INTRIGUING INVERTEBRATES

Background Information, Hands-on Activities, Teacher and Student Resources

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TEACHER RESOURCE PACKAGE

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BACKGROUND INFORMATION

You were enjoying the hot sun and a delicious summer lunch on the beach. However, your beautiful serene picnic has been disturbed by an annoying deer fly that keeps buzzing around your head. Unexpectedly, you feel something crawling on your skin…ugh, get it off. Then you remember your class discussion on insects…maybe you should think twice and take a second look before swatting it. Wow – it is a stunning emerald green dragonfly. You watch it spin and turn to maximize the warmth of the sun. Suddenly it takes off and then abruptly swoops back towards your head – no, it did not launch an attack on you but instead it just ate that buzzing deer fly. Thanks to this amazing creature your picnic is peaceful once again!

We are outnumbered by bugs! There are more of them than humans, they have lived on Earth longer than humans and they adapt to change faster than humans. Bugs are invertebrates and do not have a backbone or vertebrae. The animal kingdom is classified into approximately 35 different phyla, or large groups, of which many contain creatures we would consider as bugs, including:

- Arthropods – insects, crustaceans, arachnids (spiders), centipedes and millipedes;
- Annelids – earthworms;
- Molluscs – snails and slugs.

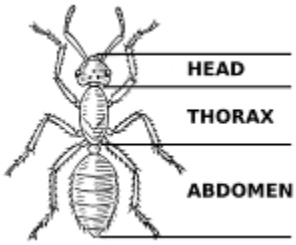
The World of Arthropods

Arthropods are characterized by having an exoskeleton, a tough hard skin that is similar to a close-fitting suit of armor. It gives the creature shape and support as well as protects its inner body organs. As an arthropod grows, it molts, sheds its old skin and grows a new one. This process begins when a new layer forms under the exoskeleton. The exoskeleton then splits open near the head and the bug wriggles out of it. Some arthropods molt many times in their lives.

Insects

Insects are the largest group of bugs with over one million identified species in the world. Scientists estimate that there could be as many as 5 to 6 million more that are unidentified. Currently, the identified insect species represent about 80% of animal species worldwide; as well they have the largest biomass of terrestrial animals. Entomologists are scientists that study insects, identify new species and classify them into different groups based on key features they share. Common insects include beetles, dragonflies, damselflies, cicadas, houseflies, crickets, cockroaches, butterflies, bees and wasps.

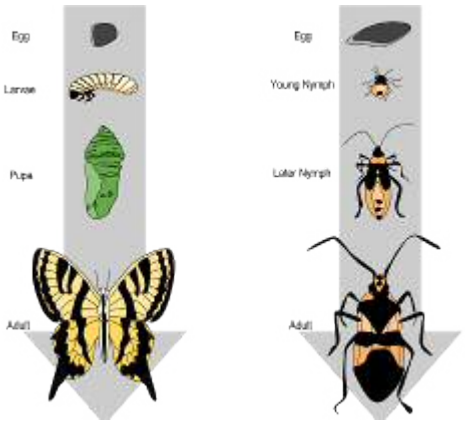
Insects are arthropods that are characterized by having six legs and three body parts; head, thorax and abdomen. On its head are mouthparts, eyes and antennae. The legs are attached onto the thorax as are the wings, if present. Most insects have one or two pairs of wings at some stage in their life, which allow them to fly away as an adaptation that helps them survive. Other adaptations include camouflage and being night-dwellers.



Insect Life Stages and Metamorphosis

Most insects lay eggs, usually near a food source for the young ones. A few insects, such as aphids, give birth to live young. Among insects, there are three different classifications of development based on the degree of change and the stages involved. One type of development involves very little change, as the insect, such as a silverfish, is born looking as a young adult and simply grows bigger as it gets older. Most insects however go through one of the other two types of development, either complete or incomplete metamorphosis. Metamorphosis means to transform or change.

Complete metamorphosis involves four stages of development which include eggs, larvae, pupae and adults and at each stage, the creatures look different. The adult insect lays eggs. The larvae that hatch from the eggs are worm-like creatures. If it is a larva of a moth or butterfly, it is called a caterpillar. Larvae have huge appetites and they can eat several times their body weight every day. At the end of the larval stage, they develop a hardened skin and pupate. During the pupal stage, they do not eat or move. The pupa of a butterfly is called a chrysalis and is a hardened protein casing. The pupa of a moth is within a cocoon that has been spun from silk. The pupae change and slowly turn into adult insects. Ants, wasps, beetles, flies, butterflies and moths are examples of insects that undergo complete metamorphosis.



Source: https://commons.wikimedia.org/wiki/File:Holometabolous_vs._Hemimetabolous.svg

Some insects undergo the three stages of incomplete metamorphosis which include eggs, nymphs and adults. The eggs hatch and the young nymphs often look like adults but not exactly. For example, they may have small wings or none at all, like a cockroach. The nymphs will shed their thin exoskeletons as they get bigger. Aphids, grasshoppers, termites, dragonflies, cockroaches, praying mantises, crickets and lice are examples of insects that undergo incomplete metamorphosis.

Arachnids

Another common arthropod group is arachnids which include spiders, scorpions, mites and ticks. There are more than 40 000 species of spiders in the world. They are an important animal to have around as they hunt other bugs and keep many bugs under control. Some spiders make webs to catch food; others, like the crab spider, lurk in flowers hunting bugs; while some, such as the jumping spider, search for prey. Spiders are not insects as they have eight legs and two body parts, the cephalothorax (fused head and thorax) and abdomen. Spiders have long legs covered with tiny hairs that detect small vibrations. Once spiders are close enough to their prey, they stab their fangs into the prey to inject venom. Once the prey has died, they squirt digestive juices on the body to make it more edible.

Crustaceans

Terrestrial crustaceans include pill bugs and sow bugs. They are important detritivores that further break down decomposing organic material and help turn it into soil. They have 14 legs and a flat body that is divided into several segments. These gentle creatures are fun and interesting to observe.

Centipedes and Millipedes

These arthropods have the most legs of any invertebrate. The carnivorous centipede has about 30 legs and the millipede, a detritivore, has up to 700 legs. Their bodies are divided into a head with antennae and many rings, called segments.

A FEW OTHER COMMON BUGS

Earthworms

Earthworms belong to the group of annelids and they have many adaptations to survive in the soil. They are creatures with a soft body, no antennae and many body segments. They do not have eyes but rely on their sense of taste. Their skin is covered with many sensitive nerves to help them detect food.

Snails and Slugs

These common creatures are types of molluscs. Snails have a shell whereas slugs do not. They have one or two pairs of tentacles and a flat underpart on its body called a muscular foot.

Bug's Habitat and Habits

Like all living things, bugs need food, water, shelter and conditions for breeding. Bugs live in a huge variety of habitats around the world, from the hot desert sands to the cold snowy mountain rocks. In our own backyards, bees and butterflies live near flowers, dragonflies live near ponds and streams and pill bugs live in leaf litter. Some insects live in very different environments at different stages of their life. Dragonflies, for example, begin life in freshwater but once they change into adults, they take to the air.

Most bugs live a solitary lifestyle, although some well-known insects are social. Social insects include termites, ants and some bees and wasps. These insects live together in large groups or colonies, similar to a city, with each insect having its own job. They use chemicals to communicate and cooperate in food gathering, defense and rearing their young.

Relationship of Bugs to Humans

Most bugs are either harmless or beneficial. Insect pollinators are a farmer's friend as many species help pollinate plants that are then able to produce fruit for human consumption and seeds for new plants. When a bee visits a flower to drink its nectar, the bee's hairy body picks up grains of pollen and carries them to the next flower. Here the pollen brushes off against the pistil, the female reproductive part of a flower, and pollinates the flower so it can produce fruit and seeds. Pollinators are specially adapted to feed on specific types of flowers. Bees can open petals to reach inside for pollen and nectar. Butterflies prefer flowers shaped like a narrow tube for their specialized tongue, called a proboscis, to draw up nectar and hoverflies prefer flat flowers as they have a short tongue. Pollinators improve the quality and quantity of food that we eat and are responsible for bringing us approximately one out of every three bites of food.

Insects provide us with many other useful products such as silk scarves, from silkworm cocoons; honey and beeswax, from bee hives; dye in makeup, from parasitic beetle bodies; and shellac, from lac insect resin secretions. Another beneficial impact is from bugs that feed on dead plant and animal remains, known as organic matter. As they feed on organic matter, they add nutrients to the soil and make it easier for plant roots to grow through the soil. Fruit flies are used in research to study genetics and pollution; as they are easy to raise and feed, produce lots of young and have short life cycles. Insects and bugs are the sole food source for many animal species and a critical part of many food chains and food webs. For humans in many countries, they represent an alternative and sustainable source of protein. Grubs, locusts, cicadas, scorpions, crickets, caterpillars, spiders, termites, ants and large beetles have been a significant diet for thousands of years and among some cultures are considered delicacies. Entomophagy, the technical term for eating insects, is prevalent in many countries and over 1900 species of insects make up the diet of over two million people worldwide.

Less than one percent of all insect species are pests, yet they are the most known. Pests impact our lives by feeding on agricultural crops and trees, competing for food or transmitting diseases to humans or livestock. For example, ticks spread Lyme disease and mosquitoes spread West Nile virus. There are some insects, such as aphids and grasshoppers that cause crop damage as a result of feeding on plant tissues. Other insects do indirect damage by transmitting a viral, fungal or bacterial infection to plants. Dutch elm disease is caused by a fungus and is most often transmitted by a bark beetle. As an alternative to chemical pesticides, beneficial insects can be used as pest control. Ladybugs are natural insect predators of aphids and successfully control aphid populations, particularly in enclosed environments like a greenhouse.

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ACTIVITY ONE

Time: 30-60 min

Key Terms: food chain

Group Size: Individual

Materials (per student):
Nested Food Chain datasheet

Pencil and/or pencil crayons

Research time using books or computer

4 precut rectangle sheets of paper, preferably cardstock, in two colours (e.g., beige and green) as follows:

- 4cm x 10cm, green
- 8cm x 16cm, beige
- 12cm x 21cm, green
- 16cm x 28cm, beige

Scissors

Glue or tape

NESTED FOOD CHAIN

Learning Goal: Students will learn about a bug's importance in a food chain.

Living things need food and energy to survive. Animals get energy from the food they eat. Similar to nested Russian dolls, or Matryoshka dolls, a food chain illustrates how nutrients and energy are passed from one living creature to another. Some animals, called herbivores, eat plants, while other animals, called carnivores, eat other animals. Omnivores eat both animals and plants.

Procedure:
Before Class:

1. Before class, precut four rectangular pieces of paper for each student. Cardstock works well as the tubes stand better. Alternating colours helps students to visualize each level. The four sizes should be: 4cm x 10cm; 8cm x 16cm; 12cm x 21cm and 16cm x 28cm.

Activity:

2. Provide students with a *Nested Food Chain* datasheet, pencil and/or pencil crayons. Instruct students to select a favourite bug that they would like to learn more about. Provide students with time on the computer and with books to help them research different bugs.
3. Have students draw or write the name of their favourite bug in the #2 rectangle of the datasheet.
4. Have students research what their bug's favourite food might be. Have students draw or write the name of the food item in the #1 rectangle on the datasheet. The food item may be plant or animal, depending on the type of bug they chose.
5. Have students identify a creature that might eat their bug. Have them draw or write the name of the food item in the #3 rectangle on the datasheet.
6. Have students determine what might eat the animal they selected for the #3 rectangle. Have them draw or write the name of the food item on the last largest rectangle shape, #4.
7. Have students cut out each of the rectangular shapes.
8. Provide each student with four precut rectangle sheets of coloured cardstock. Have students glue or tape their numbered rectangular shapes such that:
   - #1 is glued in the centre of the 4cm x 10cm piece;
   - #2 is glued in the centre of the 8cm x 16cm piece;
   - #3 is glued in the centre of the 12cm x 21cm piece;
   - #4 is glued in the centre of the 16cm x 28cm piece.

9. Have students create a tube with each rectangular shape and either glue or tape the ends together.
10. Have students place the smallest tube upright. Have students nest the shapes to illustrate the concept of a food chain and that energy and food moves up the food chain.
11. Ask students what would happen to their food chain if their bug was extinct.

Observations:

Some sample food chains that students may have discovered include:

- grass → grasshopper → sparrow/bird → hawk
- aphid → ladybug → spider → bird
- house fly → spider → toad → snake
- animal blood → mosquito → dragonfly → frog
- flower/nectar → butterfly → frog → heron.

Discussion:

While students created their food chains, they may have realized that some classmates had selected herbivores and others selected carnivores as their favourite bug. A close examination of a bug's anatomy, and in particular its mouthparts, provides us with clues as to what they might prefer to eat. For example, bugs such as a praying mantis, with legs adapted for grasping and chewing mouthparts, are carnivorous. Flies have a sponge for a tongue to absorb liquid. Bees and butterflies have a straw-like mouth part, called a proboscis, to suck up sweet nectar from flowers. Dragonflies have strong toothed mandibles for chewing. Examining the physical characteristics of bugs, in addition to a study of their behaviour, helps scientists determine a bug's role in the food chain.

Although many people consider insects and bugs as pests, they are essential for many reasons. Many plants would disappear due to the loss of insect pollinators, insect-eating animals such as spiders would starve, larger predators would lose their food source, food chains would collapse and entire ecosystems could crash without bugs. It would be detrimental to the world if there were no bugs. Another very important role bugs have in our world is as detritivores. A detritivore eats plant and animal waste and plays an important role in decomposing organic materials and turning it back into nutrients that plants use to survive and grow.

Extensions:

1. Have students extend their food chain to include other levels within a food chain including the sun, producers and decomposers.
2. Have students share their nested creations by placing all the tubes upright on a table. Have students take turns creating new food chains by selecting different creatures/tubes from the assortment available.

FUN FACT!

Living Thermometer!

The snowy tree cricket has a regular rate of chirping that is related to the ambient temperature. If you count the number of chirps in eight seconds and add four, you'll have the approximate temperature in Celsius!

Name:

NESTED FOOD CHAIN

1.

2.

3.

4.

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ACTIVITY TWO

Time: 15-30 min

Key Terms: surface tension

Group Size: Small table groups

MUSIC AND MOTION

Learning Goal: Students will learn about how some insects communicate and how some insects move.

The insect world is pretty amazing when you take a closer look and listen intently. By late summer and early fall, the night sounds are a chorus of insects ranging from trills to chirps, scrapes and buzzes. Water striders are a common freshwater insect and are often seen skimming the surface of ponds and streams. They are carnivorous insects that seem to literally walk on water.

PART A. MUSIC – SINGING SONGS OF INSECTS:

Materials (per table group):
Variety of sanding materials of differing grit (the lower the grit number, the coarser it is); a good selection may include emery boards (rough side is usually 100 grit) as well as 80 grit, 120 grit and 220 grit sandpaper

Variety of paper materials of differing thickness such as index cards, cardstock, pieces of cardboard and boxboard

Variety of different toothed combs

Procedure:
1. Listen to sound clips of different insects. Some suggestions include:
   - http://songsofinsects.com/identification-basics (26/07/21), brief clips of different sounds of crickets and katydids.
   - http://songsofinsects.com/biology-of-insect-song (26/07/21), click on "singing insect sound sampler".
   - https://www.youtube.com/watch?v=9XSsHJjLJq0 1:40min (26/07/21), insect sounds recorded in Alberta.
2. Ask students if they can come up with ideas as to how insects make these sounds.
3. Provide each table group with a variety of sanding materials, toothed combs, and paper pieces.
4. Encourage students to experiment with the materials and challenge them to make insect-like noises. Ask students if they can explain how the items they are using are making sounds. Can they now think of ways insects might make noises?

Observations:
Students will have discovered that they are able to make rasping sounds when they hold an index card, or other paper piece, upright and rub sand paper along the edge. Students will have discovered they can make different sounds depending on the combs and materials they are using.

Discussion:
Insects use their body parts like instruments to make sounds to communicate. Insect songs are usually performed by males to attract females while others use it as a scare tactic on predators or to defend their territories. The sounds insects make depend on the species. Some species look identical, yet their songs are very unique and identifiable.

When sandpaper was rubbed over the paper, the rough surface of the sandpaper plucked the papers edge causing it to vibrate and create a sound. Insects such as crickets, katydids and grasshoppers produce sound in the same way. These insects make sounds by rubbing two body parts, usually one sharp-edged and the other rough or file-like, against each other. This is called stridulation. Crickets and

katydids make music by rapidly rubbing their forewings together to make noise. The scraper, or sharp edge on the upper surface of the lower wing, rubs against the file, the row of bumps or serrated teeth on the underside of the upper wing. The wings amplify the sound so other insects can hear. Katydids may rub their wings together up to 50 million times in one summer! In contrast, grasshoppers rub the rough surfaces of their large hind legs against their bodies or wings to produce sounds. Some grasshoppers use a different technique of rapidly snapping their wings to create a crackling noise as they fly.

Other insects create sounds using different methods. For example, cicadas make a very loud buzzing noise that sounds similar to heavy power lines or fluorescent lights. They produce this sound by contracting special muscles. Cicadas have a pair of drum-like membranes on their abdomens. Inside the abdomen's air chamber is a group of muscles attached to the drumhead. As they tighten the muscles, the drumhead is tense, like pulling back on an elastic band. When the muscles relax, the drumhead vibrates and the vibrations hit the inside of the abdominal walls and produce sound. Another example of a different method of creating sound is the loud whining of mosquitos and buzzing of bees. These sounds are due to the speed of their wings beating. The faster their wings beat, the higher the pitch will be.

The following clips are close-up videos of insects making various sounds:

- https://www.youtube.com/watch?v=CQFEY9RIRJA 1:15 min (26/07/21), cricket chirping;
- https://www.youtube.com/watch?v=8E6q9W8Ur2k 2:11 min (26/07/21), close-up of cricket's wing while chirping;
- https://www.youtube.com/watch?v=nyglT-rWE5c 1:13 min (26/07/21), grasshopper sounds;
- https://www.youtube.com/watch?v=S42Nd1APmzs 0:39 min (26/07/21), katydid sounds using wings.

Extension:
Keep crickets in a jar as classroom pets and listen to the sounds that they make. Crickets can be readily purchased in pet stores as they are a common food source for pet reptile owners. Place a wet sponge in the jar to provide the crickets with moisture and feed them a variety of food such as tender leafy greens, fruit slices and grains. Ensure the lid has holes to allow them to breathe or alternatively use a piece of cheesecloth secured with elastic bands as the lid. Adult crickets live for about 1-2 months. If considering releasing the crickets following class observation time, check with the store where they were purchased to ensure they are a native species.

FUN FACT!

First Sound

Fossil evidence suggests that insects were the earliest organisms to produce sounds and to sense them.

PART B. MOTION – WALK ON WATER:

Materials (per table group):

Transparent plastic or glass bowl(s), two-thirds full of water

Tweezers

Forks

Small squares (2cm x 2cm) of tissue paper or paper towel

Handful of small metal paperclips

Procedure:

1. Discuss different habitats that insects live in. Ask students if they have seen insects in freshwater, such as a pond. How do they move?
2. Provide each table group with a few paper clips and a transparent bowl(s) filled 2/3 full with water.
3. Have students drop a paper clip into the water. Ask students what they observe.
4. Provide students with a pair of tweezers, forks and small squares of tissue paper. Challenge students to find ways to make the paper clip float.
5. Have students look closely at a floating paper clip. Ask students if they can explain how it floats. Can they now think of ways that an insect floats and adaptations it might have?

Observations:

Students will have observed that when a paper clip is dropped into the bowl that it sank to the bottom.

Students will have discovered that they are able to make a paper clip float any number of ways:

- using tweezers, the paper clip could be gently placed horizontally on top of the water;
- using a fork, the paper clip could be gently placed horizontally on top of the water and the fork could be moved out from under the clip;
- using another paper clip that is unfolded, a paper clip could be balanced on top of it and placed gently in the water (similar to using a fork);
- using tissue paper, the paper clip could be placed on top of a floating piece of tissue paper. Eventually the tissue paper would sink or it can be pushed down and the paper clip would be left floating.

Students will have observed, upon close examination of the floating paper clip that it appears that the water is bulging near the paper clip. The paper clip was held up by the surface tension of the water. If the tension was broken, the paper clip sank to the bottom.

Discussion:

The cohesion of water forms a very strong, skin-like surface where it meets the air. Water is made up of tiny particles called molecules that attract and repel each other. This attraction, called hydrogen-bonding, is very strong between water molecules and it requires a lot of energy to break these bonds. This gives water a very high surface tension, which results from the inward attraction of the other water molecules. If the conditions are right, then the water molecules can support an object. If the object is too dense, then it will break through the surface and sink.

Specially adapted insects can stay afloat by taking advantage of the properties of surface tension. The common water strider, for example, has feet that are designed to keep the animal on the surface. Their water-repellent feet are covered with hairy tufts that act like snowshoes and spread the insect's weight over the surface so it can 'stride'. Their back legs work like rudders and steer the water strider from behind. Their front legs detect ripples from drowning insects. Water striders then pounce on other insects that have landed accidentally in the water and stab them with their jaws. Their claws are not on their feet but part way up their legs. This prevents the claws from breaking the water's surface tension.

Extension:
Visit a pond or stream and look for insects on top and in the water. Water striders are commonly seen on the surface of the water. Have students observe the surface and wait for insects to come to the surface to breathe. Some of these insects are full-time water animals and some leave the water when they grow up. For example, a damselfly nymph stays in the water for two years and then climbs out to start its adult life. It sheds its skin one last time and then unfolds its wings so that it can fly away. Many underwater insects have wings that propel them through the water. Mosquito larvae have tiny snorkels and will dive down when they are disturbed but will come back to the surface in a few minutes.

FUN FACTS ABOUT BUGS

Bugs do not have lungs, most have compound eyes and they are cold-blooded.

Bugs are the only group of invertebrates to have developed flight.

Insects live on every continent – barely. Only one type of insect lives on Antarctica.

The only biosphere where there are no insects is the ocean.

The dung beetle is the strongest insect in the world and can pull over 1, 100 times its own body weight, which is like a human pulling six double-decker buses.

Image Source: https://www.vecteezy.com/free-vector/nature; Nature Vectors by Vecteezy (01/25/22)

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ACTIVITY THREE

Time: 30 min

Group Size: Pairs

Materials:

For Classroom:
Glass or plastic terrarium for holding bugs or a plastic box and lid with breathing holes poked in it or alternatively, create a lid using cheesecloth secured with two elastic bands

Materials for terrarium including soil, leaf litter, bark, wet sponge and food such as a piece of peeled potato or apple

Per Group (pair):

Bug Observation:
Washed and cleaned recycled plastic containers, such as apple sauce or fruit containers

Two soft paintbrushes

Sheet of blank paper

Variety of materials to create a maze such as leaves, twigs and toilet paper tubes

Pill/sow bug

Magnifiers, optional

MAZE RUNNER

Learning Goal: Students will closely observe bugs and learn about their behaviour.

Pill bugs, commonly known as roly-polys, and sow bugs are small terrestrial crustaceans that are commonly found in damp places such as leaf litter and under rocks. These creatures, also known as potato bugs, are easy to find outside and excellent creatures for studying and observing in the classroom for a short period of time. Sow bugs have a feathery appearance on their sides, while pill bugs are smoother and more rounded. When pill bugs are picked up they often roll into a ball whereas sow bugs usually do not.

Procedure:
BEFORE CLASS:

1. Examine the schoolyard for pill/sow bugs in damp, dark places. If few are found, create additional habitats a week before taking the class outside. A habitat can be created by laying down a sheet of plywood or dark plastic on the ground, preferably with vegetation underneath. Alternatively, a pile of damp grass clippings also creates a great habitat for these decomposers. Pill/sow bugs will move into the habitat within a few days.
2. Create a classroom habitat for the bugs to keep them for a day or two. Use a terrarium or create a terrarium by recycling a large plastic container with a secure lid. Ensure the lid has holes in it to allow air circulation. Add about 5 cm of soil at the bottom of the terrarium. Add some wet leaves, bark pieces, a small wet square sponge for a water source and some peeled potato or apple as a food source.

ACTIVITY:

3. Show students pictures of pill/sow bugs and ask them if they have any ideas where they might find these creatures.
4. Provide each pair of students with a clean, small plastic container and a pair of soft paintbrushes. Explain to students that they will be searching and collecting pill/sow bugs. Illustrate safe and careful handling procedures of the bugs by using the soft paintbrushes to direct the pill/sow bugs to crawl into the containers.
5. Take the class terrarium outside with students. Using small plastic containers and paint brushes, have students collect pill/sow bugs by searching under objects, rocks and leaf litter. Once students have collected a bug in their container, it

Bug Experiment (optional):

Cereal box

Scissors

Masking tape

Marker and ruler

Dead, damp leaves

Figure 1:

Figure 2:

Figure 3:

Figure 4:

can be transferred carefully into the terrarium by turning the small container on its side and letting the bug slide out.

6. Keep the terrarium in a dark place in the classroom. After a day, have students look in the terrarium and ask them what they notice. Where are the bugs found? Do they notice anything about the leaves or potato piece?
7. For a close-up observation of pill/sow bugs, provide each pair of students with a sheet of white paper and materials to create a maze for their bugs such as leaves, twigs and toilet paper rolls. Provide each pair of students with two soft paintbrushes and a small plastic container containing a pill/sow bug.
8. Have students gently place their bug on the sheet of blank paper by letting it slide out of the container. Allow time for students to observe how they move. When the bugs move off the paper, have students carefully direct them back onto the paper or small plastic container using their paintbrushes.
9. Have students create mazes out of toilet tube rolls, leaves and twigs. Have students observe how pill/sow bugs navigate through the maze. Place bugs back in terrarium.
10. For an interesting optional experiment, provide each pair of students with a cereal box, scissors, marker, masking tape and ruler to create a maze for a habitat preference experiment.
11. Have students lay the box down and cut out the front panel/one side of the box as shown in Figure 1.
12. Have students cut the front panel into three strips. To ensure students cut straight, have them first draw lines with rulers. These strips will be used to create the maze within the box and it is important that they are flush to the bottom and that there are no gaps for bugs to crawl through. If the edges appear very crooked, recut them to create straight edges.
13. Two strips will be used to create a passageway for the bugs. Fold one end of a strip about 1/3 of the way down as in Figure 2. Have students make a second fold about 2 cm from this edge. This 2 cm fold provides an edge to be taped to the inside of the box as in Figure 3. Have students secure the strips with masking tape. As pill bugs may avoid walking on masking tape, suggest students only tape on the side not being used by the pill bug which is towards the outside of the box. Ensure students tape the strips flush to the bottom to minimize gaps. Repeat with the second strip as in Figure 4.
14. Before adding the third strip, have students label the inside of the box, with a marker, as illustrated: the start of the passageway, X; top left corner, A and the top right corner, B.

Figure 5:

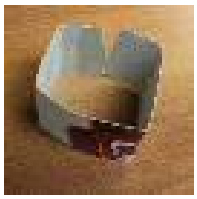

Figure 6:

15. The third strip will be used to create a T-junction. Fold each edge of the third strip about 1/3 of the way down. Fold each edge again about 2 cm to create a box as shown in Figure 5. Tape the small box into the larger box as shown in Figure 6.
16. Provide students with their own pill/sow bug, dead leaves and soft paintbrushes. Students can use a piece of scrap paper or leaves to move the bugs around.
17. Have students place their pill/sow bug at the X. Have students watch and record which side the pill/sow bug travels towards – A or B. Repeat at least three times.
18. Add damp, dead leaves on top of B. Repeat step 17. Ask students what they observed.

Observations:

Student will have observed that the pill/sow bugs in the terrarium were mostly under the bark and leaves. Students may have observed holes in the leaves and peeled potatoes/apples. Students will have observed how the bugs move and their use of antennae. If students created a maze box, they will have observed that the bugs will mostly travel towards the damp, dead leaves.

Discussion:

Pill/sow bugs prefer damp, dark locations as it offers them a place to hide. Sow bugs and pill bugs eat rotting plants. They have a fairly broad diet, and they live in their food, which means that you'll often find them munching on damp, rotten leaves and plants. Pill/sow bugs make small holes on leaves similar to those that a slug might make. When these bugs move, their antennae, often called feelers, wave around. The paired antennae are considered a bug's nose as they are mainly used for sense of smell. Antennae, made up of many individual joints, can vary greatly in size, shape and function among different bugs. Other than sense of smell to locate food and damp habitats, antenna functions may include sensing touch, air movement, heat, vibration and taste.

Extensions:

A variety of different conditions can be tested using the T-junction maze box. For example, students may examine:

- whether bugs prefer light or dark environments by creating a roof and covering up one end of the container.
- whether bugs have a food preference by offering different types of food such as carrot, apple or leaves.
- whether bugs have moisture preferences by testing dry and wet paper towels.
- whether bugs prefer certain textures by observing their navigation abilities and setting up different types of barriers with different textures, such as aluminium foil, dryer lint, leaves, bark, and Lego pieces. Do the bugs travel over or around them?

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ACTIVITY FOUR

Time: 60 min

Key Terms: metamorphosis, life cycle, eggs, larvae, cocoon, insect

Group Size: Class activity

Materials (optional):
Magnifiers

Tablet or camera

Small containers

Scissors or clippers

Paper

Pencils

Clipboards

Peeled crayons for rubbing

Umbrella or light-coloured sheet

Selection of field guides

Containers for bug collecting to bring into classroom

Classroom terrarium

BUG DETECTIVE

Learning Goal: Students will learn about identifying signs of bugs in their natural world.

Exploring the natural world is an ideal way to learn about bugs and their habitat. There are numerous signs and traces of bugs, many of which we are not aware of or look for on an everyday basis. These bug traces tell us information such as where they like to live, seasonal stage of development and the type of food they prefer.

Procedure:

1. Discuss with students the places that bugs like to live in the neighbourhood. Ask students what they have to look for when searching for signs of bugs.
2. Review metamorphosis and the various stages insects may be in during their life cycle including terms such as eggs, larvae, nymph, caterpillar, pupae, chrysalis and cocoon.
3. Collect a variety of tools for students to use and record observations, such as magnifiers; a tablet or camera for taking pictures; small containers for collecting live specimens; scissors or clippers for cutting stems; scrap paper and crayons for bark rubbings; as well as paper and pencil for drawing and recording findings.
4. Take the class on a bug hunt in the schoolyard, neighbourhood park or outdoor area. Different times of the year will reveal different traces and signs of bugs – autumn, mild winter days and late spring are all good times. In autumn and winter, cocoons, galls and nest-cases are easily spotted. In spring, there are many signs of young larvae feasting on new growth. Areas to take students to observe for traces and signs of bugs include:
    - tall grass;
    - small or medium-sized rocks, fallen branches or any objects stored outside;
    - leaf litter;
    - trees and shrubs;
    - gardens and flower-heads;
    - pavement cracks and crevices between walls and windows.

Ensure students are aware of potentially harmful bugs such as bees, wasps and ticks. Remind students to disturb the natural area as little as possible and to only move small rocks and branches. Instruct students to replace stones and fallen branches they overturn so that they leave the area as it was.

Below are some photos of some common signs that may be found.

5. The table on the subsequent page lists a variety of observations of bug signs and the types of bugs that create them.
6. If tunnels in bark are found, have students make a bark rubbing to take back to class. Ensure students rub with the peeled crayon held sideways to get the best picture.
7. If leaf miners are found, collect a sample of leaves to bring back to the classroom to hang on the window and trace the paths. As leaf miner larvae feed, in their wake they leave behind tissue that has dried out and died. This provides the ability to trace their path in the leaf.
8. While looking for signs of bugs, undoubtedly living specimens will be discovered. Additionally, to find some bugs to investigate close-up, take a white or light-coloured sheet and place under a tree or shrub. Alternatively, take an umbrella, open it up and place under the tree or shrub. Vigorously shake the shrub or tree branch, which will then cause the bugs on the leaves to fall and be collected in the umbrella or white sheet below. Be careful to not shake too hard to damage the plants.
9. Ask students if they think the discovered bug belongs to the insect group by examining whether they have six legs and three body parts. With assistance, have students try to identify the bugs using a field guide such as:
    - Ultimate Explorer Field Guide: Insects. Libby Romero. 2017. National Geographic. ISBN 13-9781426327407
    - Kaufman Field Guide of Insects of North America. Eric R Eaton and Kenn Kaufman. 2007. HarperCollins. ISBN 13-9780618153107
10. Encourage students to put the bugs back where they were found after observing them.
11. If collecting any bugs to take back to the classroom for a brief time, discuss the responsibility of looking after them properly. The temporary home should be an escape-proof container with snug-fitting lid and air holes or an open container with cheesecloth at the top secured with two elastic bands. Temporary homes should be similar to their existing home and contain appropriate leaves or bark for a food supply and a water source such as a wet sponge. They should be stored out of direct sunlight in the classroom and after a day or two, the bugs should be released back into their original habitat.

Observations and Discussion:

The following table outlines some typical bug signs found and identification of the bug that created the signs and traces left behind.

Description and Identification of Various Bug Traces and Signs

Trace/Sign	Description	Type of Bug	Cause
Stem or Twig Galls	These are hardened round shapes that look like small buttons or fruit and are most commonly seen on goldenrod as well as oak, poplar and willow trees.	Grubs or larvae of flies and wasps	If found in late spring, there is often a hole in a goldenrod gall where the adult has emerged and flown away. Some helpful websites for gall identification: https://tidcf.nrcan.gc.ca/en/insects/factsheet/79 (26/07/21), galls on Canadian hardwood trees; https://extension.umn.edu/yard-and-garden-insects/insect-and-mite-galls (26/07/21), description and images of galls; http://www.pbase.com/laroseforest/galls (26/07/21), images of different types of galls.
Leaf Galls	These are knobs on the underside of leaves, commonly found on oak leaves and many other deciduous trees and shrubs.	Grubs or larvae of insects and mites	
Blistered or blotchy leaves	Blistered leaves with tunnel outlines are found in spring and early fall on the leaves of many trees and shrubs such as oak, poplar, birch and fruit trees. Have students collect leaves to bring back to class.	Larvae of leaf miners that include flies, beetles, sawflies (wasps) and moths.	Leaf miners create a winding maze of trails on a leaf. Eggs have been laid on the underside of the leaf. Larvae, that are often too small to see, hatch and burrow into the leaf, between the top and bottom surface. They feed on the soft plant tissues and leave a trail behind. The leaves can be collected and taped to a window to easily trace the track left behind.
Malformed, shrunken or shriveled fruit	Apples, cherry, chokecherry and other fruit trees.	Worm-looking larvae	Larvae or maggots of flies feed on the fruit. Larvae then drop to the ground and burrow in the soil to pupate.
Extensive grooves, tunnels or patterns on bark	These bark patterns, called tree galleries, are found on dead standing trees or fallen logs, sometimes discovered by lifting off a piece of bark. Have students do bark rubbings to take back to class.	Boring insects such as bark beetles, carpenter ants, engraver beetles and carpenter bees	Bark beetles feed on wood and chew tunnels under the bark. Each tunnel is made by one larva. Emerald ash borer, Asian long-horned beetle and elm bark beetle are well-known destructive tree pests.

Trace/Sign	Description	Type of Bug	Cause
Leaves with holes	Semicircular holes missing from a leaf	Leaf Cutter bee	These bees use their sharp jaws to cut out semicircular pieces of a leaf to take back to their hive.
Half-eaten young leaves	Leaves with large holes or only half a leaf	Caterpillars of butterflies or moths (e.g. inchworm)	Tender, young leaves are a favourite food source for caterpillars. By looking under the leaf, the caterpillar can often be found. The inch worm, tent caterpillar and gypsy moth caterpillars are common examples of chewing insects that defoliate trees.
Rolled up leaves	Leaves may be rolled into a tubular shape such as maple and aspen trees.	Moth caterpillars	Eggs are laid in the fall, larvae feed on the leaves in the spring and then with silk, they roll up the leaves and pupate.
Spittle at forks of leaves and stems	Spittle is found in the garden and grassy places, particularly in the spring. Wipe the foam away to reveal the young soft-bodied bug inside.	Spittle bug nymphs	Spittle bugs are small sap-sucker bugs. The young spittle bugs blow bubbles to make a sticky froth to hide in.
Sooty-looking snow at base of tree	These tiny black specks are insects gathering on the snow surface.	Springtails (snow fleas)	Springtails gather on the snow surface on mild winter days and feed on pollen, spores and fungi.
Nest cases	These can be found on twigs or plant stems in open fields.	Praying mantis	In the fall, praying mantis lays eggs inside a protective covering called ootheca. The young nymphs hatch in the spring and begin feeding on other insects and bugs.
Webworm tents	These can be found in the crotch of deciduous trees and shrubs such as chokecherry.	Tent caterpillars	The larvae of several moths and caterpillars are collectively known as tent caterpillars. During the early morning and evening times, as well as rainy days, they use these webworm tents as a refuge area to be protected from the elements and predators.
Silky webs	These can be spotted between branches and objects.	Spiders	By examining spider web patterns, the species of spider may be identified (e.g. http://sciencing.com/identify-spider-pattern-8635659.html (26/07/21)).
Cattail seed heads in late winter	Cattail seed heads that have not dispersed by late winter likely house insects that are keeping them intact.	Cattail moth larvae	Cattail moth larvae lay down silk trails that bind the seed head together. Gently breaking the seed head apart will reveal larvae.

Trace/Sign	Description	Type of Bug	Cause
Silky egg sacs	These can be found on surfaces or on top of a female spider.	Spider eggs	Many spiders lay their eggs inside a silky egg sac that is often inside a web or even carried on top of a female for protection.
Cocoons	Late fall is a great time to search for cocoons in outdoor spaces.	Moths, ants and wasps	Cocoons shield the pupae and they are often camouflaged to protect the bug from predators.
Pupae	Hardened cases that can be found in the soil or suspended on trees. For example, cecropia moth pupae may be found on maple and elderberry trees.	Many insects	Pupae are a transformation stage for a number of different insects.
Slime trail	These silvery trails can be found on many surfaces including leaves and pavement.	Slug or snail trail	The mucous that creates a trail behind a wandering snail or slug helps the creature move along the surface without damaging its soft body parts.

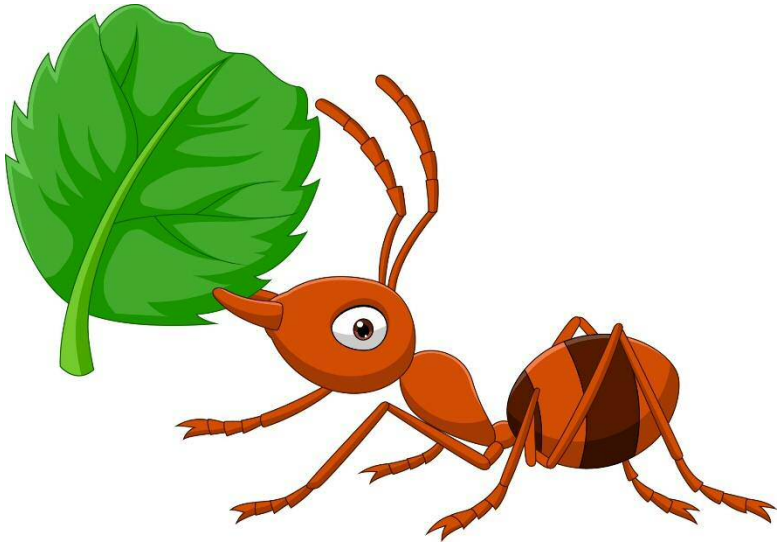

Image Source: https://www.vecteezy.com/free-vector/nature; Nature Vectors by Vecteezy (01/25/22)

Bugs camouflage to protect themselves from predators such as other bugs, mice and birds. Many bugs are herbivores that feed off living plants, such as tender, young growth shoots, plant sap or nectar from a flower. Bugs may also be carnivores that eat other bugs and insects as their prey items. Some bugs are omnivores and eat both plants and animals. Many bugs are detritivores or decomposers that eat and break down decaying organic matter. Live bugs that may be found include:

- pill and sow bugs (commonly known as potato bugs), detritivores found under dead wood, leaf litter and rocks;
- millipedes, detritivores found under dead wood, leaf litter and rocks;
- centipede, carnivores found under dead wood, leaf litter and rocks;
- spiders, carnivores found in many different habitats;
- earthworms, detritivores found under rocks, dead wood and leaf litter;
- ants, omnivores often found on pavement and sidewalks;
- aphids, herbivores that suck plant sap on young leaves and shoots;
- ladybugs, carnivores found in gardens or wooded areas;
- caterpillars, herbivores found on leaves and young shoots of plants.

The following website has some additional information and pictures that may be useful:

- https://tidcf.nrcan.gc.ca/en/insects *(26/07/21)*
- https://www.insectidentification.org/ *(26/07/21)*
- https://bugguide.net/ *(26/07/21)*

Extension:

1. Goldenrod galls are commonly found in fields and along the roadside and appear as strange growths on the plant. They make for interesting specimens to study. The cycle begins when an adult insect lays an egg on the surface of the plant's stem. When the egg hatches, the larva crawls along the stem, bores a hole and crawls in. The plant becomes irritated with this invasion and makes extra layers of plant tissue around the grub or larvae. These extra plant layers form a gall. Meanwhile, the gall is like a mini-habitat for the insect as it is protected over winter by the layers, has a source of food and is hidden from predators. In early spring, the larva pupates and by early summer a tiny adult fly or moth emerges from a little hole in the gall, completing the life cycle. In the fall, galls may be collected and kept for several months to observe the small creature that emerges in the spring. Place the gall in a jar covered with cheesecloth that is secured with elastic bands. Store the jar in an outdoor unheated area, such as a garage. In the spring, bring the jar inside the classroom to watch for the emergence of a tiny adult insect. Alternatively, galls may be carefully dissected in the fall to discover the larvae inside.
2. Repeat the bug hunt in different seasons to compare the variety of signs and life cycle stages that may be discovered.

FUN FACT!

Insects for the Birds

Favourite foods of woodpeckers are insects. They commonly drill holes into wood searching for insects, like wood-boring beetles. In the wintertime, insects living in galls also provide a tasty treat for bug-eating birds, such as chickadees and woodpeckers.

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ACTIVITY FIVE

Time: 20 – 30 min, observations during the year

Key terms: solitary, beneficial, pollinator

Group Size: Individual

Materials:
500mL or 2L clear recycled plastic bottles

Scissors

Duct tape

Awl

Materials for creating shelters such as dead leaves, twigs, seed heads, hay, pinecones, loose bark, corrugated cardboard, stems/reeds of ornamental grasses or other varieties with thick plant stalks, bamboo

Waterproof marker

Twine or fishing line

Extensions: The following sites have some great suggestions for building larger structures: https://gardentherapy.ca/build-a-bug-hotel/ *(26/07/21)*; https://www.audubon.org/multimedia/insect-hotels *(26/07/21)*; https://ww2.rspb.org.uk/get-involved/activities/give-nature-a-home-in-your-garden/garden-activities/build-a-bug-hotel/ *(26/07/21)*.

BUG HOTEL

Learning Goal: Students will learn about making a home for bugs.

Our gardens contain many bugs; some estimates are over 2,000 species in a backyard. Some bugs can be beneficial, while others have a negative impact on our gardens. Some live together as social insects such as ants and bees, while some, such as spiders and praying mantises, lead a solitary lifestyle. By providing a manmade structure using materials where bugs can shelter and overwinter, our gardens will benefit from a balanced ecosystem.

Procedure:
Before Activity:

1. Prepare bottles by cutting off the top. Duct tape can be used to cover any rough or sharp edges. Alternatively, clay pots, wooden boxes or tin cans may be used as the building block of the shelter structure instead of plastic bottles.
2. To create a few bottles for hanging, use an awl to poke two holes in the middle of the length of the bottle side by side, approximately 3 cm apart.
3. Create a space in the classroom that offers a variety of materials that students can use to create their bug's shelter. Materials may include dead leaves, seed heads, pine cones, hay, twigs, reeds, bamboo or loose bark.

Activity:

4. Instruct students that they will each be creating a shelter for bugs inside a plastic bottle. Each shelter/bottle will be one room of a bug hotel. The class will create a number of hotels using these individual shelters. The hotels will be placed in different environments to see what kinds of bugs they may attract. Have students decide if they want their section of the hotel to be on the ground or hanging.
5. Have students select a bottle and write their names on the bottom with a waterproof marker.
6. For those students that have selected to put their shelter in a tree, provide them with twine/fishing line. Have students thread the twine through both holes. This will allow their bottle to hang.
7. Have students select and fill their bottles with available materials. Their material may be all the same or a mixture. If students select corrugated cardboard, suggest that they roll up the cardboard to create spaces for bugs to enter.
8. Once students have completed their shelter, take the class outside and chose several different environments for the bug hotels, such as a shady spot on the ground or a dappled

Note: *Exercise caution and move slowly and non-threateningly when approaching the bug hotels. Avoid being stung by wary inhabitants, such as bees or wasps, defending their new home.*

sunny spot in a tree to hang the hotel. Some shelter from rain and snow is often helpful, like under eaves or shrubs.

9. Students may create a hotel by connecting several bottles together using several elastics or twine. Place the hotel in the desired location. Check the hotels periodically at different times of the day to see who has moved in. Are there any differences in the creatures that are at each location?
10. Check the hotels at different times of the year. Are there any differences in the types of creatures in the hotels?

Observations:

Students will have observed many different creatures depending on materials used in their shelter, location, time of day and time of year. The table below outlines a few potential bugs that may use the bug hotel and their preferred materials and locations for shelter.

Bug	Material	Location
Solitary bees	Hollow stems – bamboo, reeds or thick plant stalks	Sunny and dry
Butterflies	Narrow empty spaces	Protected areas often above ground level (overwintering)
Moths	Narrow empty spaces	Protected areas at or above ground level (daytime)
Lacewings	Rolled corrugated cardboard	Sunny and dry
Ground beetles	Loose bark and plant material	Dark and damp ground
Centipedes	Loose bark and plant material	Dark and damp ground
Spiders	Loose bark and plant material	Dark and damp ground / dry above ground
Millipedes	Loose bark and plant material	Dark and damp ground
Pill/sow bugs	Loose bark and plant material	Dark and damp ground
Lady bugs	Twigs and other dry plant material	Protected areas at or above ground level (overwintering)

Discussion:

An insect hotel provides free accommodation to beneficial insects that provides us with pollinators and pest control – a great symbiotic relationship where bugs and people both benefit! Some bee, wasp, ladybug, butterfly, lacewing and moth species hibernate over the winter and bug hotels are a perfect environment for them to stay warm and protected until spring.

Pollinating insects are important to the planet as they help fertilize flowers that provide us with food. We can assist these populations by providing them shelter and places to safely overwinter. Solitary bees, such as mason bees, are non-aggressive and are important pollinators. Hollow stems in the warmth of the sun provide them with an ideal nesting site.

Beetles, centipedes and sow bugs help to decompose dead plant material in our gardens and also add needed nutrients back into the soil. These creatures prefer damp and dark places to live and they will inhabit bug hotels placed on the ground in a shady area, particularly if they contain a food source such as decaying bark or dead leaves. Spiders will catch pesky insects like mosquitoes in their webs. They often will spin cocoons and lay eggs in protected niches.

TEACHER RESOURCES

Websites Resources

http://bugguide.net/ (23/07/21).
An online resource devoted to North American insects, spiders and their kin, offering identification, images and information.

http://www.pest-help.com/bug-facts/ (23/07/21).
A great resource with lots of information about insects and non-insects.

http://songsofinsects.com/ (23/07/21)
An amazing website dedicated to singing insects that includes in-depth descriptions, identification and tips about keeping as pets.

http://canadianbiodiversity.mcgill.ca/english/species/insects (23/07/21)
A comprehensive description and listing of insect species in Canada. Also, a good resource for reader students to research about insects.

https://www.amentsoc.org/insects/ (23/07/21).
A comprehensive website from the Amateur Entomologists' Society including identification tips, facts, conservation and care sheets.

https://www.si.edu/Encyclopedia_SI/nmnh/buginfo/start.htm (23/07/21).
A Smithsonian website filled with information all about entomology and the world of insects.

http://blog.growingwithscience.com/2009/10/pill-bug-activities-for-kids/ (23/07/21).
Information about pill bugs including activities and resource links.

http://www.suekayton.com/silk.htm (23/07/21).
A compilation of information related to the silkworm.

https://seeds.ca/pollination (23/07/21).
An informative website on pollinators in Canada and includes many resources and links.

https://www.bees.techno-science.ca/english/bees (23/07/21).
A comprehensive website all about bees from Canada Agriculture Food Museum, also includes activities.

http://www.monarchwatch.org (23/07/21).
Many resources and links related to monarchs.

https://cwf-fcf.org/en/resources/encyclopedias/fauna/?src=menu *(23/07/21)*. A comprehensive selection of fact sheets including categories on Insects and Pollinators in Canada.

Multi-media

https://www.youtube.com/watch?v=mah26og11ms 1:08 min *(26/07/21)*.
Cicada making noise using abdomen.

https://www.youtube.com/watch?v=nyglT-rWE5c 1:13 min *(26/07/21)*.
Grasshopper sounds using their feet.

https://www.youtube.com/watch/4CU8gYYkwSw 1:15 min *(26/07/21)*.
Water strider walking on water.

https://www.youtube.com/watch?v=rKQfJFAHW8Q 5:44 min *(26/07/21)*.
Comprehensive overview from Free School about insects including body parts, eyes, diapause and metamorphosis.

FUN FACT!

Hungry Herbivores and More!

Insects eat more plants than any animal on earth.

A female praying mantis often cannibalizes her mating partner.

A spider eats about 2, 000 insects a year.

An anteater can eat a few thousand insects a minute!

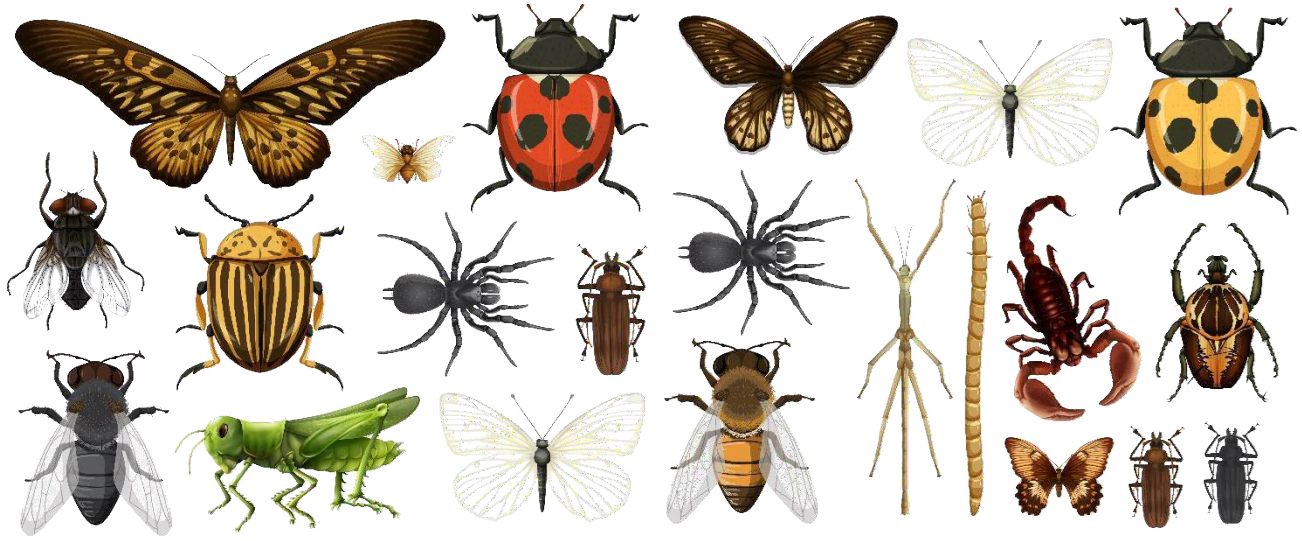

Image Source: https://www.vecteezy.com/free-vector/cartoon; Cartoon Vectors by Vecteezy (01/25/22)

STUDENT RESOURCES

Literary Resources

The Backyard Bug Book for Kids: Storybook, Insect Facts, and Activities. Lauren Davidson. 2019. Callisto Media. ISBN - 13:9781641525251

Insects and Bugs for Kids: An Introduction to Entomology. Jaret C. Daniels. 2021. Adventure Publications. ISBN - 13:9781647551643

Websites

http://mrnussbaum.com/science/insects/ *(23/07/21).*
Comprehensive student website including descriptive information about a number of different insects, insect anatomy and interactive games and activities.

http://www.primarygames.com/science/insects/games.htm *(23/07/21).*
A selection of games about bugs and insects.

https://pestworldforkids.org/ *(23/07/21).*
A comprehensive site about all kinds of bugs for educators, students and parents including games, crafts, fact sheets and more.

FUN FACT!

Instead of a Trip to the ER!

Soldier ants have been used as a natural alternative to stitches for closing wounds.

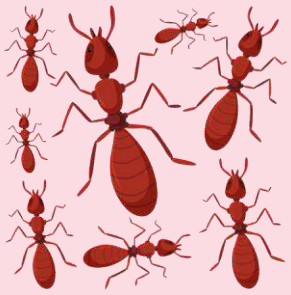

Image Source: https://www.vecteezy.com/free-vector/nature: Nature Vectors by Vecteezy (01/25/22)

REFERENCES

In addition to resources listed above, the following websites were also used to develop this package:

Nature Explorer. David Burnie, Ben Morgan, Richard Walker and John Woodward. 2010. DK Publishing Inc. ISBN 9780756662929.

203 Icy, Freezing, Frosty, Cool and Wild Experiments. Janice Van Cleave. 1999. John Wile & Sons, Inc. ISBN 0471265950.

The Usborne Book of Science Experiments. Jane Bingham. 1991. Usborne Publishing. ISBN 0746008066

http://www.brainfacts.org/Sensing-Thinking-Behaving/Senses-and-Perception/Articles/2015/Making-Sense-of-Scents-Smell-and-the-Brain (26/06/17);

https://www.scientificamerican.com/article/bring-science-home-cricket-temperature/ (10/07/17);

http://news.nationalgeographic.com/news/2006/09/060905-crickets_2.html (02/07/17);

https://www.thoughtco.com/how-insects-make-sounds-4016953 (02/07/17);

http://www.clemson.edu/extension/hgic/pests/plant_pests/trees/hgic2001.html (04/07/17);

https://www.treehelp.com (04/07/17);

http://www.wikihow.com/Identify-Spider-Egg-Sacs (04/07/17);

http://capriplus3.com/2016/05/roly-poly-adventures-science-experiments-with-pill-bugs.html (04/07/17);

https://www.education.com/science-fair/article/biology_learning-behavior-sow-bugs/ (04/07/17);

http://www.thecanadianencyclopedia.ca/en/article/insect-pests/ (10/07/17);

https://askabiologist.asu.edu/complete-metamorphosis (10/07/17);

https://kidskonnect.com/animals/bugs/ (10/07/17);

https://www.livescience.com/52022-startling-facts-about-insects.html (10/07/17);

https://www.natgeokids.com/uk/discover/animals/insects/15-facts-about-bugs/ (10/07/17);

http://www.iflscience.com/environment/will-we-all-be-eating-insects-50-years/ (17/07/17).

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Science Education through Partnership

Scientists in School is a leading Canadian science education charity that has reached over 11 million young scientists since 1989. Through our hands-on, inquiry-based STEM classroom and community workshops, we ignite scientific curiosity in children so that they question intelligently, learn through discovery, connect scientific knowledge to their world, get excited about STEM, and have their interest in careers in those fields piqued. The funding from corporate, community, government, and individual donors supports us in developing/revising programming and topic kits; subsidizing the cost of every workshop; providing at least 10% of our workshops on a complimentary basis to schools serving marginalized communities; and developing the infrastructure to ensure relevant, high-quality experiences for students wherever they live in Canada.

Catalyst

Drax Foundation* | NSERC (Natural Sciences and Engineering Research Council of Canada)* | Ontario Ministry of Education

Innovation

Calgary Foundation* | John and Deborah Harris Family Foundation* | MilliporeSigma* | Nuclear Waste Management Organization* | Ontario Power Generation*

Imagination

AMD Canada* | ATB Financial* | DOW | Fund for Gender Equality - Government of Canada* | G. Murray and Edna Forbes Foundation Fund, South Saskatchewan Community Foundation* | Pickering Mayor's Gala | Rio Tinto - IOC | SC Johnson* | TD Friends of the Environment Foundation* | The Catherine and Maxwell Meighen Foundation* | Trottier Family Foundation

Discovery

Access Communications | Alectra Utilities | Apotex Inc. | AWS InCommunities Calgary Fund* | Brant Community Foundation* | Burns Memorial Fund | City of Brantford* | Elementary Teachers Federation of Ontario | Elexicon Energy* | F. K. Morrow Foundation | Finning Canada | General Motors* | Gerdau Whitby Mill* | Gore Mutual Insurance Company* | Healthy Horizons Foundation | Hunter Family Foundation* | Huronia Community Foundation - Heart of Georgian Bay Community Forward Fund, LabX Charity Fund, Lynda Zuidema Endowment Fund, and Tom and Lucille Gay Memorial Endowment Fund* | Innisfil Community Foundation | J.P. Bickell Foundation | J & W Murphy Foundation | Northwestern Alberta Foundation – Ainsworth Legacy Community Fund and Mighty Peace Youth Fund* | Oshawa Community Grants* | Ottawa Community Foundation* | Paul & Anne Lake Fund, held within the Stratford Perth Community Foundation* | PortsToronto* | S.M. Blair Family Foundation* | Saint John's Legacy Foundation* | Syngenta Canada Inc.* | TC Energy* | TELUS and TELUS Friendly Future Foundation* | The Arthur & Audrey Cutten Foundation* | Town of Ajax Partnership Fund* | Town of Whitby, Mayor's Community Development Fund* | Yuill Family Foundation

Exploration

Brampton and Caledon Community Foundation* | Cajole Inn Fund – Ottawa Community Foundation* | Cameco Blind River | Cameco Ontario | Cameco Port Hope | Canadian Progress Club Durham South* | Carleton North Community Foundation* | Centre Wellington Community Foundation* | CFUW Owen Sound & Area* | CFUW St. John's, NL* | City of Hamilton – City Enrichment Fund | Community Foundation for Lennox & Addington* | Deep River and District Community Foundation* – Milton Family Fund and Tucker Tennant Endowment Fund | Durham Community Foundation* | Dwight and Karen Brown Family Fund – Ottawa Community Foundation* | Ecclesiastical Insurance – Movement for Good | Epson Canada Inc. | GrandBridge Energy | Guelph Community Foundation* | Jackman Foundation* | Kawartha Credit Union* | Kerina and David Elliott Family Fund – Community Foundation Grey Bruce | Leanne Children's Foundation | Magna International | Municipality of Clarington | Municipality of North Grenville | OTIP | PUC Inc. | Rotary Club of Bolton* | Rotary Club of Brampton | Sisters of Charity Halifax | Sun Family Fund | Superior Glove Works* | The Smart & Caring Children and Youth Fund at the Mississauga Foundation | The Community Foundation of Orillia and Area | The Township of Tiny* | Town of Orangeville | Unifor Social Justice Fund | Waterloo Region Community Foundation – The Woolwich Community Fund | Weyerhaeuser Giving Fund*

We are also thankful to Macdonald & Company LLP, McMillan LLP, MLT Aikins LLP, Stewart McKelvey and Taylor McCaffrey LLP for providing in-kind support to Scientists in School.

*A special thank you to our multi-year partners.

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