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The ABCDEFGs of Entomology

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The ABCDEFGs of Entomology

MARIA T. GUTIERREZ

As a parent of three kids, I love finding ways to spark their curiosity and love for learning, so combining my interest in entomology and my experience as a parent, I came up with a fun yet informative book about insects. I selected the most common insects kids might encounter daily at home, school, or while playing at the park: ants, butterflies, cockroaches, dragonflies, earwigs, flies, and grasshoppers.

I aimed to develop an activity book that anyone could use, whether they are a teacher or a parent without a scientific background. By focusing on these seven specific insects, I wanted to showcase their incredible features, like anatomy, flight capabilities, and feeding behaviors. Despite their small size and many challenges, insects thrive with impressive strengths, and only by understanding their world can we appreciate their significance and value in our lives.

Ultimately, I hope that more kids and adults will be inspired to explore the outdoors and appreciate the wonders of insects. If we respect and protect their habitats, we can help ensure a brighter future for ourselves.

WHY ARE INSECTS IMPORTANT?

Did you know that insects are the most **diverse** animals on Earth and have the largest population in numbers? It is estimated that there are 10 quintillion individual insects. To put that into perspective, there are over 1 billion insects for every human on the planet, and with such an enormous number, it's no surprise that we always seem to come across them wherever we go.

~10,000,000,000,000,000,000

~8,045,311,447

Insects play a crucial role in our survival, whether we realize it or not. They contribute directly and indirectly to our food supply, aid in waste decomposition, assist in disease management through biological control, and even provide a means to study genetics due to their short generation times. Their existence is intertwined with our daily lives in many ways.

WHAT IS AN INSECT?

Insects belong to the group called **arthropods**, which include animals with an **exoskeleton** and jointed legs, like spiders and crabs. The exoskeleton provides a rigid body, which is a point where muscles attach, similar to the skeleton of a human, but it is outside of the body. This tough outer layer protects the internal organs and is a **sensory organ** that provides feedback from the environment while helping to avoid losing moisture.

An insect can have many forms and shapes, but all insects have 3 **tagmata,** the head, thorax, and abdomen.

The **head** always has a pair of **antennae** which can vary in size, length, and shape. If the insects have eyes, they are also located on the head; this could be a pair of compound eyes, simple eyes, or both. The head also has insect mouthparts, which can vary by insect order and species.

The **thorax** has 6 legs and 2 pair of wings in most insects, although some are **wingless** or some have modified wings like beetles and flies.

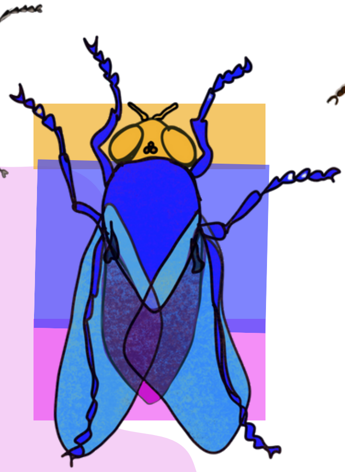
The **abdomen** is where the **reproductive organs**, some **defense mechanisms**, and also **excretory systems** are located.

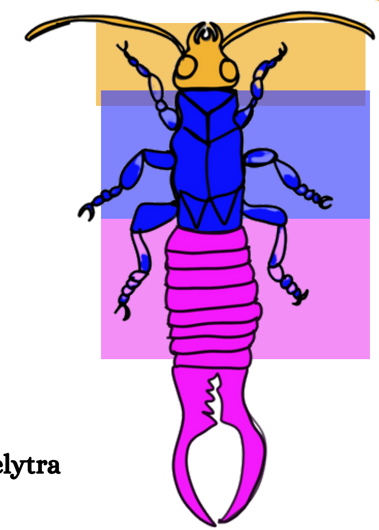
Use the colored boxes as a guide to observe how all insects, despite their different appearance, have the same 3 segments, or tagmata.

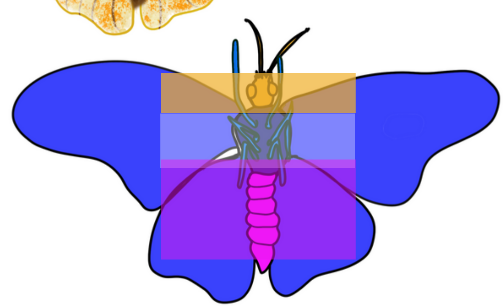
3 Body Segments

- **Head**
- **Thorax**
- **Abdomen**

- **6 Legs**
- **Antennae**
- **Zero or 2 Pair of wings***







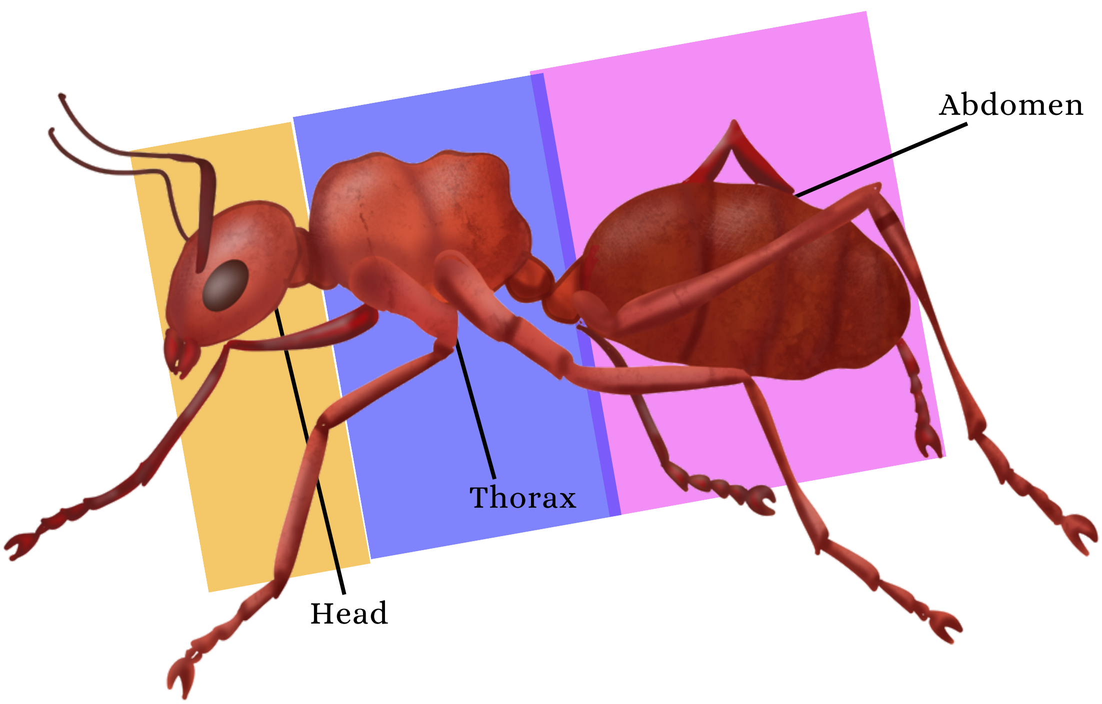
*sometimes modified as **tegmina**, **halteres**, **elytra**, **hemelytra**

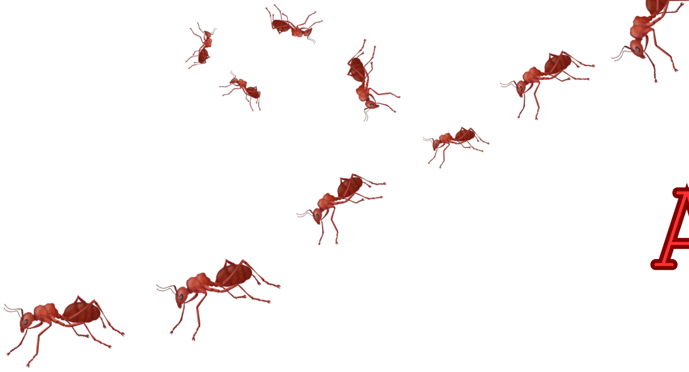
Insect Order:
Hymenoptera
Family:
Formicidae

ANTS

Ants are incredible insects, and although tiny in size, one of the easiest to find and recognize in your yard, playground, or even inside your home. They belong to the **insect order Hymenoptera**, which includes some of the most important insects that pollinate our crops and flowers, like bees and wasps. These are **social insects** that live in **colonies**, where ants work together, each with a different job depending on their body; some ants are males, some are female worker ants, and then there is the **queen**, who can live up to 25 years! Have you ever watched how ants interact, how they work, and how they react to anything or anyone that they encounter? By observing them, we can learn how their anatomy plays a role in their success as individuals and as a **colony**.

Ants, like all insects, have 3 different segments to their body, and each has even more specific smaller features that work together to create a perfect little creature. Each segment has its own unique and essential systems that help insects not only just survive but thrive in their environment.





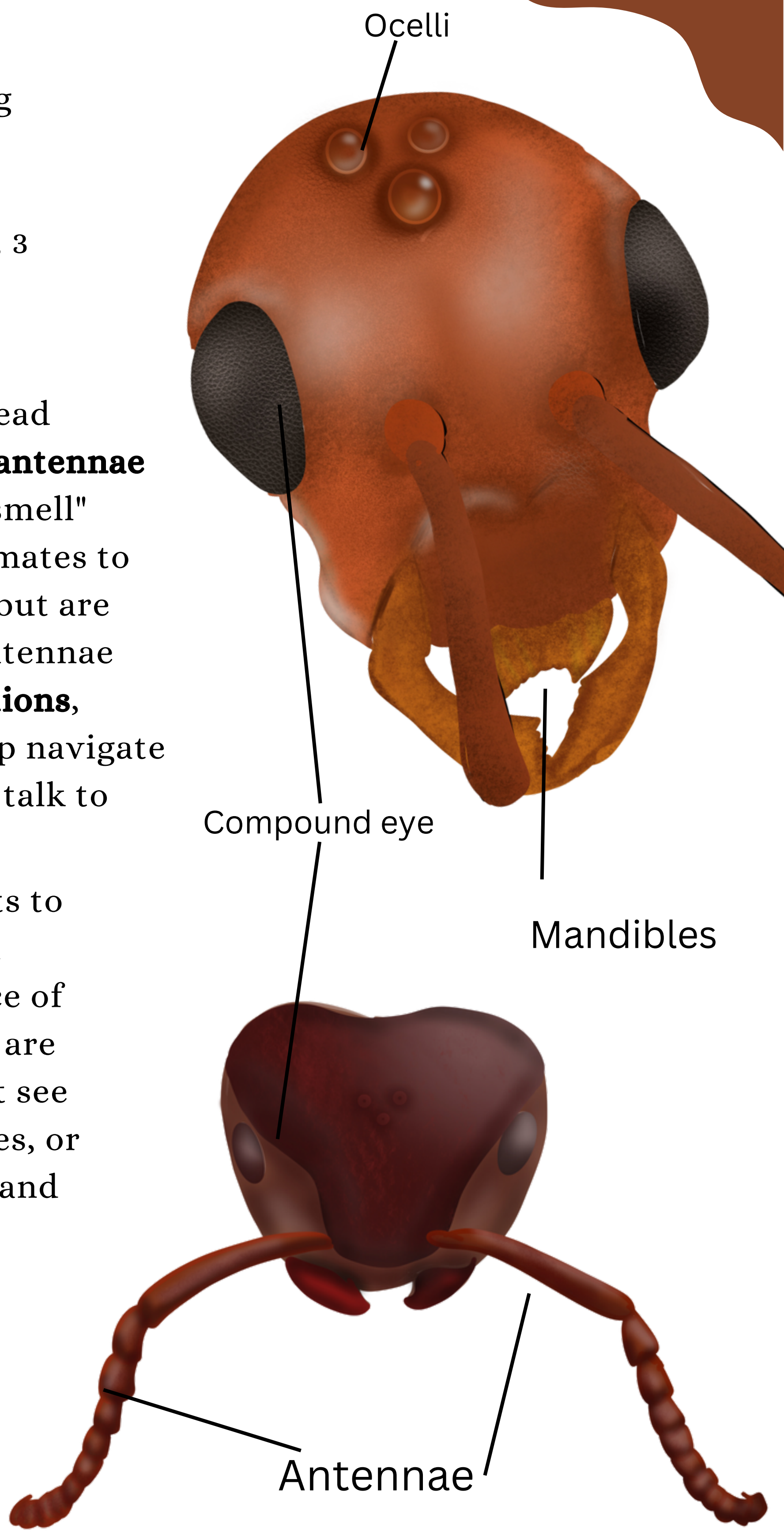
ANTS

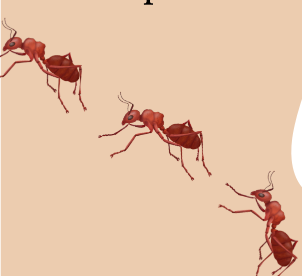
Insect Order: Hymenoptera
Family: Formicidae

The head of an insect has the vital role of seeing, tasting, and detecting chemicals and vibrations around them; ants have 2 **antennae** at the front of the head, 2 **compound eyes**, 3 small, simple eyes (**ocelli**), and the pair of strong **mandibles.**

Each of these smaller parts of the head segment serves a specific purpose; **antennae** are small **sensory organs** that can "smell" chemicals sent out by their colony mates to communicate amongst themselves but are also used to detect food sources. Antennae can also "feel" sound through **vibrations**, which helps ants detect danger, help navigate the environment around them, and talk to each other.

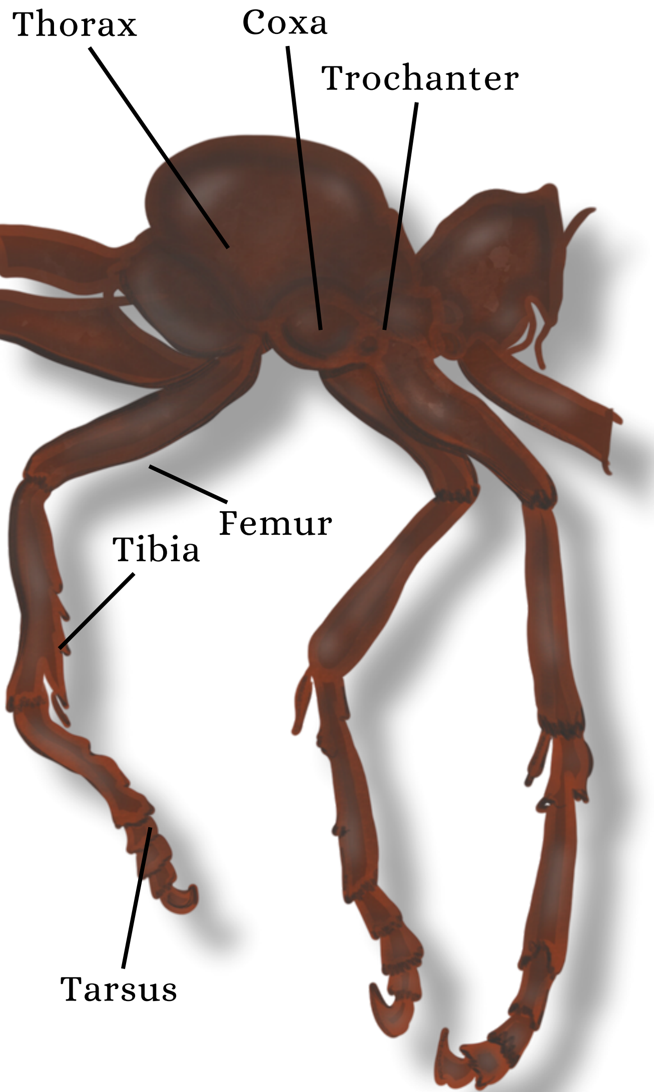
Having 2 types of eyes allows insects to gather information about the world around them increasing their chance of survival. Ants have **compound eyes** are made up of thousands of lenses that see movement and light. The simple eyes, or **ocelli**, allow the ant to see the light and help with direction and navigation.





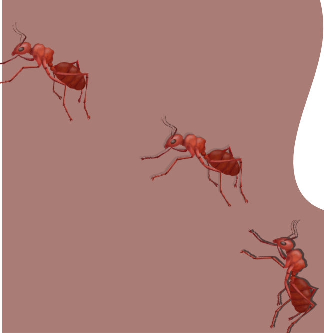
ANTS

Insect Order:
Hymenoptera
Family:
Formicidae



The segment known as the **thorax**, recognized as the movement section, is where the 6 legs and wings, if present, are attached to an insects body. In ants, having wings is depends on whether male or female and if it can reproduce.
Ants have 6 powerful legs, divided into 5 segments each (coxa, trochanter, femur, tibia, tarsus). Some ant legs are specialized and modified for carrying, digging, climbing, and swimming and some are useful in communication by using little hairs that can sense chemicals from other ants and environmental stimuli in dark environments.

The insect **abdomen,** the third and last segment, is where the **digestive system**, **reproductive** organs, and some **defense mechanism**, such as stingers in ants, are located.

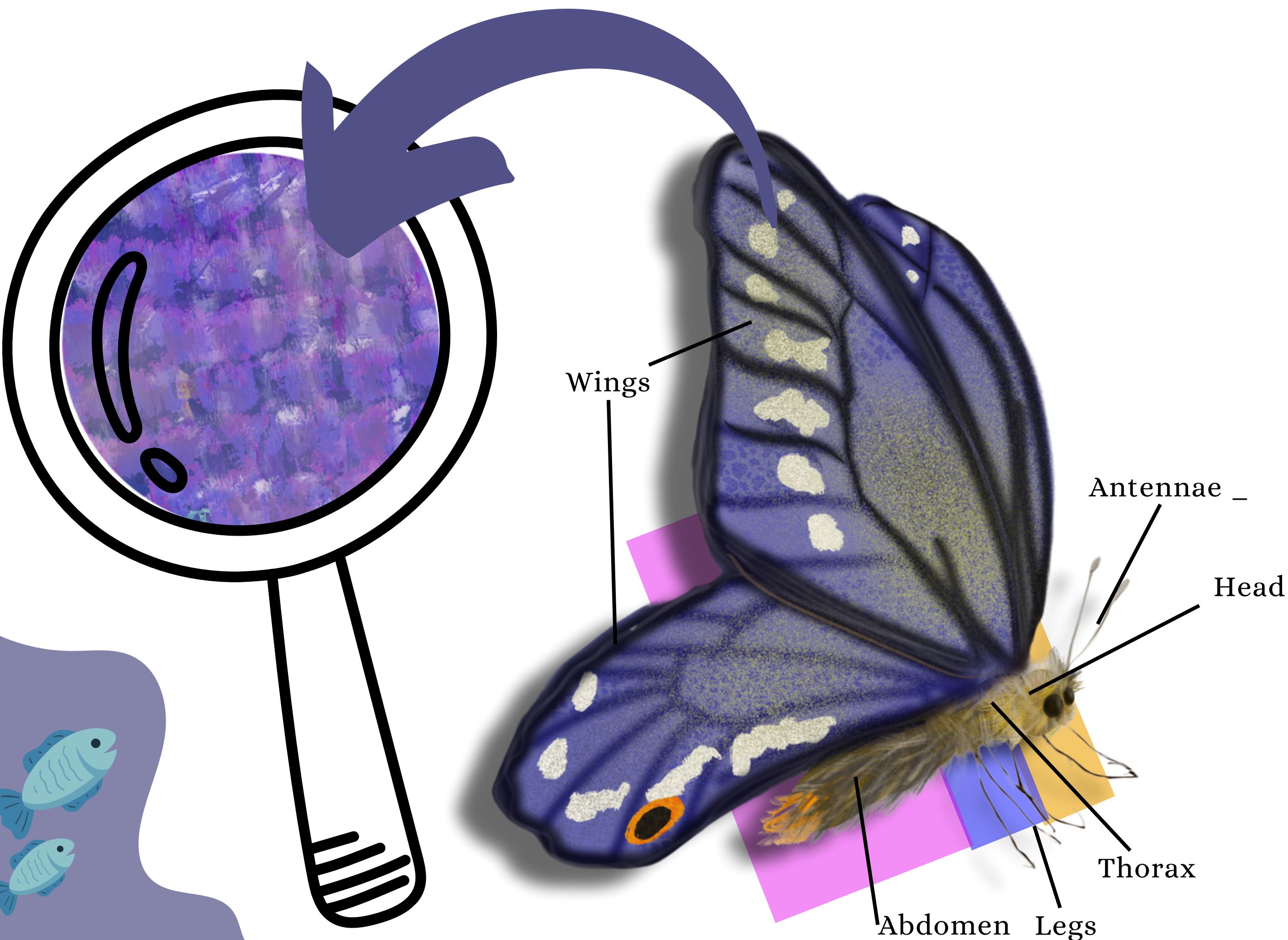


BUTTERFLY

Insect Order:
Lepidoptera

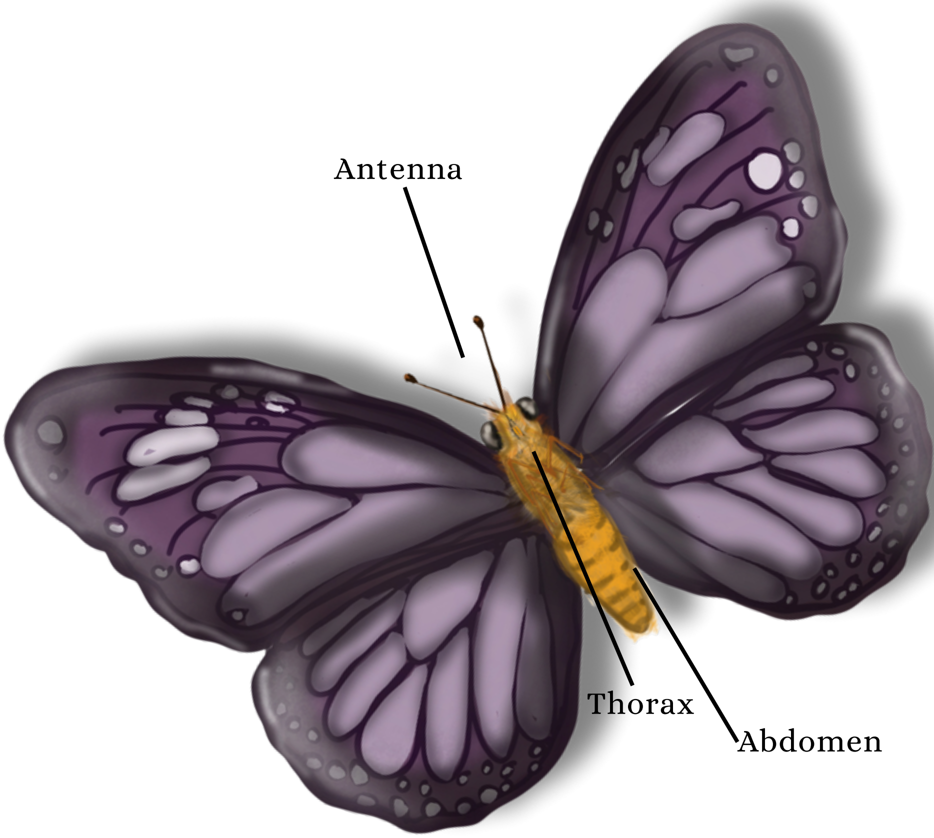
Butterflies and springtime seem to go together. We can spot a fairy-like creature fluttering about the yard or resting on a flower or leaf. Have you ever wondered how a butterfly could fly using those tiny thin wings or what those wings are made of? If you have ever had the opportunity to observe a butterfly's wing, you might have been surprised to see that the wings are covered in tiny, **iridescent scales**. So, are fish , reptiles, and butterflies more similar than we think?

The size, shape and color of their wings can vary butterflies, but like all insects, they have a head, thorax, abdomen, 6 legs, and a pair of antennae.



BUTTERFLY

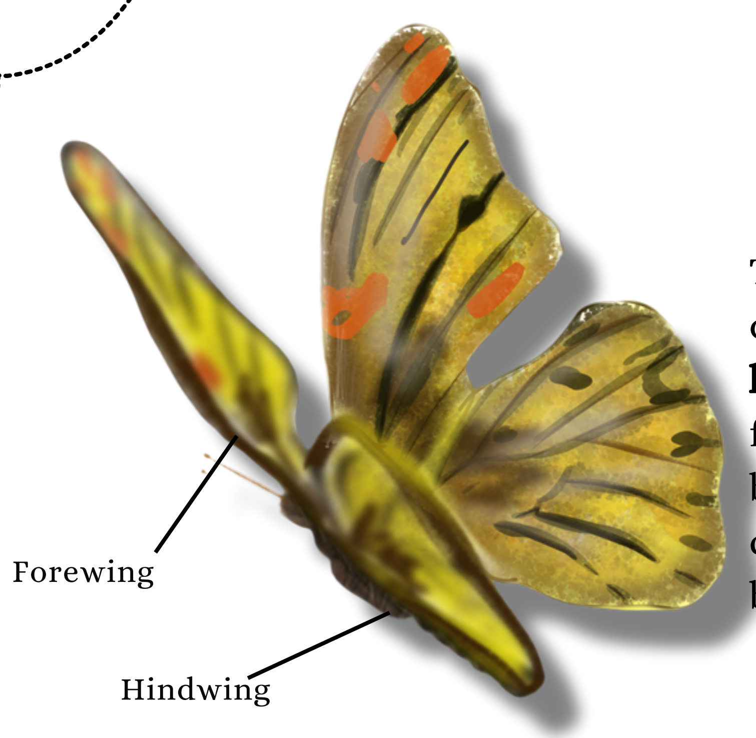
Insect Order:
Lepidoptera



Wings on butterflies can help identify their species, their age, and some of their behavior. If you've ever touched one, you might have noticed an almost metallic powdery glitter left on your fingertips. These are the crushed scales that you rubbed off the wing. **Scales** have a wide range of functions; amazingly, each is the growth of a single **epidermal cell**. This means the wing is tightly covered by these minuscule overlapping scales made of chitin, making them a great form **insulation** while staying lightweight and durable during **turbulent** flight.

What are some of the colors you've seen on butterflies? The scale colors and patterns can vary widely, and some can be **species-specific** in inviting mates or warning others, like **predators**.

BUTTERFLY



The 2 pair of wings of an insect are distinguished as the **forewing** and the **hindwing,** each with its specific function and purpose. In butterflies, both wings are covered in scales; their color will vary depending on what the butterfly needs in pattern and color.

The **forewings** are the front wings, usually larger and more rigid, and are responsible for the lift and **propulsion** during flight.

The hindwings are the back wings, usually smaller, more flexible, and act like a steering wheel providing balance and **directional steering**.

Both wing pairs are important in **thermoregulation**, helping the butterfly maintain an ideal temperature by absorbing or reflecting sunlight using their chitinous scales like a mirror.

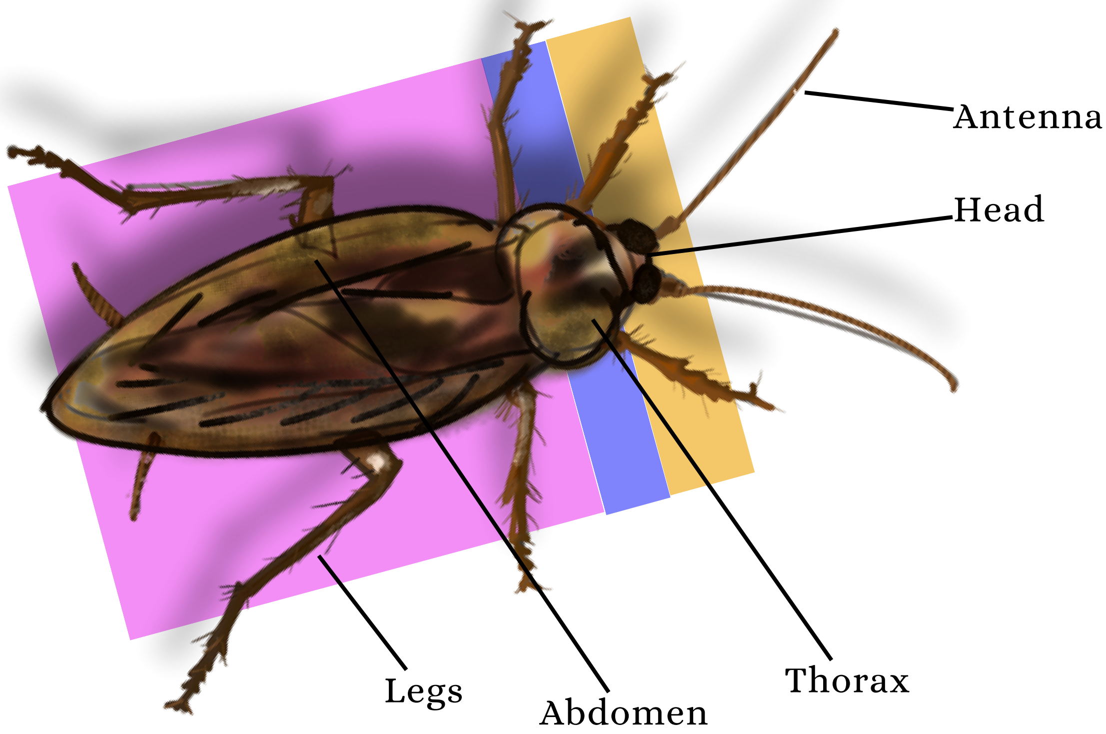
COCKROACH

Insect Order:
Blattodea

Have you ever come across the myth that cockroaches can survive explosions or be the last surviving creatures after a catastrophic event that nearly wipes out the planet in movies? Have you ever wondered where this idea originated from? One of the reasons behind this legend could be the presence of an exoskeleton in their body.

Insects, such as cockroaches, have developed a protective layer that enables them to thrive in harsh environments, leading many to view them indestructible. They are notoriously difficult to eliminate, mainly when found inside homes or buildings. Despite numerous attempts to eradicate them, they seem to persist! These resilient creatures use their flattened bodies and agile legs to move quickly and hide, and even when confronted, their **exoskeleton** makes it challenging to crush or squash them.

Like all insects, cockroaches have 3 segmented bodies, 6 legs, and a pair of antennae.



COCKROACH

Insect Order:
Blattodea

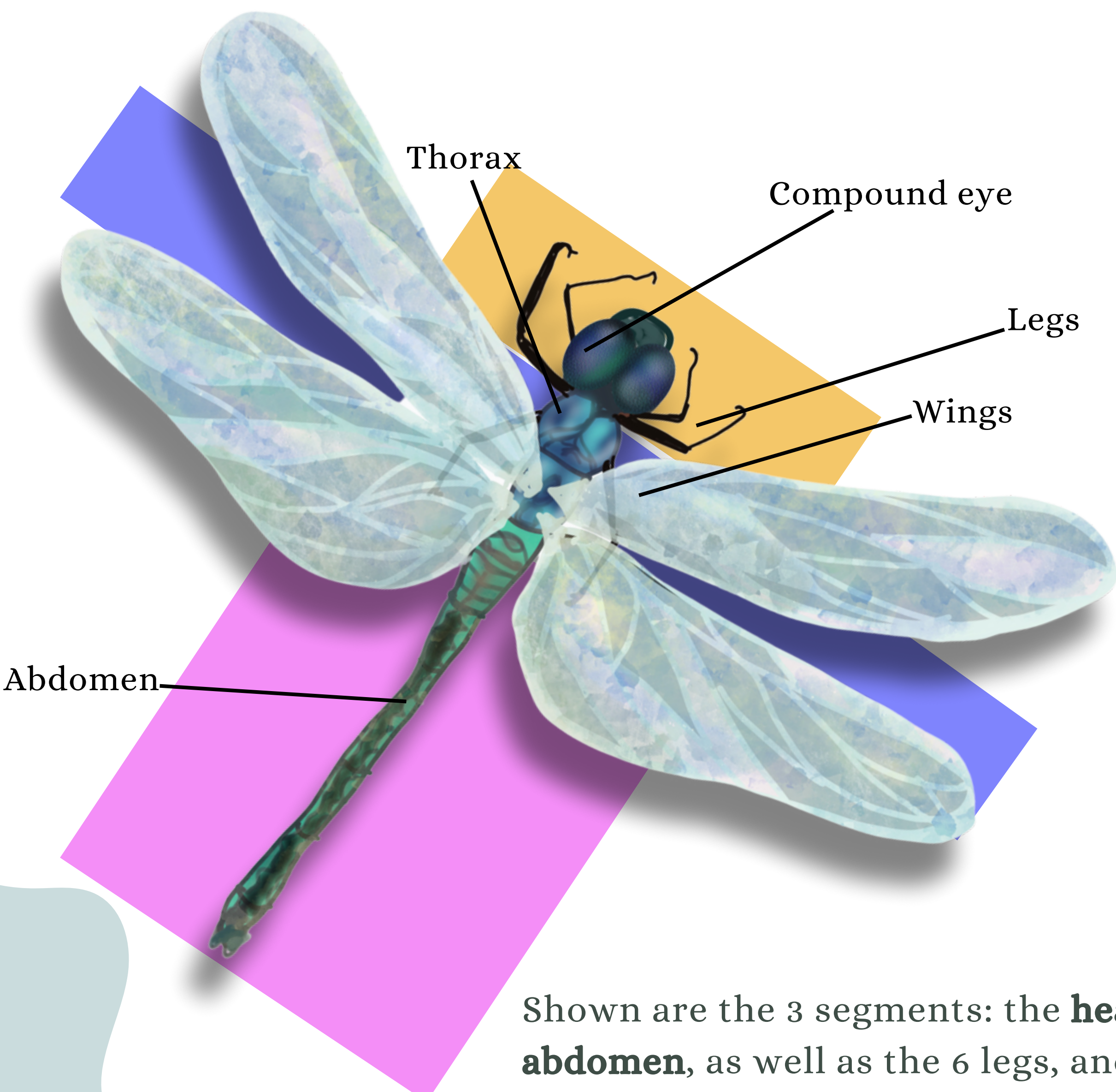
The **exoskeleton** shields insects against predators, prevents water loss, and gives them a solid structural body that, like in the movies, seems to be able to withstand a nuclear bomb.
This outer skeleton is made up of **chitin**, and this same rigid body can also be found in other **arthropods** like crabs, lobsters, and beetles. The thickness and size of the exoskeleton differ by species and have varying flexibility and movement range according to their own needs. This hardened outer protective layer is a fantastic modification that has allowed insects to adapt to harsher, more dangerous environments and gives insects like cockroaches a significant advantage and a higher chance of survival.

Like a knight's armor, this hardened outer covering allows insects to thrive under sharp bark and debris or squeeze into tight, narrow crevices that would otherwise scratch or tear through their skin or wings. This shield safeguards their delicate organs, much like armor would protect a person in a thorny forest where they would otherwise be constantly poked. It's not difficult to see why some people might believe their self-built armor might help them survive anything.

DRAGONFLY

Insect Order:
Odonata
Infraorder:
Anisoptera

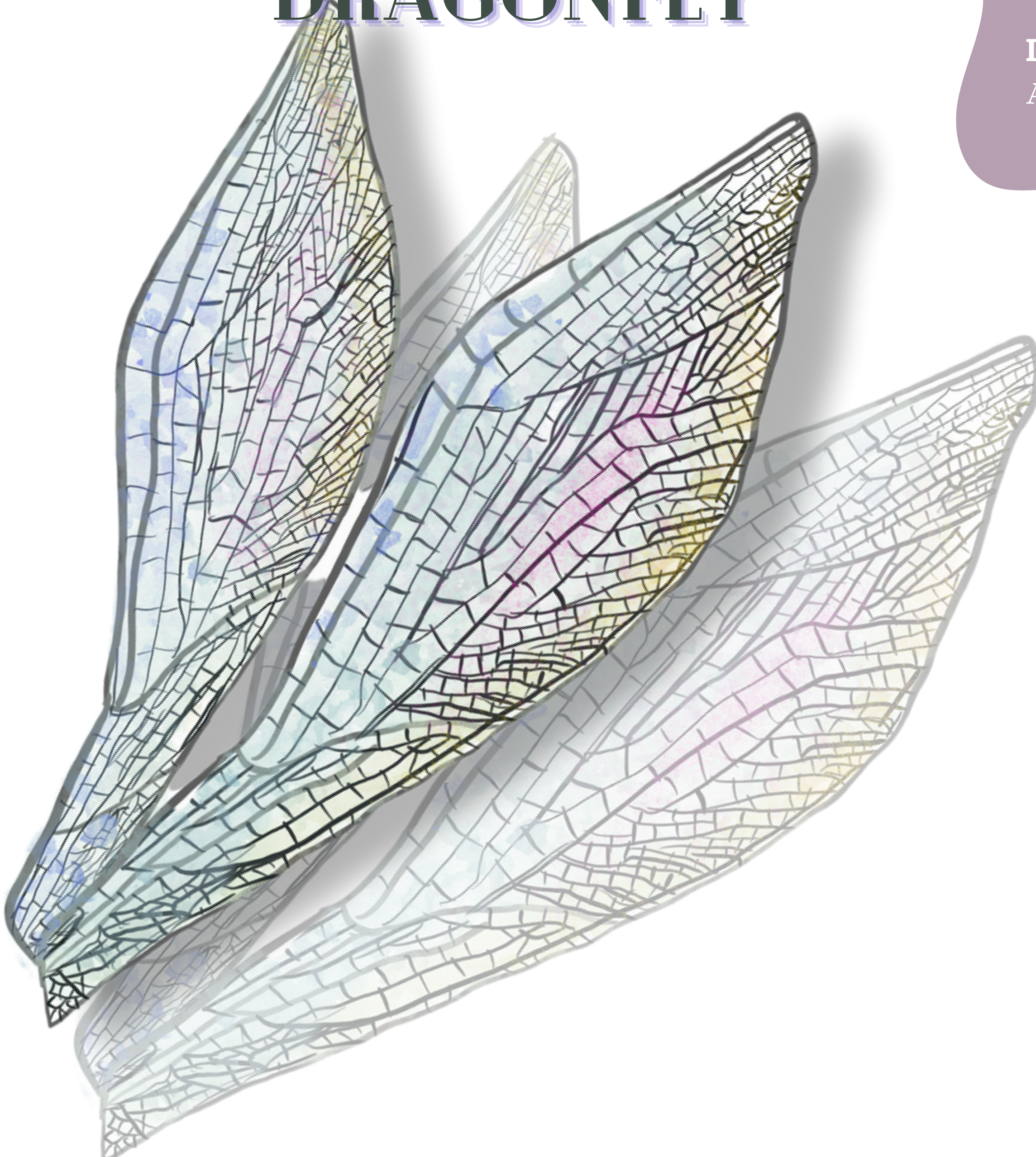
This insect order has one of the most beautifully colored flying insects in its grouping: dragonflies. Dragonflies are swift flyers, but if you're lucky and still enough, you can observe how colorful they are and how their wings rest over their bodies.
Their 2 pairs of wings resemble the propellers on a helicopter because of their long slender shape and give the insect the ability to fly in any direction. These characteristic wings provide it with stability and speed.



Shown are the 3 segments: the **head**, **thorax**, **abdomen**, as well as the 6 legs, and 2 pairs of wings and **antennae** of a dragonfly.

DRAGONFLY

Insect Order:
Odonata
Infraorder:
Anisoptera

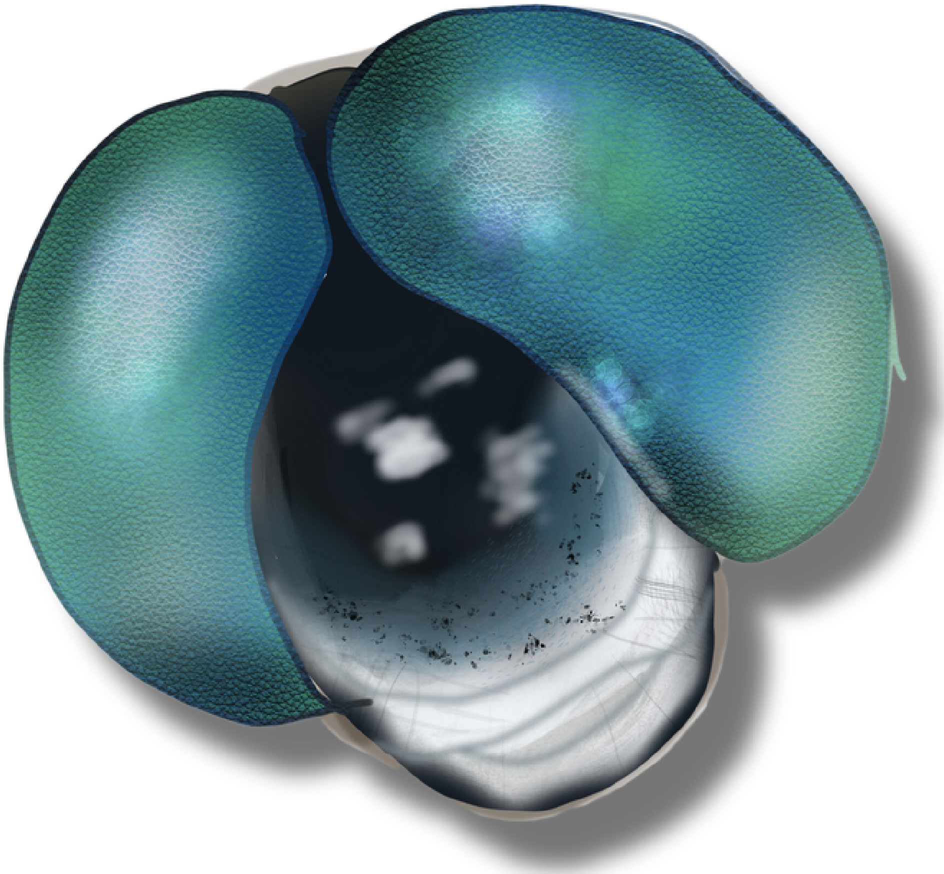


Their wings have different veining patterns that can be species-specific and provide stability to the dragonfly in flight. The veins are crucial to maintaining the wings' health because they contain the **nerves** and blood vessels necessary to control the wing muscles.

The wings of a dragonfly are made up of **chitin**, making them strong but lightweight, vital to the success of their flight ability. They are also **transparent**, which is an excellent adaptation because this allows the dragonfly to **camouflage** and avoid being spotted by predators.

DRAGONFLY

Insect Order: Odonata
Infraorder: Anisoptera

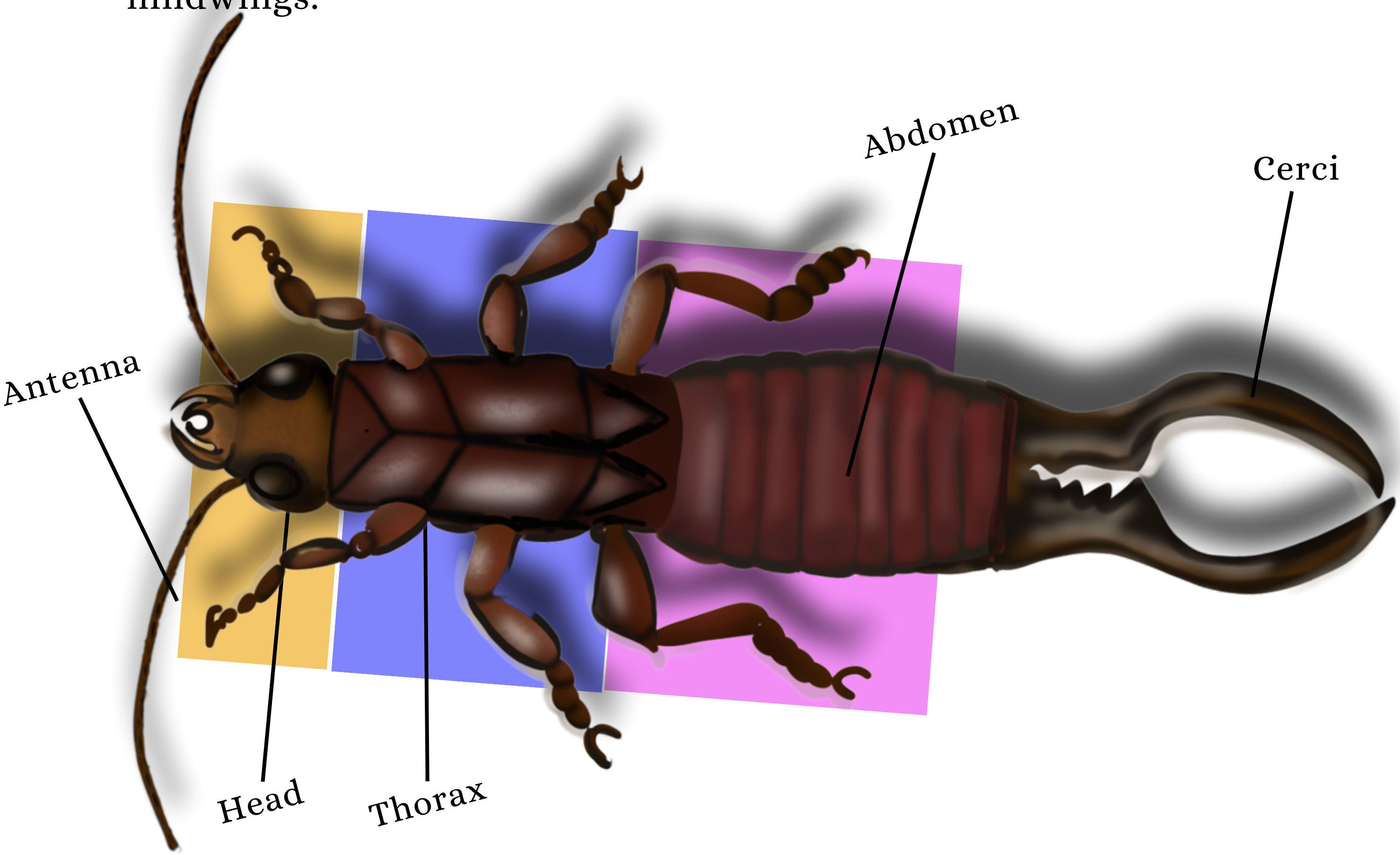


Their enormous **compound eyes** are another body characteristic that helps them be successful flyers. They're not only beautifully colored but also crucial to dragonflies' speed and agility while in flight because they allow the insect to monitor all their surroundings.

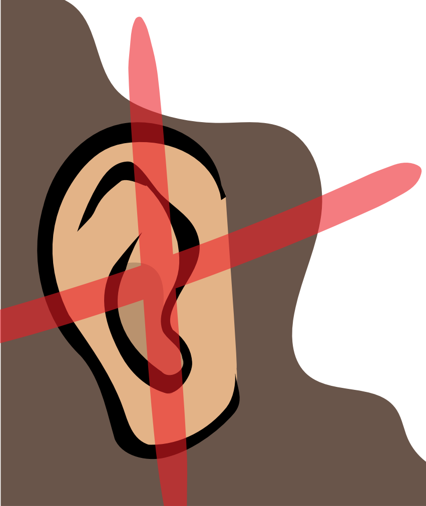
Insect Order:
Dermaptera

EARWIG

Earwigs, also known as pincer bugs, have long and slender bodies, and their last abdominal segment has been modified into powerful **cerci**. Although intimidating to look at and can cause a painful pinch, this modified last segment of the abdomen, known as cerci, acts as a pair of **sensory organs**. These powerful pincher-like **forceps** are used in predation and mating and help the insect fold its delicate hindwings.

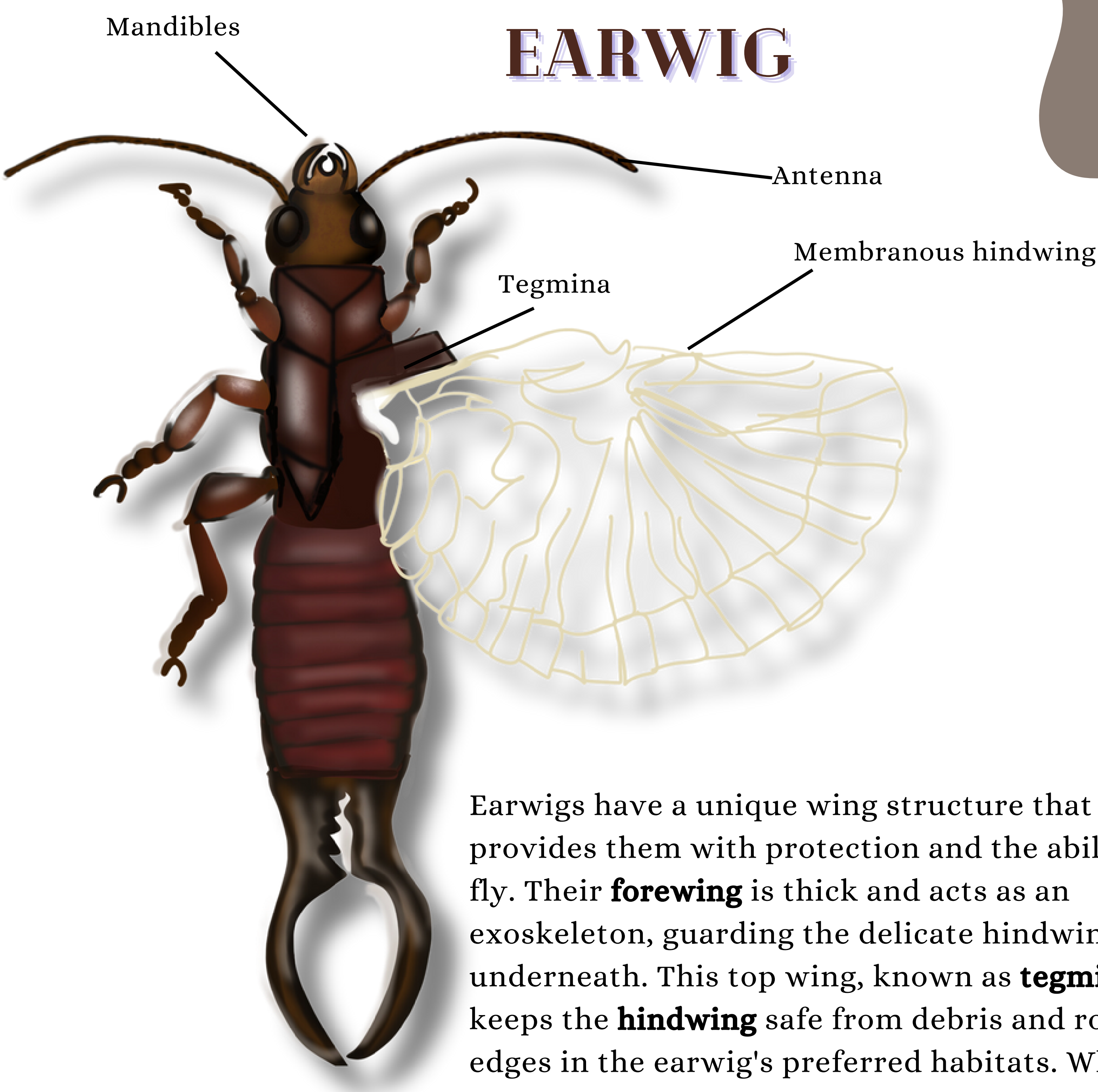


Despite their name, earwigs do not actually crawl into people's ears. These insects may look intimidating, but they are not as scary as they seem! Interestingly, it is not their **cerci** that have captured the attention of insect enthusiasts and scientists. Instead, it is their **hindwings** that have been studied due to their unique folding mechanism. This mechanism has even been used as a model for folding patterns in tents, maps, and electronic technologies.



Insect Order:
Dermaptera

EARWIG



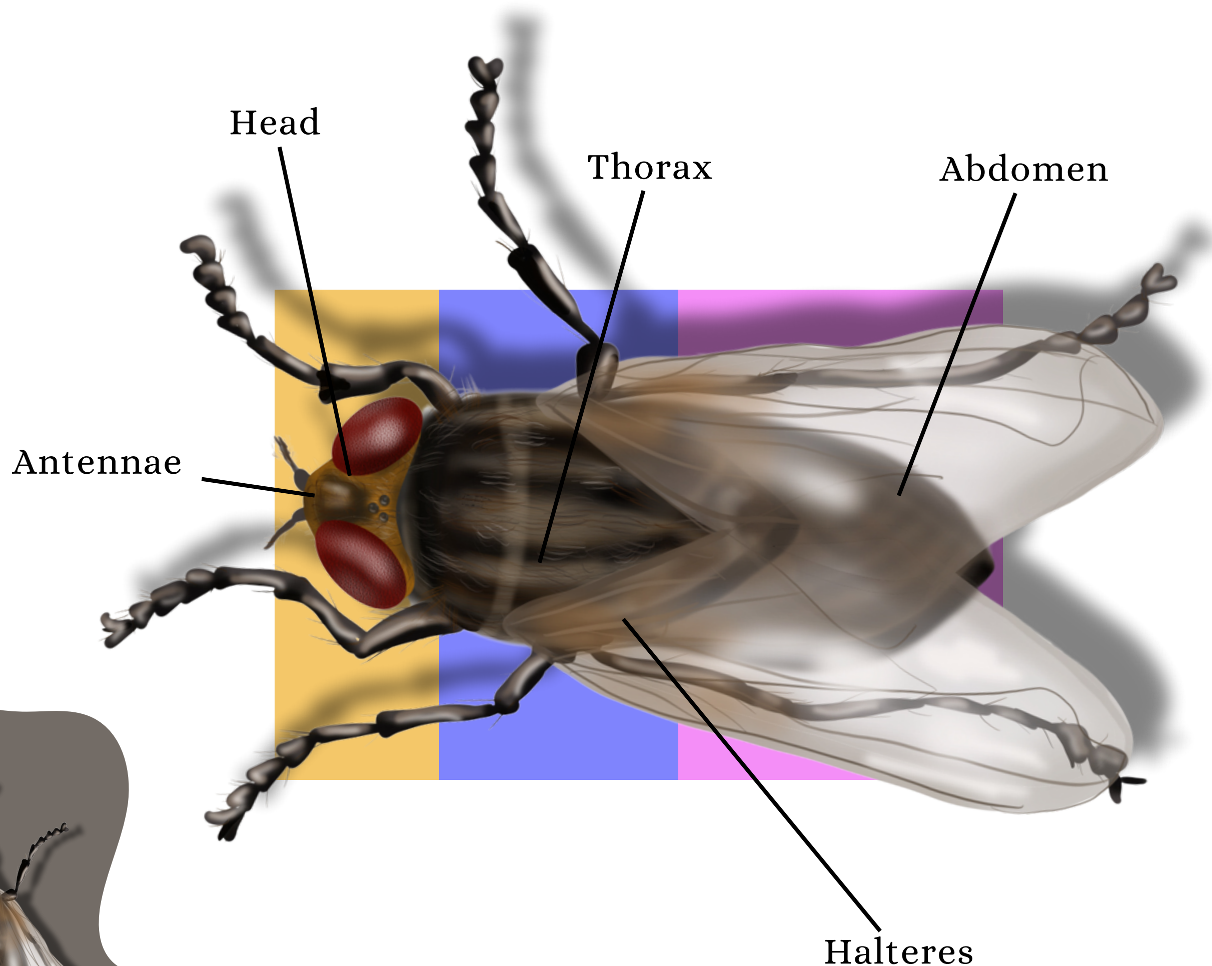
Earwigs have a unique wing structure that provides them with protection and the ability to fly. Their **forewing** is thick and acts as an exoskeleton, guarding the delicate hindwing underneath. This top wing, known as **tegmina**, keeps the **hindwing** safe from debris and rough edges in the earwig's preferred habitats. While the hindwings are not frequently used, they give the earwig an advantage by allowing them to escape predators and increase their chances of survival.

FLY

Insect Order: Diptera
Family: Muscidae

House flies can be pretty bothersome, especially when they try to invade our food. Although they may not be as charming or enjoyable as butterflies, they are among the most varied insect orders and possess fascinating features.

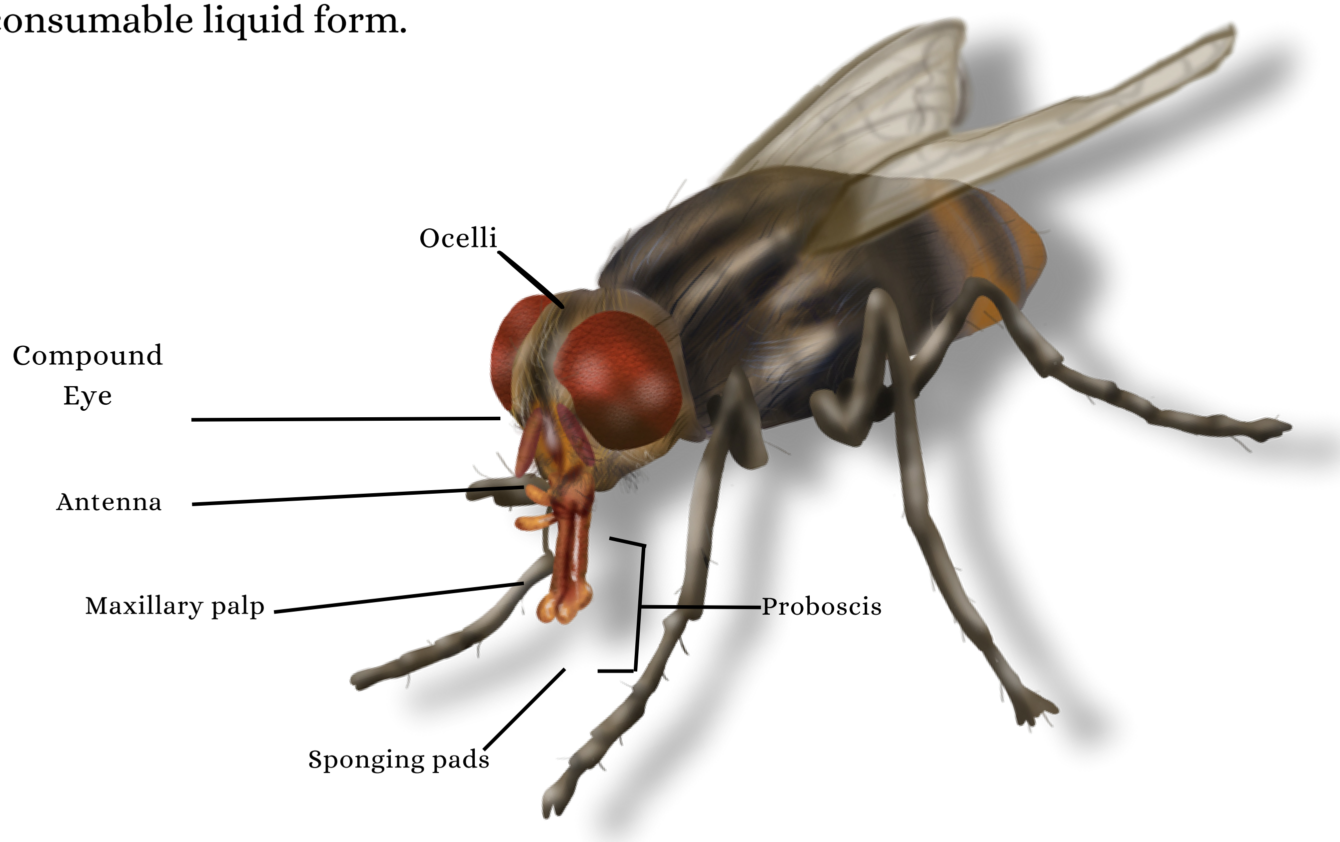
Like all insects, flies have 3 segments: head, thorax, and abdomen, but they have one pair of wings and a pair of modified hind wings called **halteres**. These act like steering wheels, enabling them to fly swiftly and quickly. The modifications fly has made have helped them survive and adapt to their ever-changing environment and needs.



FLY

Insect Order:
Diptera
Family:
Muscidae

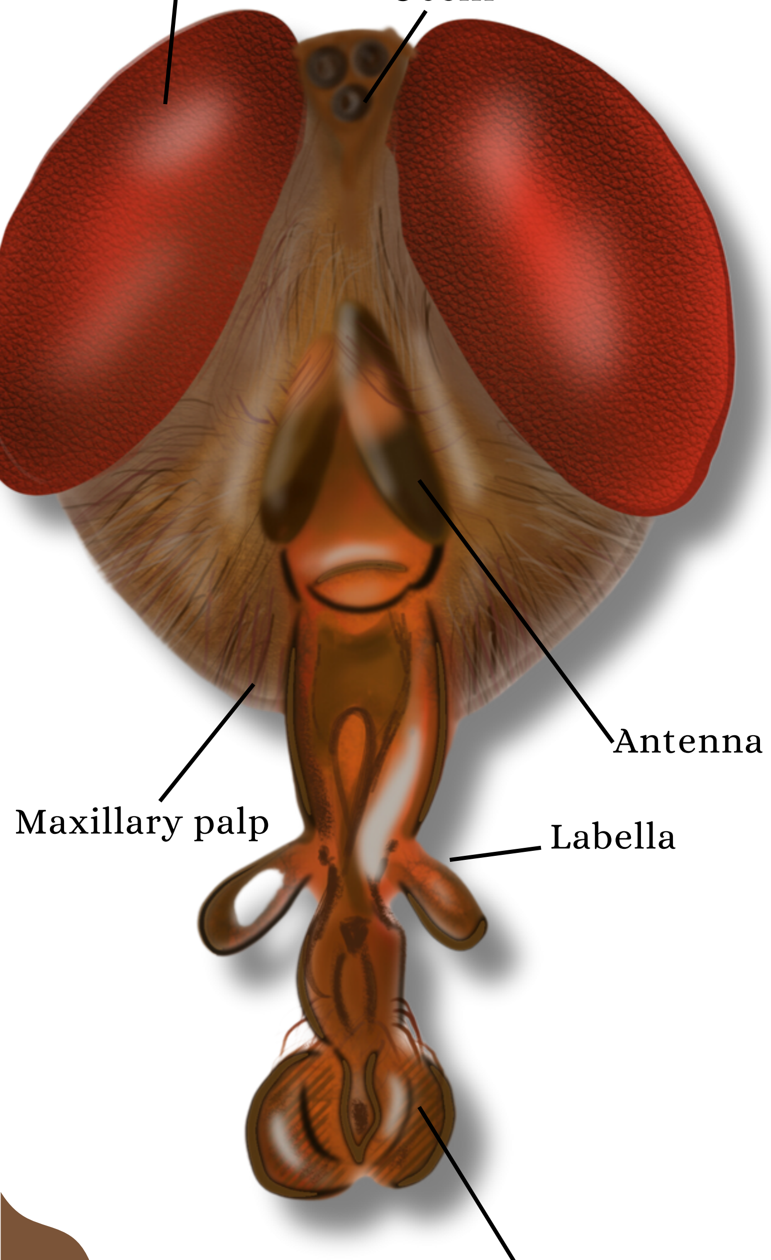
Different species of flies have developed specialized mouthparts that are evolved to their specific diets. House flies have mouthparts that only absorb liquid food, so they have developed feeding mechanisms that break down solids into consumable liquid form.



House flies use their **antenna** and **maxillary palps** to detect chemical scents, aiding them in finding potential food sources, mates, and ideal mating locations. When they find food, they land on a surface, their **labella** sample a small amount of the substance to determine if it's a suitable food source. They also use the **gustatory receptors** in their mouthparts and feet to taste their food. If the substance is deemed satisfactory, the **sponging pads** soak up the liquid food for absorption. To drink liquids like nectar, fruit juice, or even blood, house flies use their **proboscis** to suck it up, similar to a straw.

Insect Order:
Diptera
Family:
Muscidae

FLY

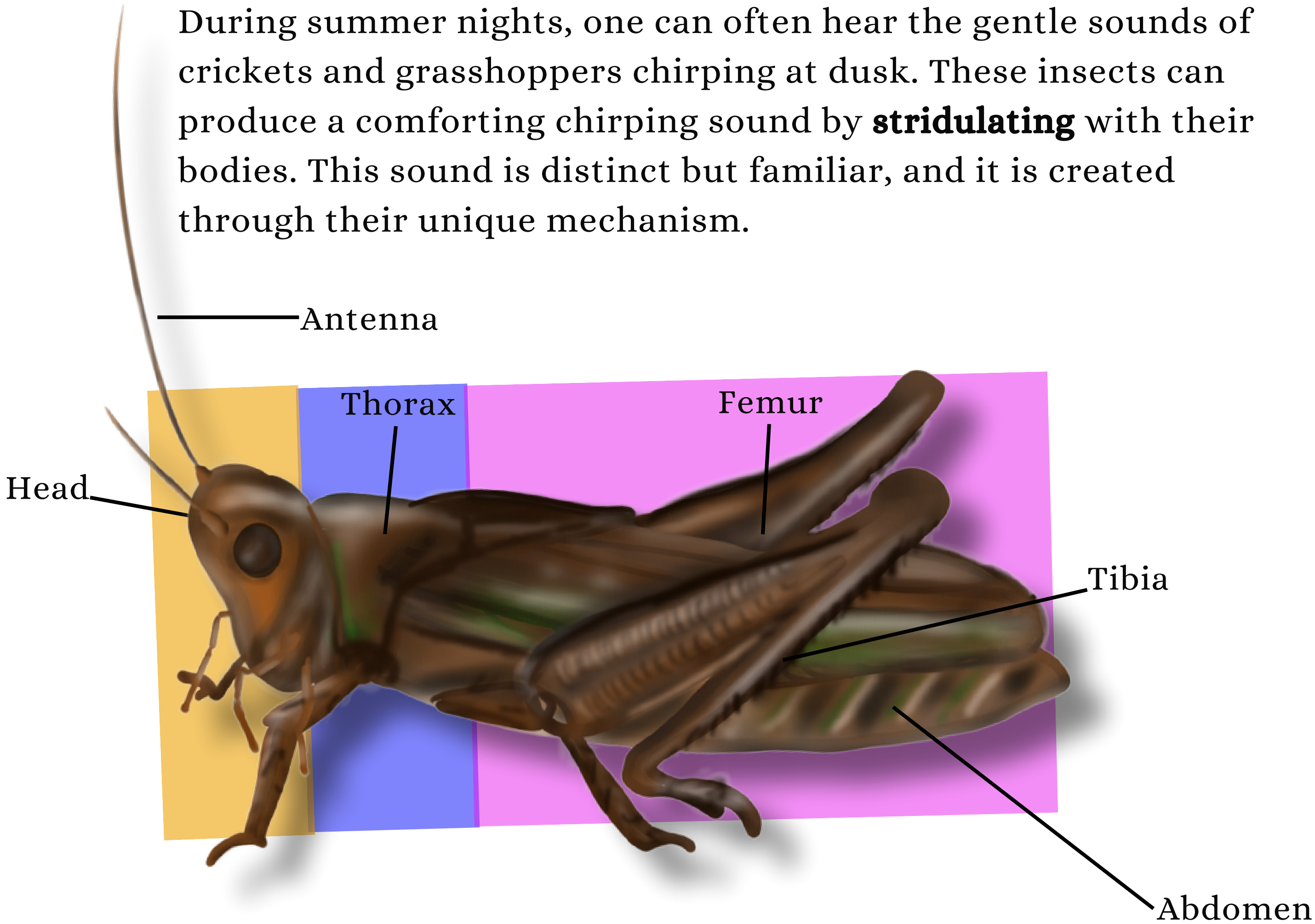


The house fly has a pair of **antennae** between their pair of **compound eyes** and also 3 small, simple eyes (**ocelli**) at the top of their head. This combination of eyes allows them to be swift fliers and expert food scavengers.
When the house fly cannot find a fully liquefied food source, it uses its evolved ability to dissolve food by **regurgitating** its digestive juices onto it. The fly absorbs as much liquid as possible using its **sponging pads**, which is then vomited onto the solid food. The **digestive enzymes** mix with the regurgitated juice to create a vomit that breaks down the solids, and the fly can slurp it up using its **proboscis**.
The ability to break down solids allows house flies to tap into a second food type, increasing feeding potential.

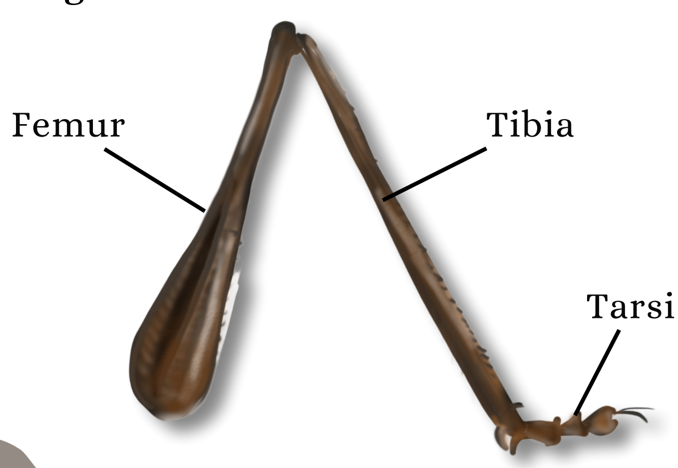
GRASSHOPPER

Insect Order:
Orthoptera

During summer nights, one can often hear the gentle sounds of crickets and grasshoppers chirping at dusk. These insects can produce a comforting chirping sound by **stridulating** with their bodies. This sound is distinct but familiar, and it is created through their unique mechanism.



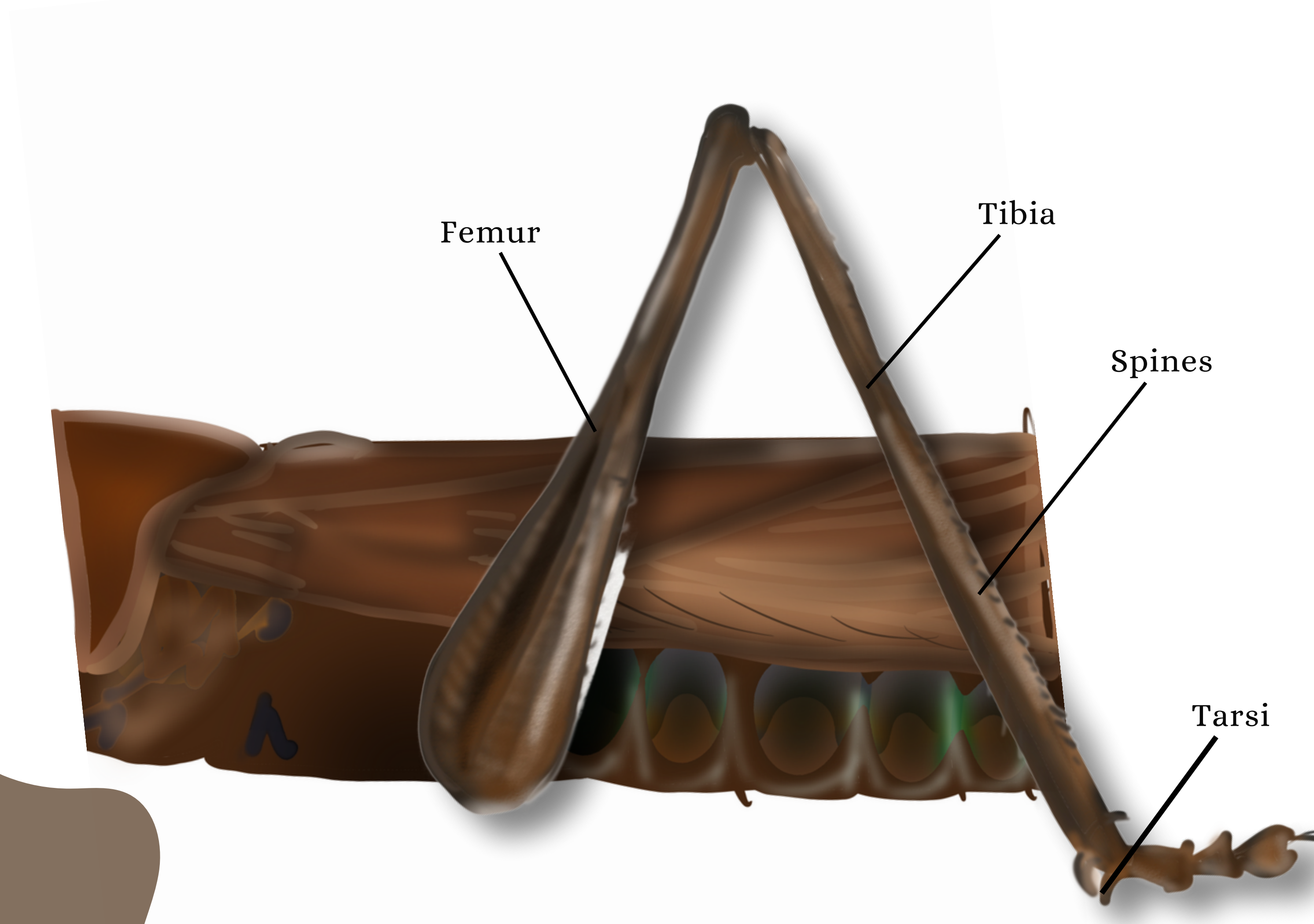
They have 2 pairs of wings and 6 legs, but their legs are in very different proportions compared to most other insect orders; these larger and more **muscular hind legs** allow them to jump to incredible distances, considering their small size.



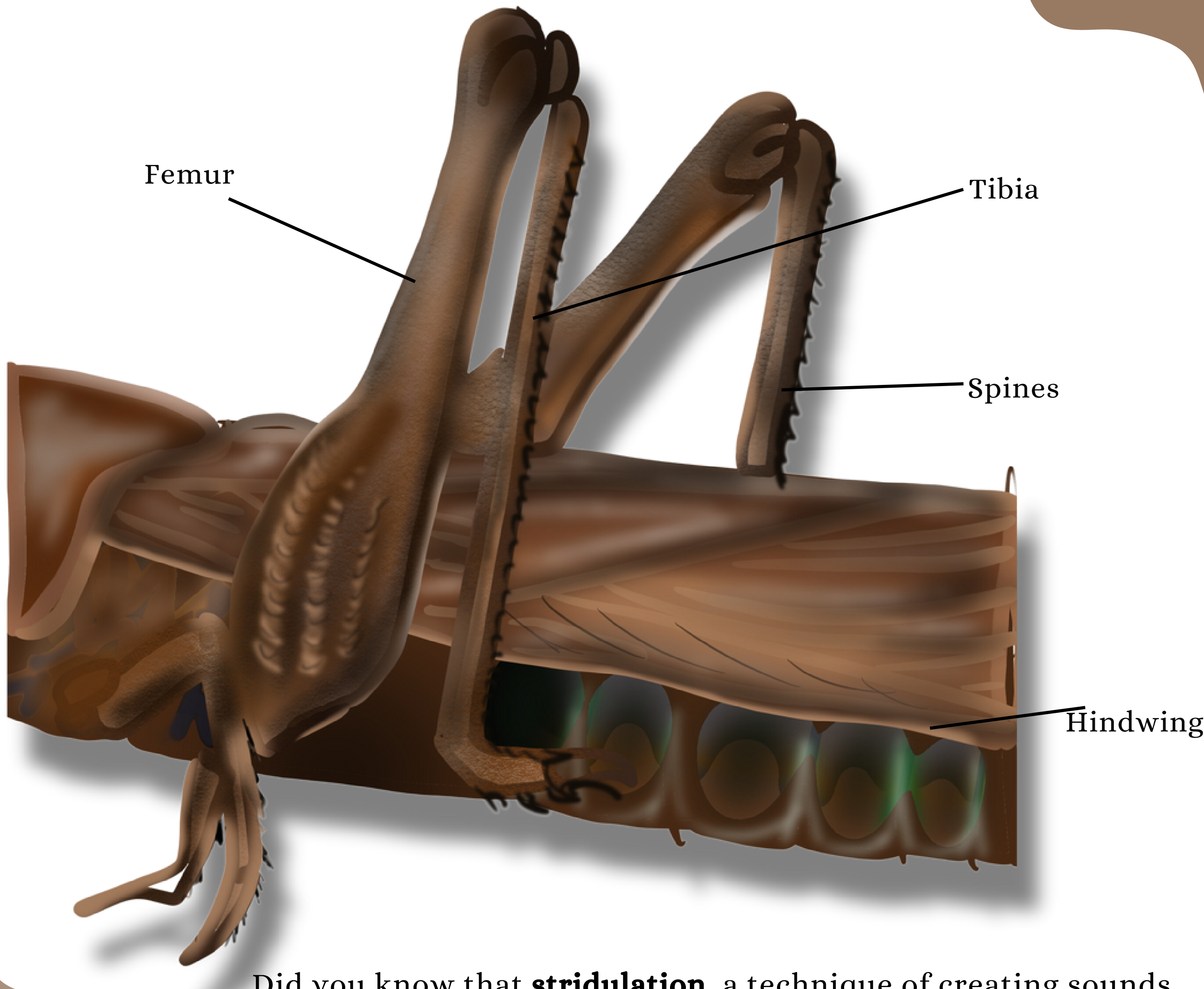
Insect Order:
Orthoptera

GRASSHOPPER

Grasshoppers have spines through their hind legs, but most can be seen on the tibia with the naked eye. The femur and tibia are elongated, and the leg looks solid and broad at the base, connecting to the thorax. These legs are flexible, allowing the grasshopper to rapidly flick the spines over and over through the rough edge of the hind wing, like a fine-tooth comb running through your nail, producing a rhythmic sound through **stridulation**.



GRASSHOPPER



Did you know that **stridulation**, a technique of creating sounds by rubbing body parts together, is not only used by grasshoppers and crickets? Other **arthropods** such as beetles, ants, and even some tarantula species also use this method to attract a mate and defend their territory by warning against potential competition or predators. Although the structures may vary, the purpose remains the same.

ACTIVITIES

Hands-on learning is crucial for developing new interests and exploring the world around us, regardless of age. The activities presented are centered on insects and their unique characteristics. They encourage children to express creativity while learning about insect abilities, strengths, and bodies.

Parents and educators can choose from two versions of the activities, designed for either home or classroom use. The activities come with scaffolding to ensure that each child learns at their own pace and maximizes their exploration and learning.

The media pages accompanying the activities provide a wealth of resources for both home helpers and teachers. These resources include fascinating videos, pictures, and educational materials about the discussed insects. They serve as the perfect starting point for new insect orders and exploring the fascinating world of entomology.

Ants

Goal:

By creating a 3D model of an ant's body, we will learn about its anatomy, including the 3 major segments and their smaller parts within each segment of the head, the thorax, and the abdomen.

Materials:

·Clay/playdough
·Pictures/diagram of ant body
·Construction paper
·Labels
·Markers

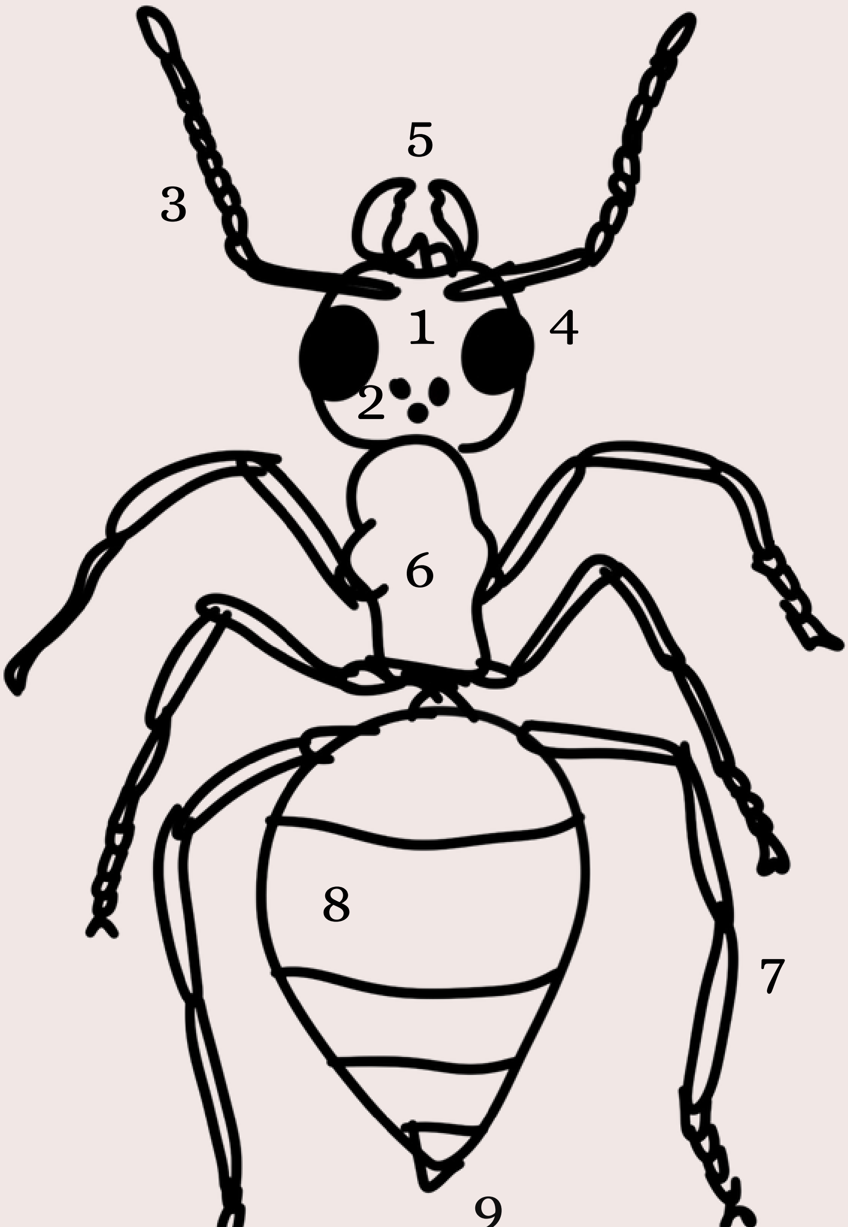
Instructions:

1. With the materials above create an ant making sure that you include correct anatomical structures.
2. Provide guidance and answer questions about each section.

Questions:

·How does each part of an ant help make them a successful insect order?
·Why do you think some ants can fly and others can't, even from the same colony?
·Why do you think ants need 2 types of eyes? What's the benefit?
·What environment do you think is ideal for ants, and why?
·If you were an ant, what part of your body would you make the strongest and why?
Would you rather be a queen ant, a worker ant, or a male? Why?

Ant Anatomy



1. **Head**
2. **Oceli**
3. **Antennae**
4. **Compound Eye**
5. **Mandibles**
6. **Thorax**
7. **Leg**
8. **Abdomen**
9. **Stinger**

Butterfly

Goal:

By creating a butterfly wing and covering them with colorful paper mâché scales, we will learn how the butterfly's scales cover its wings.

Materials:

·Construction paper sheets
·Scissors
·Glue
·Paintbrushes
·Black markers
·Variety of tissue paper cut into smaller pieces.
Photos or drawings of real butterfly wings for reference

Instructions:

1. Look up pictures or drawings of real butterflies and choose your favorite to use as inspiration.
2. Using construction paper sheet, fold it in half, creating a "wing" shape.
3. Draw a wing outline on construction paper and cut out the wings.
4. Using the small tissue paper pieces, dip them into the glue and then place them into their butterfly wings, creating a "scale" effect.
5. Once the wings are covered in scales, you can choose to paint them, adding more color and decoration.
6. Allow wings to dry.
7. Draw on wing venations over their colorful scales once dry.

Questions:

- What other animals have scales?
- Why are scales important to butterflies?
- How do scales help protect butterflies from predators?
- What colors and patterns did you use, and why?

Cockroach

Goal:

To understand the purpose of armor and exoskeletons in protecting knights and insects. Compare and contrast the features of both the armor and the exoskeleton. Design and construct a model of exoskeletons and test the durability of your creations.

Materials:

·Craft materials such as cardboard, paper, foil, straws, tape
·Scissors
·Glue
·Objects to test the strength, such as books, small weights.
·Ruler to measure how much the weights push on their armor.

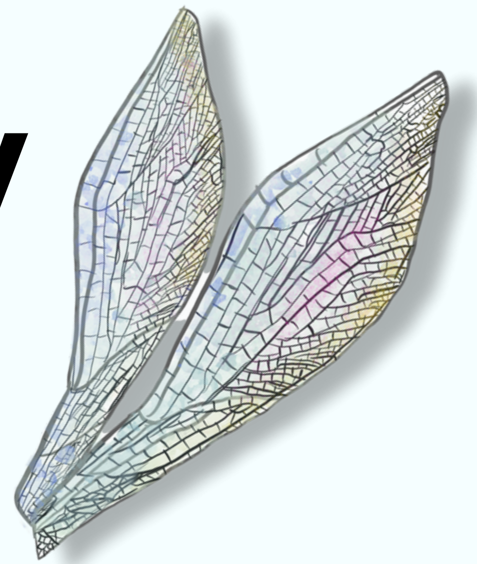
Instructions:

1. Using the the materials above create amodel of an exoskeleton thinking creatively and use various materials.
2. Test the durability of your creations by placing them all on a flat surface and then placing the books/weights on top.
3. Use the ruler to measure how much weight each can stand before collapsing.

Questions:

- Why do tougher structures with harder edges and more robust materials withstand more pressure before collapsing?
- How would this support the idea that cockroaches can survive catastrophes when other organisms, such as mammals, cannot?
- How does having an exoskeleton give them a survival advantage?
- Do you think their size also helps this be true? Why would it not make sense for insects to be giant when having to produce an exoskeleton?

Dragonfly



Goal:

To practice math skills while learning about dragonflies, flight, and their wings.

Materials:

·Colored construction paper
·Markers
·Stickers, glitter
·pipe cleaner for body and antennae
·Scissors
·Glue
·Ruler or tape measure
·Recording sheets
·Pencils
calculator

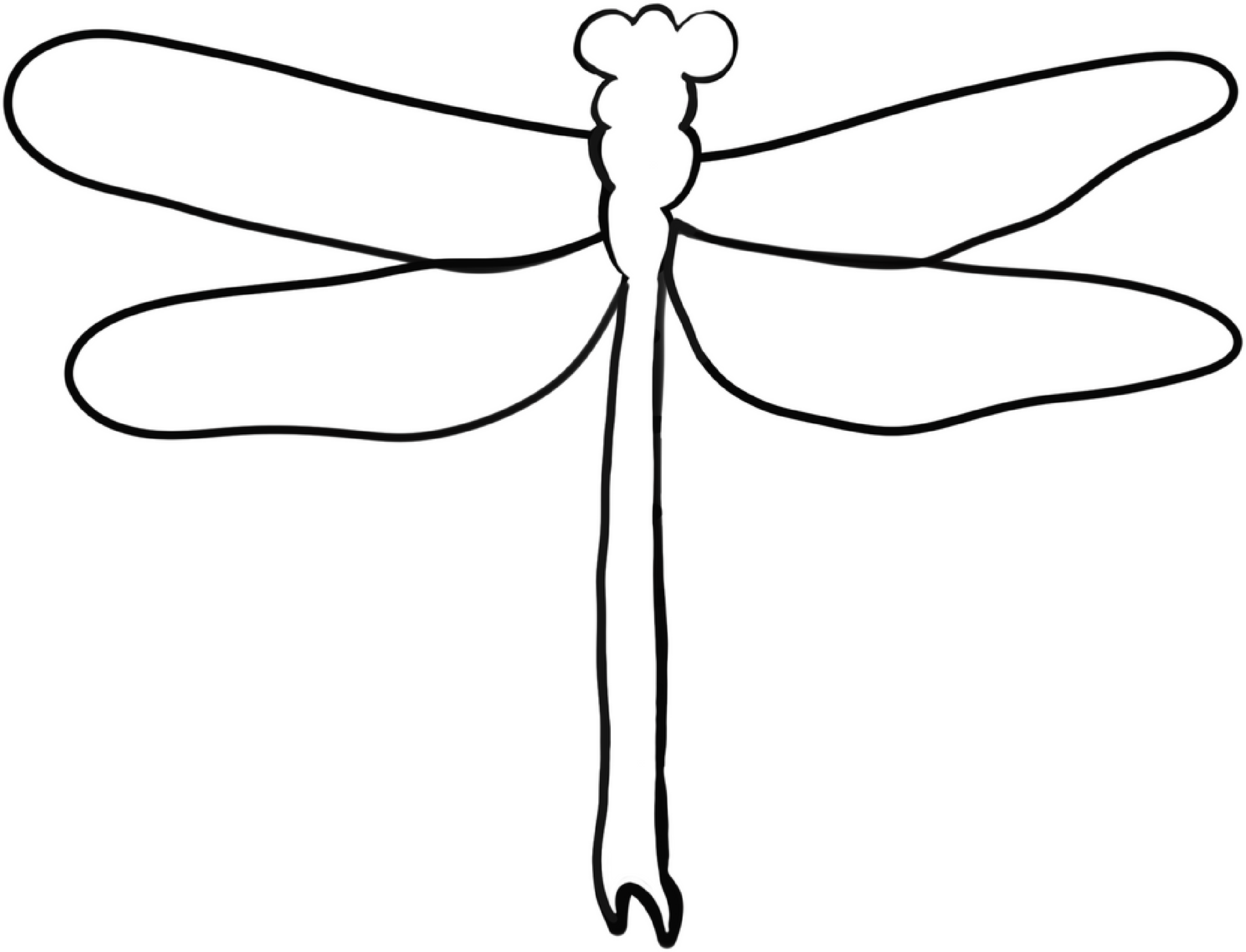
Instructions:

1.Choose a piece of colored construction paper and fold it in half.
2.Draw a dragonfly shape on one half, ensuring symmetrical wings.
3.Cut out the dragonfly shape carefully using scissors.
4.Decorate the dragonfly using markers, glitter, and stickers if desired.
5.Take a pipe cleaner and attach it to the dragonfly using glue. You can fold the paper body to give it a 3D effect.
6.Shape the remaining part of the pipe cleaner into antennae and attach.
7.Let the glue dry completely.
8.Take turns measuring the distance their dragonflies fly using a ruler or tape measure.

Questions:

- How do lightweight and stable wings help produce a longer distance?
- Why would it be a massive advantage for the wings to be so light and durable?

Dragonfly template to cut



Earwig

Goal:

Practicing fine motor skills and creativity by trying to recreate the earwigs membranous wing folding mechanism.

materials:

·Scissors
·Paper (8.5x11 inches)
·White tissue paper
·Markers
·Crayons
·Tape
·Cardstock

Instructions:

1.Using a piece of paper, tissue paper, and 2 parts of tape, secure the white paper to the desk
2. Fold the tissue in half and then in small folds creating a fan. Fold the fan in half, then tape the middle to plain paper. Place the cardstock rectangle over the folded fan middle the long way to cover the fan with it completely.
4. Unfold the tissue paper fan carefully under the cardstock flap, opening the "wings."
5.decorate their wings using markers and patterns. Encourage the students to fold the tissue wings so neatly and small that they fit under the cardstock.

Questions:

- What about the environment that caused this to evolve?
- Why is it an advantage?
- What worked and what didn't?
- Why?

Fly

Goal:

To understand the feeding behaviors and food preferences of house flies.

Materials:

- Scissors
- Paintbrushes
- Glitter
- Googly eyes
- Small sponges
- Tissue paper in different colors
- Fly outline paper
- Party blower
- Markers
- Glue
- Small plates or bowls
- Spray bottle
- water

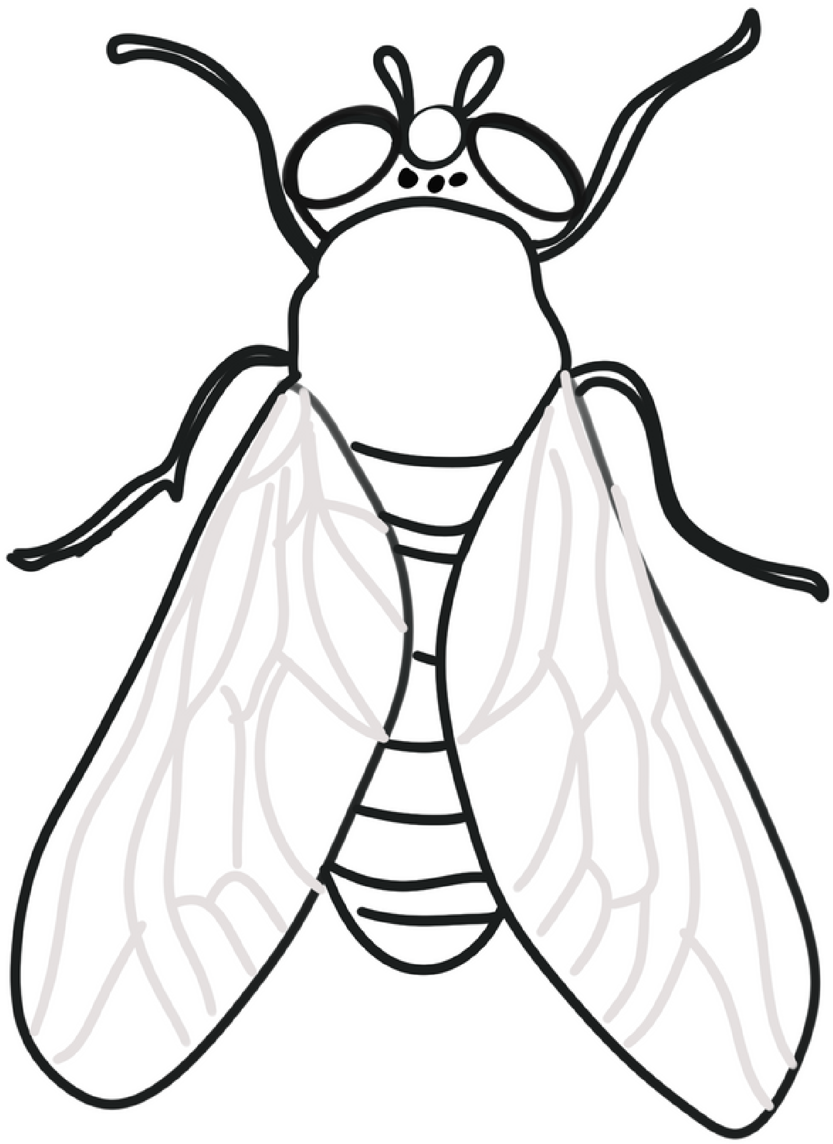
Instructions:

1.Using a fly outline, color and personalize their fly, add googly eyes, and cut out a small hole where the proboscis would be on the head.
2.Place the tube of the party blower through the paper and secure it with tape. At the tip of the party blower, tape a little double-sided tape and attach the small sponge strip.
3.Cut out different shapes of the colored tissue paper to make their "food" and place each type of food on a small plate or bowl. Some food should be small, crumbled tissue paper balls and put in dry plates or bowls.
4.Using the proboscis, attempt to eat each type of food by blowing the proboscis and trying to pick up the food (tissue paper). Observe how they can only eat liquid food because only the wet paper sticks to the sponge.
5.They then "vomit" by spraying water onto the dry plates with tissue paper balls. Let those soak up and attempt to pick them up, representing how a fly ingests its liquified food, but understanding that it is much more work to choose the type of food over already liquified foods.

Questions:

- Why is it beneficial to choose easier-to-digest foods?
- What advantage is it to only having liquid foods?
- What would you choose if you could choose between what type of foods to eat? Solids, liquids?
- Why?

Fly Outline



Grasshopper

Goal:

To learn how grasshoppers make sounds, use rubber bands to create leg models. Try different tensions and scraping or plucking methods to see how it affects the sound.

Materials:

- ·Empty tissue box
- ·Rubber bands of various lengths and tensions
- ·Fine tooth comb
- ·Markers or colored pencils (optional to decorate ther box)

Instructions:

1.Using the empty tissue box, attach rubber bands of differing lengths and thicknesses to their boxes.

2. experiment by stretching, plucking, and rubbing the fine-tooth comb across the rubber bands while observing the differing sounds.

4. Predict how the difference in lengths and thickness of the rubber band will affect the pitch and volume of the sound produced.

Questions:

What form of sounds do we use to communicate that are not words?

How is our use of language like stridulation?

Think about our vocal cords vibrating.

Lesson plans for educators
See Word File
"Lesson Plans AthruG"

GLOSSARY

- **Abdomen**: the last segment of the body, houses the organs used for digestion, excretion, and reproduction. This segment can have as many as 11 fused segments.
- **Adapt**: the ability of an organism to adjust to new environmental changes.
- **Ant Queen**: may live up to 25 years; her primary role is to lay eggs. She produces workers, males, and new queens. New queens are produced when the queen has winged females and winged males that will mate and start the cycle once more.
- **Antennae**: sensory organ located at the head above the mouthparts, used to sense smell, temperature, sound, and movement in the air. Usually different among species and even between males and females of the same species.
- **Arthropods**: an invertebrate animal with jointed appendages.
- **Brood**: a group of offspring born simultaneously
- **Butterfly Scales**: overlapping “shingle-like” formations that provide aerodynamic efficiency, color, camouflage, waterproofing, and insulation.
- **Camouflage**: the ability to use one’s color, formation, or pattern to blend into the surrounding, avoiding predation.
- **Cerci**: the last segment of the abdomen that develops as a pair of sensory organs.
- **Chitin**: a polymerized compound found in insects and other arthropods like crabs and lobsters. These compounds are common in nature and form the base of wood, hair, and horns.
- **Colony**: a group of insects that lives in a nest and works together to care for the offspring and share resources and tasks.
- **Compound eyes**: an organ that allows the insect to see, usually made up of many individual eyes,
- **Debris**: the surface layer of the habitat with non-living organic matter, such as decaying plant matter, leaves, and branch bunches.
- **Defense mechanisms**: this type varies widely depending on the insect’s abilities and the type of predation or danger the insect faces. This could be a chemical defense, like poison, and strong chemical odors to ward off predators. Others use physical defense using mandibles, spines, horns, and camouflage.
- **Digestion**: the breakdown of food into a more suitable form where nutrients can be absorbed.
- **Digestive enzymes**: chemicals that degrade the molecules of the food source, making them easier to be absorbed in the gut.


GLOSSARY

- **Digestive system**: all insects have a complete digestive system. This means food processing occurs lengthwise through the body from mouth to anus.
- **Diptera**: the insect order where true flies belong. They have one pair of forewings used for flight and a modified pair of hindwings that are halteres.
- **Directional steering**: many small muscles control the power of the wing muscles to move in a particular direction.
- **Diverse**: having a wide variety
- **Elytra**: front wings formed as a chitinous protective cover.
- **Epidermal Cells**: the cells responsible for producing the outermost cell layer of the insect; in Lepidoptera, these are responsible for the production of scales.
- **Excretory system**: the system responsible for removing waste through the anus.
- **Exoskeleton**: provides a rigid body and is where muscles attach, like the skeleton of a human, but it is outside of the body, like a tough outer skin layer protecting the internal organs and avoiding drying out the insect.
- **Feeding habits**: the behavior of an insect that serves them to choose the specific type of foods they can digest and receive nutrients from.
- **Female worker ant**: the first offspring a young ant queen has; they are sterile and do the work to maintain the colony, including nest construction, food gathering, and care of the young.
- **Flexibility**: Some minerals are produced to harden the areas that need to be more stable, while some areas of the exoskeleton have more elasticity.
- **Forceps**: the last abdominal segment is formed into pincer-like cerci in earwigs. These are used in predation and mating and help the insect fold its hindwings.
- **Forewing**: the first 2 wings on a 4-wing insect. Some insects develop these as tough protective layers of the thinner, more delicate hind wing (beetles, cockroaches, grasshoppers).
- **Gustatory receptors**: receptors that sense taste by detecting molecules.
- **Habitat**: an environment where an organism lives.
- **Halteres**: knobbed guidance organs in flies, formed instead of the hindwings.
- **Head**: the first segment of an insect body with mouthparts, antennae, brain, and eyes.

GLOSSARY

- **Hindwing**: the second pair of wings on 4-wing insects. Usually membranous but can have other characteristics like scaled or fringed as the butterflies and thrips.
- **Hymenoptera**: the order of insects, including bees, wasps, flies, and ants.
- **Insect enthusiasts**: people who are interested in insects.
- **Insect order**: the classification and categorization of insects, mainly using their wings structures and usually ending in “ptera.’
- **Insulation**: prevents the flow of heat of the body by using layers to stop the flow from the body
- **Iridescent**: showing glittering colors that seem to change as seen from different angles.
- **Labella**: spongy structure in flies that dabs liquid into the proboscis.
- **mandibles**: chewing mouthparts, jaw.
- **Mate selection**: any behavior that helps one member of one sex to choose or select a member of the opposite sex. In some organisms, the colors, dancing, and size is part of what helps the female choose them to mate.
- **Maxillary palps**: olfactory organs that play a major role in host detection and other sensory behaviors.
- **Membranous wing**: a rigid yet delicate wing that uses veins to toughen the structure.

- **Microscope**: a tool used to magnify small or minute objects
- **Mimic**: to copy.
- **Modifications**: a change in an organism acquired from its activity or behavior
- **Modified hind legs**: the legs of a grasshopper are longer at the femur and tibia, and they are specialized for jumping long distances and used in stridulation.
- **Nerves**: in flying insects, the veining of the wings contains nerves that help control the information shared with the insect to act according to the stimulus.
- **Ocelli**: simple eyes, usually 2 or 3, sense light.
- **Predator**: organisms that feed on other animals, their prey.
- **Proboscis**: a tube formed by the maxillary elements through which food passes in liquid form. It is coiled in when not in use.

GLOSSARY

- **Propellers**: spinning blades that create a thrust pushing upward, as a helicopter uses.
- **Propulsion**: the act of pushing forward
- **Regurgitating**: insects have a crop organ where they store juices that mix with digestive enzymes, which they vomit onto a food source to break down the material for them to consume or slurp up the liquid as flies do quickly.
- **Reproduce**: the ability to produce offspring. The power of insects to reproduce is one of the most important features.
- **Reproductive organs**: organs used in the act of reproduction.
- **Sensory organs**: organs that are specialized in perceiving stimulation from the surroundings.
- **Species-specific**: limited to one species.
- **Sponging pads**: the mandibles and maxillae are nonfunctioning, and the proboscis has a fan-like sponge at the tip. This mops up the liquid.
- **Stimuli**: insects move toward or away from triggers such as light, humidity, air, vibrations, and scents.
- **Stridulate**: the creation of friction by rubbing specialized body parts together.
- **Tagmata**: a distinguished region typically made up of adjoining segments. In insects, there are 3 tagmata- the head, thorax, and abdomen.
- **Tegmina**: thickened forewings of insects.
- **Thermoregulation**: the ability to maintain a stable body temperature based on environmental changes.
- **Thorax**: the middle section between the head and the abdomen. The locomotive unit where legs and wings are attached. It has 3 modified segments where a pair of legs are connected to each.
- **Transparent**: see-through about the insect wings in insect orders such as Odonata
- **Turbulence**: the changes in air movement and low around a flying organism or object.
- **Veining**: a system of veins runs throughout the membranous wings, giving strength and rigidity to the wing. These formed veining maps are used to classify insects and identify them.
- **Vibrations**: movement of the body in back and forth, up and down motion

MEDIA & REFERENCES

- (2020, April 20). How do insects make sounds? OpenScieEd. Retrieved June 20, 2023, from https://www.openscied.org/wp-content/uploads/2020/06/8.2-Lesson-2-Handout-How-do-insects.pdf
- (Junior encyclopedia) . 2016. Junior encyclopedia. Miles Kelly Publishing Ltd, Essex, UK.
- [Abhishek Drawing]. (2021, January 28). How to Draw a Housefly step by step [Tutorial] [Video]. YouTube. https://www.youtube.com/watch?v=HS7hPQ688EI
- [Art With B]. (2021, December 16). How to draw head and mouth parts of housefly | housefly head part diagram | mouth part diagram [Video]. YouTube. https://www.youtube.com/watch?v=tfdTxQwPJp0
- [Asst Prof SSNAIK ENTO PJTSAU]. (2014, October 18). INSECT THERMO DYNAMICS [Video]. Slide Share. https://www.slideshare.net/srinivasnaik52643/insect-thermo-dynamics
- [Draw Curiosity]. (2019, March 28). 5 Things You Didn't Know About Insect Wings [Video]. YouTube. https://www.youtube.com/watch?v=exdL2H9PzJA
- [ETH ZüRich]. (2018, May 23). Earwigs and the art of origami [Video]. YouTube. https://www.youtube.com/watch?v=0NQ_nn3VLiY
- [Heatherly Photography]. (2018, October 8). Fly Regurgitation [Video]. YouTube. https://www.youtube.com/watch?v=DUXr-0x-FLY
- [Hungry SciaNNtist]. (2021, September 15). 10 Things You Didn't Know About Flies | Housefly Facts | Interesting Facts for Kids [Video]. YouTube. https://www.youtube.com/watch?v=q4Reo-TFp14
- [It's All Primary]. (2020, October 27). HOW To CREATE A LESSON PLAN: WHAT TO PUT INTO YOUR TEMPLATE [Video]. YouTube. https://www.youtube.com/watch?v=PSNqNzX8S2c
- [KyushuUniv]. (2020, July 13). Earwig-inspired fan [Video]. YouTube. https://www.youtube.com/watch?v=HWJjVeB8GJo
- [Movie Vertigo.] (2018, June 17). Grasshopper Stridulation Nikon P900 Raynox DCR-250. YouTube. https://www.youtube.com/watch?v=nHl01ZvEV1Y
- [Real Science]. (2021, February 6). The Insane Biology of: Ant Colonies [Video]. YouTube. https://www.youtube.com/watch?v=VLBDVXLiWxQ
- [Sherry Drawings.] (2021, August 19). How to draw a fly easy. YouTube. https://www.youtube.com/watch?v=AoJjtVvG1A8
- [SmarterEveryDay]. (2013, May 21). Dragonfly Wings in Slow Motion - Smarter Every Day 91 [Video]. YouTube. https://www.youtube.com/watch?v=oxrLYv0QXa4
- [SmarterEveryDay]. (2013, November 1). The Magic of Butterfly Scales - Part 1 - Smarter Every Day 104 [Video]. YouTube. https://www.youtube.com/watch?v=zsjyWg-Lhek
- [SmarterEveryDay]. (2013, November 29). The Magic of Butterfly Scales - Part 2 - Smarter Every Day 105 [Video]. YouTube. https://www.youtube.com/watch?v=LE2v3sUzTH4
- [The Infographics Show}]. (2012, April 12). How Can A Cockroach Survive A Nuclear Explosion? YouTube. from https://www.youtube.com/watch?v=KjfOnWpX44E.

MEDIA & REFERENCES

- [University of Virginia]. (2014, September 17). Investigating the Secrets of Dragonfly Flight [Video]. YouTube. https://www.youtube.com/watch?v=cJJowVxiaRU
- [Wildlife Chronicles]. (2020, July 28). The Anatomy of Insects [Video]. YouTube. https://www.youtube.com/watch?v=58hDAxPbMIs
- American Museum of Natural History (n.d.). Parts of an Insect (Grasshopper). Www.Amnh.org. Retrieved June 27, 2023, from https://www.amnh.org/learn-teach/curriculum-collections/biodiversity-counts/arthropod-identification/arthropod-morphology/parts-of-an-insect-grasshopper
- Ant. (2023, July 5). In Wikipedia. Add a little bit of body text
- Britannica, The Editors of Encyclopaedia. "housefly". Encyclopedia Britannica, 5 May. 2023, https://www.britannica.com/animal/housefly. Accessed 5 July 2023.
- California Department of Education (2022, April 14). Common Core State Standards. Www.cde.ca.gov. Retrieved May 3, 2023, from https://www.cde.ca.gov/re/cc/
- California Department of Education (2022, April 14). Common Core Search. Www2.cde.ca.gov. Retrieved May 3, 2023, from https://www2.cde.ca.gov/ccsr/
- California Department of Education (n.d.). CCSS Mathematics Resources. Www.cde.ca.gov. Retrieved May 3, 2023, from https://www.cde.ca.gov/re/cc/mathresources.asp
- Cockroach. (2023, July 5). In Wikipedia. Add a little bit of body text
- Dragonfly. (2023, June 18). In Wikipedia. Add a little bit of body text
- Earwig. (2023, July 1). In Wikipedia. Add a little bit of body text
- Faber, J. A., Arrieta, A. F., & Studart, A. R. (2018). Bioinspired spring origami. Science. https://doi.org/aap7753
- Gifford, C., S. Kennedy, P. Parker, and J. Challoner. 2017. Science year by Year. Dorling Kindersley, London.
- Grasshopper. (2023, June 12). In Wikipedia. Add a little bit of body text
- Hedenström, A. (2014). How Insect Flight Steering Muscles Work. PLoS Biology, 12(3). https://doi.org/10.1371/journal.pbio.1001822
- Housefly. (2023, June 18). In Wikipedia. Add a little bit of body text
- Lepidoptera. (2023, July 3). In Wikipedia. Add a little bit of body text
- Liu, G., Wang, Q., Liu, X., Li, X., Pang, X., & Zhang, D. (2021). Antennal and palpal sensilla of three predatory Lispe species (Diptera: Muscidae): an ultrastructural investigation. Scientific Reports, 11(1), 1-12. Add a little bit of body text
- Lundberg, M. (2015). Marcus Lundberg [Degree Project in Engineering Physics, KTH Mechanics]. Add a little bit of body text
- Mainz, Universitaet. "Worldwide insect decline: Causes, consequences and potential countermeasures" Phys, 27 Apr. 2023, https://phys.org/news/2023-04-worldwide-insect-decline-consequences-potential.html. Accessed July 1, 2023.

MEDIA & REFERENCES

- Michelsen, A. (1998). The Tuned Cricket. Physiology. https://doi.org/10.1152/physiologyonline.1998.13.1.32
- Next Generation Science Standards- For States By States (n.d.). 1-LS1-1 From Molecules to Organisms: Structures and Processes. Https://www.Nextgenscience.org/. Retrieved May 5, 2023, from https://www.nextgenscience.org/pe/1-ls1-1-molecules-organisms-structures-and-processes
- Next Generation Science Standards- For States By States (n.d.). 4.Structure, Function, and Information Processing. Https://www.Nextgenscience.org/. Retrieved May 5, 2023, from https://www.nextgenscience.org/sites/default/files/4.SFIP%205.6.13With%20Footer.pdf
- Next Generation Science Standards- For States By States (n.d.). THE THREE DIMENSIONS OF SCIENCE LEARNING. Https://www.Nextgenscience.org/. Retrieved May 3, 2023, from https://www.nextgenscience.org/
- Pedigo, L. P., and M. E. Rice. 2009. Entomology and Pest Management. Pearson Prentice Hall, Upper Saddle River, NJ. Introduction, Insect Structures and Life Processes, Insect Classification.
- PNGTree (n.d.). Vectors, Png, Backgrounds used for derivative work (illustrations). Pngtree.com. Retrieved April 10, 2023, from https://pngtree.com/
- Robert Lamb. (2008, 29 April). How Houseflies Work. In HowStuffworks.com. Retrieved 5 July, 2023 https://animals.howstuffworks.com/insects/housefly.htm
- Share My Lesson- 10 Years (n.d.). CCSS.ELA-Literacy.SL.1.1. Https://Sharemylesson.com. Retrieved May 6, 2023, from https://sharemylesson.com/standards/nga-center-ccsso/ccss.ela-literacy.sl.1.1
- Stridulation. (2023, May 23). In Wikipedia. https://en.wikipedia.org/wiki/Stridulation
- Tabua , Esava Koraniu . "Characteristics of Sponging Mouthparts - How Flies Feed"Dipteramouthparts, 2010, https://dipteramouthparts.weebly.com/characteristics-of-sponging-mouthparts.html. Accessed June 10, 2023.
- The Common Core Standards Writing Team (2011, June 20). Progressions for the Common Core State Standards in Mathematics (draft). Https://Commoncoretools.Files.Wordpress.com. Retrieved May 3, 2023, from https://commoncoretools.files.wordpress.com/2011/06/ccss_progression_md_k5_2011_06_20.pdf