th-8th grades

M05-S2C1-01	Formulate questions to collect data in a contextual situation
M05-S2C1-02	Construct a double-bar graph, line plot, freuency table or three-set Venn diagram with appropriate labels and title from organized data
M05-S2C1-05	Identify the mode(s) and mean (average) of given data
M05-S2C1-07	Compare two sets of data related to the same investigation
M06-S2C1-01	Formulate questions to collect data in contextual situations
M06-S2C1-05	Find the mean, median (odd number of data points), mode, range and extreme values of a given numerical data set
M06-S2C1-06	Identify a trend (variable increasing, decreasing, remaining constant) from displayed data
M06-S2C1-07	Compare trends in data related to the same investigation
M07-S2C1-01	Formulate questions to collect data in a contextual situation
M07-S2C1-06	Find the mean, median, mode and range of a given numerical set
M07-S2C1-07	Interpret trends from displayed data
M07-S2C1-08	Solve contextual problems using bar graphs, tally charts, and freuency tables
M08-S2C1-01	Formulate questions to collect data in contextual situations
M08-S2C1-03	Determine when it is appropriate to use histograms, line graphs, double bar graphs and stem-ad-leaf plots
M08-S2C1-08	Compare trends in data related to the same investigation
M06-S4C4-11	Determine the actual measure of objects using a scale drawing or map

High School

MHS-S2C1-02	Organize collected data into an appropriate graphical representation
MHS-S2C1-03	Display data as lists, table, matrices, and plots
MHS-S2C1-04	Construct equivalent displays of the same data
MHS-S2C1-10	Apply the concepts of mean, median, mode and quartiles to summarize data sets.