Activity: A Flight to Safety

Abstract: Students will explore how flying fish and airplanes both use the forces of flight including lift, thrust, weight and drag, to fly.

Age Range: Grades 3-12

Objectives/Standards:
3-PS2-1
3-PS2-2
3-LS2-1
3-LS3
3-LS3-2
3-LS4-2
3-LS4-3
3-LS4-4
4-PS3-1
4-LS1-1
MS-PS2-1
MS-PS2-2
MS-LS1-4
MS-LS4-4
MS-ETS1-3
MS-ETS1-4
HS-LS2-8
HS-LS4-4

Duration:

Materials:
- Picture of a flying fish in flight
- Picture of an airplane
- Video of flying fish – optional
- Thick cardboard pieces approximately 8 inches by 12inches – 1 each per child or group

Procedure:
1. To begin the activity, show the class the picture or the flying fish. The students should recognize the fish from the film, *Incredible Predators*. If you have access to a video clip of the flying fish in motion, play it now.
2. Ask students to recall the large dorado fish from the film chasing the flying fish through the ocean. Encourage students to offer explanations as to why this fish developed the ability to take to the air and glide for large distances above the water. Most likely, this strategy developed as a way to avoid capture by large fish and marine mammals such as dolphins.
3. Next, ask students if they know how this fish is able to fly? This fish uses special adaptations, such as their long slender body and oversized fins to accomplish this feat. Their body type allows them to glide quickly through the water with little resistance, gaining the high speed necessary to propel itself into the air and glide for long distances.

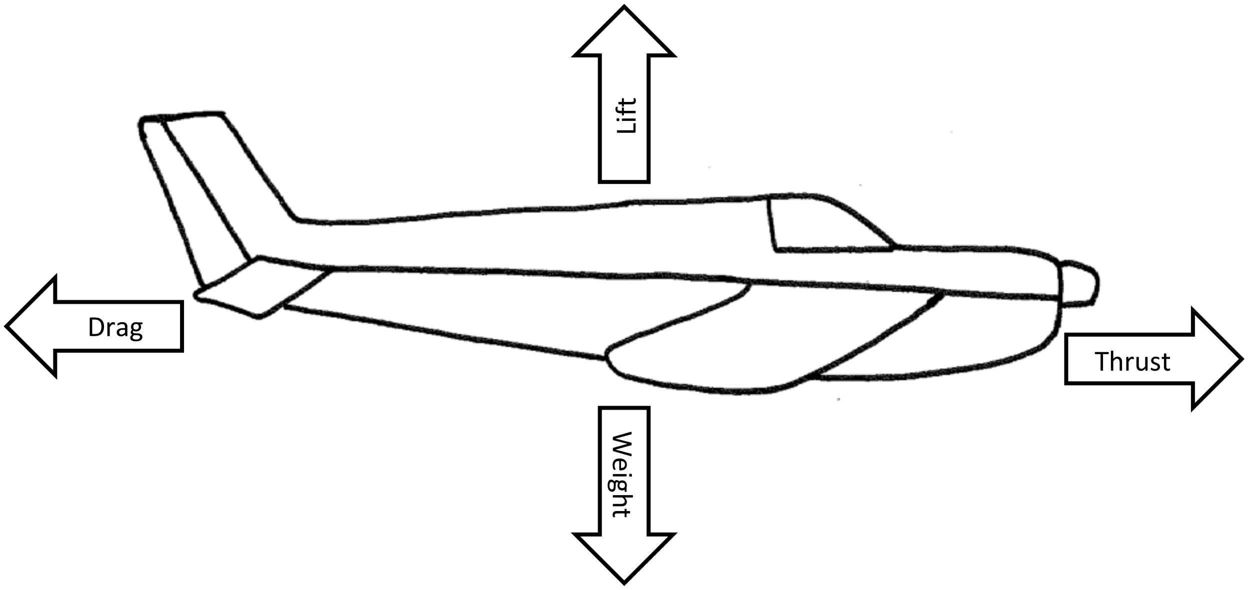
4. Draw the attention of the class to the picture of the airplane. Point to the first arrow at the nose of the plane. Explain that this arrow represents thrust and that this force is the forward motion that is provided by the engine of the airplane.
5. Next, point out the arrow, at the tail, that points in the opposite direction. Explain that this arrow represents drag. Encourage the class to imagine holding their hand outside a moving car, as a hand pushes against the wind, the wind pushes back against the hand. Tell the class that drag is the force that opposes thrust and when thrust is greater than drag, the plane can move forward.
6. Now, draw attention to the arrow at the top of the plane. Explain that this arrow represents lift and that this force is what allows the plane to lift off of the ground. Encourage the students to imagine that their hand is still outside of the window of the moving car, but now, flatten the hand and tilt the fingers upward; lift is the force that is pushing the hand up.
7. Last, draw attention to the arrow located near the belly of the plane. Explain that this downward pointing arrow represents the weight of the plane. Tell the class that when the weight of the plane and the lift are equal, the plane will fly, but if the weight is heavier than the lift, the plane will not be able to get off the ground.
8. Explain to the class that they are going to experiment with lift, one of the forces that allow both planes and flying fish to become airborne. Show the class the cardboard pieces and tell them that this will represent the wings on a plane or the fins on the flying fish.
9. Take the class to an area where it is safe for them to run for short distances. Distribute the cardboard pieces to the class. Instruct them to hold the cardboard out to their side and with the length parallel to the ground while running forward for a short distance. Next, instruct students to hold the cardboard out to their side in the same manner but with the front edge of the cardboard tilted upward from the ground. Have the student run forward a second time observing any differences. Ask students to describe how the cardboard performed differently during the two runs. What did the students feel? When the cardboard is held parallel to the ground there is less resistance. When the cardboard was held at an upward angle there was more resistance and the cardboard should have begun to lift. Students may also notice that the angle of the cardboard changed.
10. Gather the class for a brief discussion. Explain to the class this experiment works because for every action, there is an equal and opposite reaction. This Newton's third law of motion and based on this law, when there is thrust, wings are forced upward because they are tilted up, forcing air in a downward direction. The opposite reaction is the air pushing up, creating lift.
11. Ask the students to make a few additional runs with the cardboard varying the position of the cardboard to create as much lift as possible. They may choose to vary the angle of the cardboard, hold the short side of the cardboard, run into or away from the wind, etc. After a few minutes for experimentation, gather students again. What variables did they determine caused the greatest increase or decrease in lift?
12. Draw the attention of students again to the pictures of the flying fish and the airplane. Encourage students to draw comparisons between the parts of the fish and the plane. What part of the fish is functioning like the wings on the airplane? The large fins are like the wings of an airplane. Which part of the fish is like the body on the airplane? The body of the fish.
13. Ask students to consider the disadvantages of being such a specifically adapted animal. What possible drawbacks are there to being a flying fish? As students saw in *Incredible Predators*, the flying fish is able to use its unusual adaptation to escape the ocean and the dorado fish below, but this leaves it totally exposed to the frigate birds above!

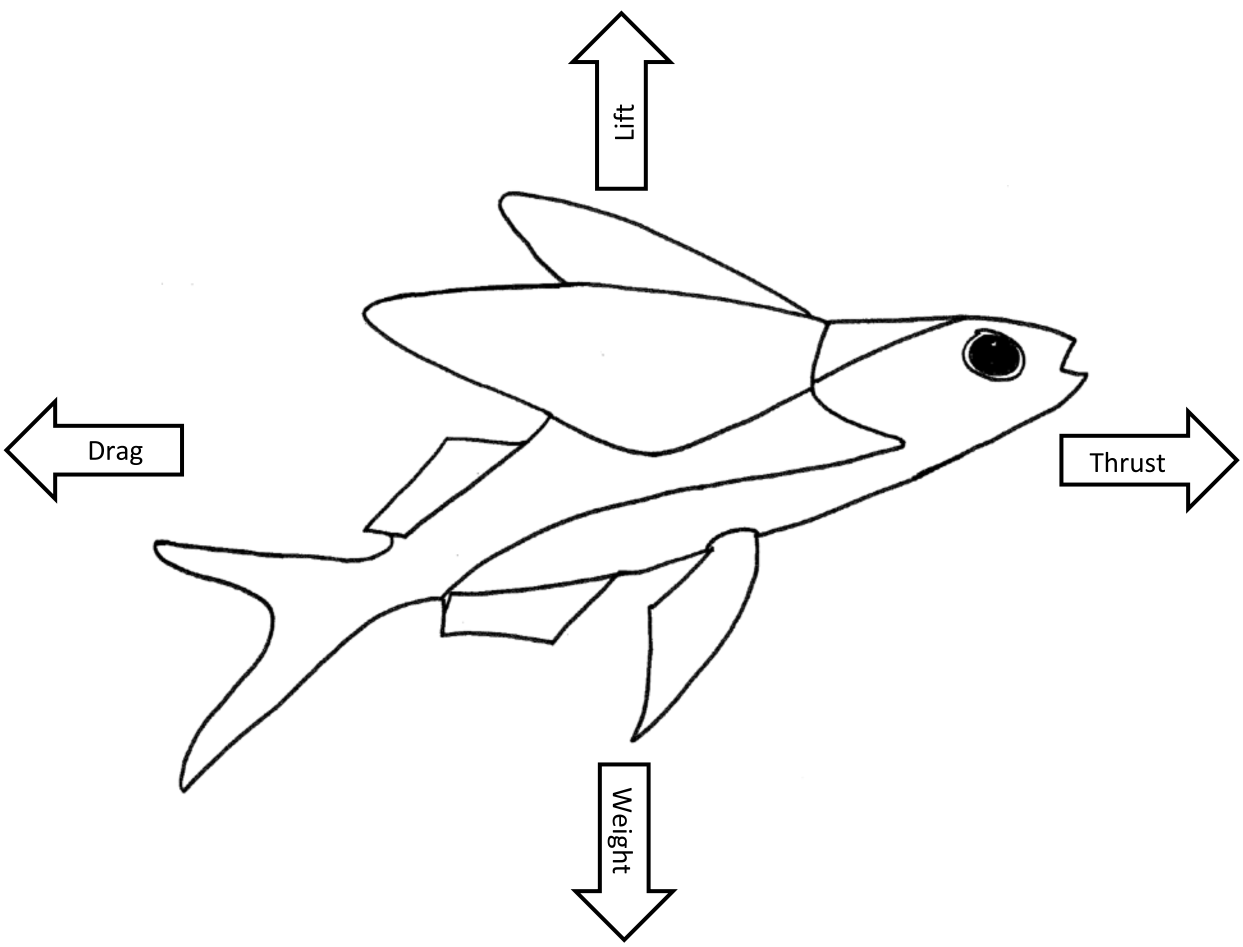
Differentiated Strategies and Extensions:

- A variable speed fan can be used to test the wings if there is no room to run or for students who are unable to run.
- As an extension, you may have students engineer a paper airplane based on the basic body design of the flying fish.

Vocabulary:

- Drag, Lift, Thrust, Weight


Lift
Drag
Thrust
Weight


Lift
Drag
Thrust
Weight

Activity: Better to Bite

Abstract/Lab Description: In this activity, students will use a mirror to inspect their own mouths for different tooth types and discuss the function of each type of tooth to better understand the remarkable teeth of animals like those in the movie *Incredible Predators*.

Age Range: Grades K - 3

Objectives/Standards:
K-LS1-1
1-LS1-2
1-LS3-1
1-LS3-2
3-LS4-2

Duration: 20-30minutes

Materials:
Mirrors – 1 per student or a large mirror to share

Procedure:

1. Begin this activity with a brief discussion. Remind students of some of the mammals in the movie *Incredible Predators,* such as the cheetah, leopard and polar bear. In the film, the vocalizing mother cheetah gave viewers a glimpse of her impressive set of canine teeth. Later in the film, while the leopard is stalking a puku, the puku can be seen using his specially adapted incisors to trim grasses. After an unsuccessful attack, the leopard opened its mouth in frustration to reveal a row of small grooming teeth on its lower jaw.
2. Explain to students that, just like the animals in this film, students have highly adapted mouths to collect and digest their food. Homodonts, such as alligators who eat only meat, have teeth designed for just one type of food. The students are heterodonts, meaning that they have multiple types of teeth in their mouths. Students are equipped with teeth to process both meat and plant matter. This makes them fantastic animal examples to study since the students can observe multiple tooth types within their own mouth. The students are also mammals, so they start their life drinking milk that mom has produced. Mammals are diphyodonts, which means they have two different sets of teeth in their life. They start out with deciduous, or milk teeth and end up with permanent teeth. If the student participating in this activity are very young, they may have a different set of teeth than older students or adults.
3. Give each student a hand mirror or line students up at a large wall mirror.
4. Ask students to identify the following teeth in their mouth. They can use their tongues to feel along their teeth for shape and texture. Describe one type of tooth at a time and work with the students to ensure proper identification. When everyone has successfully identified the current type of tooth, move on to the next.
    - Incisors - These are thin, flat-edged teeth in the front of the mouth and are used for slicing off a bite of food. These teeth are also used for grooming fur in some mammals.
    - Canines – Students should see these pointy teeth just next to the incisors. These teeth are used for tearing meat. In other animals they may also be used for threat displays, and fighting.

- Premolars – Because of the two raised edges they possess, these teeth are also called bicuspids. These raised edges come to points and are used for initial break up of food.
- Molars – Molars are used for the final break up of food and compaction into a bolus before swallowing. They are also used to grind tough plant matter.

5. Looking back to the movie, can students explain to you why the teeth of the leopard and the teeth of the puku would be different? They are both mammals, so why don't they have identical teeth? Students should be able to relate that the leopard eats the puku so it needs the incisors and canines to tear meat, and the premolars and molars to chew the meat. While the puku does have canines, it does not need them to tear meat. Instead, the puku uses its incisors to snip grass and its premolars and molars chew the grass.

Differentiated Strategies and Extensions:

- For visually impaired students, have them bite into an apple, piece of hard cheese or chewy candy to observe how their teeth puncture and break down food. Visually impaired students will be able to feel the surface of this bitten food for patterns that their teeth leave behind. Incisors will leave a thin line and canine teeth will puncture, for example. They will notice that they do not grind or chew with their incisors and canines, and their molars are too wide and far back to grab a bite of food.

Vocabulary

Heterodont, Homodont, Incisor, Canine, Premolar, Molar, Bolus, Diphyodont, Deciduous, Permanent

Activity: Caterpillar Capture

Abstract/Lab Description: Students play a game to experience how coloration helps animals blend with their environments. This activity can be paired with the Clever Coloration activity.

Age Range: Grades 1-12

Objectives/Standards:
1-LS3-1
3-LS2-1
3-LS3-1
3-LS3-2
3-LS4-2
3-LS4-3
3-LS4-4
4-LS1-1
MS-LS1-4
MS-LS4-4
MS-ETS1-3
HS-LS2-8
HS-LS4-4

Materials:
- Craft stems (pipe cleaners) – several of each color: brown, black, green, white, yellow, red, and purple
- Scissors
- String
- Sturdy dowels – 4 per square
- Measuring tape
- Small re-useable containers or paper lunch bags – 1 per student
- Clipboard, paper and pen to record data

Procedure:
1. Before you begin the activity, do the following:
   - Use magazines or the internet to gather pictures of animals using camouflage to conceal themselves from prey and predators.
   - Find a suitable outdoor location to stake out several squares with a length of one meter on each side. Stake out the squares using the dowels, string, and a tape measure. This is a two person job.
   - Cut equal amounts of craft stems into ½ inch pieces and mix all of the pieces together in a bag.
2. Discuss how some animals use their ability to mimic the color and texture of their environment to avoid being eaten. Explain that this ability can increase the chance of survival for the animal. There are many variables that go into what type of adaptation is developed to avoid being eaten. Characteristics of both the hunter and the hunted are important factors to consider. Animals that are fed upon by predators with superior vision may develop a camouflage strategy that allows them to more effectively blend with their environment making them difficult to see.

In turn, the predator may develop even better vision to help identify hidden prey. Blending with the environment using color and texture is one of the simplest and most effective camouflage strategies. Encourage students to share examples of this kind of behavior in nature.

3. Tell the class they are going to participate in a game to experience how the coloration of certain animals can help them to be more successful in certain environments. Students will play the role of predatory birds. The craft stem pieces represent insects that the birds eat. Each team will have 30 seconds to collect as many craft stem pieces as they can, and put them into their containers. Explain that "birds" can only collect "caterpillars" from the square to which they are assigned and that they may only collect one "caterpillar" at a time. Students may not begin to collect "caterpillars" until the instructor tells them to start and that they must stop as soon as they are told.
4. Bring students to the area set up for the game. A maximum of four students will be assigned to a square. Distribute the craft stem pieces equally throughout the squares you staked out.
5. Allow the first group 30 seconds to collect as many "caterpillars" as they can. When time is up, have each student count how many of each color "caterpillar" they have in their bags. Record the information as each student reports their numbers.
6. Instruct the students who just participated to scatter the "caterpillars" they collected back into the appropriate square. Allow a new group of students to participate and repeat the process until everyone has had an opportunity and all of the data has been recorded. When all students have participated at least once, return to the classroom to draw conclusions about animal camouflage.
7. Total up the number of each color of "caterpillar" collected during the entire game and list them in descending order for the entire class to see. What two "caterpillar" colors had the lowest collection rates? Why do they think this is the case? Ask students which two color "caterpillars" had the highest collection rates? Why do they think this is the case? Answers may vary depending on the location of your squares, but will typically reflect the colors that stand out against the color of the environment used for the game and are easier to see.
8. If time allows, you may elect to play this game again with the following variations:
    - Choose a different location with a different environment to create your staked squares.
    - Do not have the groups redistribute the "caterpillars" after each round. How many rounds does it take before all the "caterpillars" are eaten?
    - Remove one of the brighter colors of "caterpillars" from the sacks. Were the groups still able to collect as many "caterpillars" in the allotted time as in their first round?

Differentiated Strategies:

- This activity can be conducted as a demonstration using student volunteers if whole class participation is not possible
- Larger materials, such as thick colored rope can be used for students with vision impairment
- Students with physical limitations can be paired with another student or aide

Vocabulary:

- Predator, Prey, Camouflage

Activity: Clever Coloration

Abstract/Lab Description: Students will explore how predators and prey use camouflage as a survival mechanism to increase odds of capturing prey or to avoid predation. This activity can be paired with the Caterpillar Capture activity.

Age Range: Grades 1-12

Objectives/Standards:
1-LS3-1
2-LS4-1
3-LS1
3-LS3-1
3-LS3-2
3-LS4-2
3-LS4-3
3-LS4-4
4-LS1-1
MS-LS1-4
HS-LS2-8
MS-LS4-4
HS-LS4-4

Materials:
- Newspaper – black and white portion only
- Sheet of red construction paper
- Hole-punch
- Pictures of different animals using camouflage to conceal themselves from prey and predators

Procedure:
1. Before you begin the activity, prepare the following:
   - Use magazines or the internet to gather pictures of animals using camouflage to conceal themselves from prey and predators.
   - Punch a handful of holes from the newspaper using the hole-punch.
   - Punch a handful of holes from the red construction paper using the hole-punch.
   - Place a whole sheet of newspaper paper in a location where the class will be able to observe it. Sprinkle the red construction paper holes all over the sheet of newspaper.
2. To begin the activity, discover what students already know about how animals use camouflage for survival. Encourage students to identify animals that use camouflage to conceal themselves from predators and animals that use camouflage to conceal themselves from prey. If the resources are available you may choose to record their answers by category.
3. Next, ask students to describe how animals use camouflage to blend with their environments? Can the students give specific examples of animal camouflage that they can remember seeing in the past? An animal's coloration may match that of their environment, making it difficult for them to be seen. This is called background matching. The animal may also mimic an element in their environment, such as a leaf, or mimic the movement of that element, such as trying to appear like a leaf moving in the wind. Specific patterns can also make it difficult for a predator

to pick out its prey by breaking up the shape of the animal making it difficult for the outline to be visualized.

4. Draw the students' attention to the piece of newspaper you prepared earlier. Ask the students to tell you what they notice about the newspaper? They should immediately see the red circles on the paper.
5. Remove the red circles and sprinkle the circles made from the newspaper on the paper. What do the students observe now? Are the newspaper circles easier or more difficult to locate on the paper than the red circles? Why? The circles cut from the newspaper are more difficult to see. They are more difficult to see because the coloration of the newspaper circles are similar in color and pattern to the sheet of newspaper. This is a type of camouflage called "background matching".
6. Ask the students to imagine a situation where all the small circles represented variations in the same population of animals. Would the red circles or the newspaper circles be more successful on the newspaper background? What if they background was switched to a red piece of paper? If the circles represent predators, how would the variations in color and background affect their chances of completing a successful hunt? What might this mean to successive generations that have inherited that specific coloration?
7. Explain to students that the physical characteristics and behavior of both predator and prey often evolve together, as a result of the predator prey relationship. Point out to the class that camouflage in prey and vision in predators is an example of this coevolution. Animals with an effective camouflage strategy are harder for the predator to see, giving them an evolutional advantage over those who are more easily seen. Likewise, predators with superior vision are more likely to identify hard to see prey and be more successful in the hunt. This superior sense of sight provides a selection advantage to the predator.
8. Show the pictures of the camouflaged animals you have collected. Can students describe how these animals are using their surroundings to conceal themselves? What do the students believe would happen if the animals in those photos were dropped into a different image? Would they be more or less difficult for predators to locate?

Differentiated Strategies:

- Students can be paired with an aide for students with physical limitations
- For older students, ask them to describe what problems may occur when environmental changes happen in a particular location. These environmental changes might be natural as in erosion, or man-made as in deforestation. How do the animal populations living in those areas adapt? Is adaptation possible for all species facing environmental change?

Vocabulary:

- Predator, Prey, Camouflage, Background Matching

Activity: I Didn't See You There

Abstract/Lab Description: This activity explains what peripheral vision is and looks at the range of a student's peripheral vision.

Age Range: Grades 1 -12

Objectives/Standards:
1-LS1-1
2-LS4-1
3-LS2-1
MS-LS1-3
HS-LS4-4

Duration: 20 minutes

Materials:
Bold colored markers or crayons
Index cards or scraps of single color colored paper

Procedure:
1. Explain to students that the placement of an animal's eyes in its skull makes a big difference, it its range of vision. Animals with two forward facing eyes are generally predators with stereoscopic vision and a smaller field of view. This means that both eyes can see the same image at the same time. Stereoscopic vision allows an animal to judge distance more accurately and provides better depth perception. Animals with eyes on the sides of the head are generally prey and have a much wider field of view, but significantly decreased stereoscopic vision. Having eyes located on the sides of the head allows animals the ability to be more aware of their surroundings while feeding. Humans have eyes facing forward like a predator and so can see color, movement and details all at the same time, but only at the center of vision. Outside the center of gaze, where peripheral vision occurs, the human eye perceives these inputs but provides less information due to the internal structure of the eye.
2. To test this, have students work in pairs to prepare four colored tester cards. These cards can be scraps of single-colored paper, like plain origami paper or index cards. If using index cards, each card should be colored a different, bold color like red, blue, green and yellow, but only on half of the card. The white half will be held by the tester in the experiment. The cards should be colored as completely as possible, as gaps in the color could influence the outcome.
3. Have one of the students stand with their arms outstretched to the side. When looking straight ahead, they should not be able to see their hands or arms.
4. The partner, without showing the standing student the tester cards, will help place a tester card in each hand of the standing student. The standing student should grip the card between their first finger and thumb. The partner will make sure the card is held properly: color side up and facing toward the standing student's face.
5. The partner will then stand in front to watch the standing student's eyes. Remind students to fight the temptation to glance to the side and their partner is there to encourage them to keep looking forward!
6. The standing student will keep looking at their partner and slowly begin moving their arms forward. Keeping their arms straight, so the tester cards stay at the same level and distance

from their face, the standing student will use their peripheral vision to watch for their arms and hands to come into view. As soon as they can detect their arms and hands just inside their field of view, they should stop moving their arms. While still looking straight ahead, they should tell their partner what they can "see". This will be the starting point of the test, the edge of their field of view. Students will likely be able to tell whether the card is a darker color or lighter color, blue versus yellow for example, but should not be able to tell what color the card actually is at this point.

7. While still looking straight ahead, the standing student will continue to slowly move their arms at full extension towards their partner's face, keeping the cards and arms level. The student should stop moving their arms again, once they can accurately say what color the tester cards are. Their partner will keep them honest by watching their eyes for sideways glances. It is very tempting to look!
8. Have the students change places and repeat the test. The same tester cards can be used or different colors cards may be substituted. The standing student should not know what the cards are being used at the beginning of the test.
9. After all students have had the opportunity to try this experiment, explain to the students how peripheral vision works. The periphery in human eyes contains more rods than cones. Rods work better in dim light and cannot perceive color. Cones are responsible for color vision and function best in relatively bright light. Using colored tester cards helps students to understand where the rods diminish in the retina and the cones increase. This allows the students to understand their field of view and where they actually begin to perceive color. The cheetah's field of view is estimated to be 210 degrees with approximately 130 degrees of binocular vision, compared to a human's range of 140-180 degrees, with approximately 120 degrees of binocular vision. The impala's eye placement allows for a much larger field of view but the majority of it is viewed with monocular vision, only one eye at a time, with a narrow range of binocular vision down the length of the nose. This is an important adaptive feature for both predators and prey. In the film *Incredible Predators*, students saw peripheral vision in action as the seal, Thompson's gazelle and flying fish detected the slightest hint of movement at the outside edge of their vision to evade focused predators!

Differentiated Strategies and Extensions:

- For older students, have them create a human size protractor using tape, string, and a protractor along the edge of a table. The student should sit pressed against the table, centered on the protractor. Once they determine the outer edge of their visual field, their partner can mark the angle on the protractor by dropping a length of string from the wrist or use a meter stick. This requires patience and steady arms for the student being measured. After they determine where they can perceive the color of the tester card, their partner can mark the result. Once the students switch roles, their fields of view and color perception can be compared. In a class of students, an average can be obtained to see how it compares with the average human field of view.
- As an extension, students can also use these cards to outline their entire field of view by holding the cards at arm's length and while staring straight ahead, moving their arms up and down to outline the edge of their field of view. Students will likely notice that their field of view it is not a perfect circle.

Vocabulary: Peripheral vision, Field of View, Rods, Cones, Stereoscopic Vision

Activity: I See What You Did There

Abstract/Lab Description: This activity will help students gain a better understanding of how the physical structures in the eye provide predators with clear, sharp color visual images when hunting.

Age Range: Grades 1 -12

Objectives/Standards:
1-LS1-1
MS-LS1-3
HS-LS4-4

Duration: 10 minutes

Materials:
Picture book, magazine, clothing catalog, etc. – 1 per student

Procedure:

1. Before beginning, gather age appropriate reading materials, such as books, magazines, or even clothing catalogs.
2. Pass out the reading materials and have students randomly insert a finger between two pages without looking at either page. Students should hold the reading material at a natural arm length for reading. When students open the material, they should slide their left hand over the words/images on the left page, or fold the magazine/catalog over so they cannot see the left page, and focus both eyes on the right-hand page.
3. While continuing to stare at the right page, uncover or unfold the left side and describe what they can see. Remind students that their eyes should not drift to the central fold between the pages, but stay clearly focused on the right-hand page. Ask students to observe what they can and cannot see.
4. Discuss expectations and results of the experiment with the students. Typically, students will have a general idea of the contents of the left-hand page but not be able to tell you specifics. For example, they are often surprised to find that they can tell there is a person, wearing dark colors, and possibly sitting or crouching but very few details. When viewing text only, they should see the horizontal rows of black and white text, but not be able to read any of the words. This is due to the location and size of our fovea. The fovea is a small depression in the retina in the eye where visual acuity is highest. It contains a high concentration of cones, which are responsible for color vision and function best in relatively bright light. Opposite cones are rods, which work better in dim light and are used for peripheral vision, but cannot perceive color. Toward the edge of the fovea, the number of rods increases as the number of cones decreases. In this experiment, the left-hand page is within the field of view, but acuity is lost so it is out of focus.
5. Now ask students to turn their eyes or head to look directly at the left-hand page, bringing the image or text into sharp focus. What do they see on the left-hand page now that they are able to look directly at it?
6. Ask students how teachers and parents know that students are giving the adult their undivided attention? When students look directly at the teacher or parent, the adult is focused onto the student's fovea. Scientists studying visual perception in animals, like the cheetah in *Incredible Predators*, understand that there are variations in the eyes of different animals. The cheetah's

eyes would be able to see both pages in focus but not the entire page from top to bottom. This is believed to help cheetahs and impalas when viewing the horizon to see clear sharp images throughout their field of view without turning their head. While human fovea provides a central, primarily circular region of focus, like the center of the right-hand page, the cheetah's fovea provides a band of focus that would include the center of both pages without moving their eyes.

Differentiated Strategies and Extensions:

- For younger students, using copies of the same material at the same time, will make it easier to get a sense of class success with this. With different sources, it may be harder to judge whether young students are actually noting the same results - a decrease in color perception and blurry words or images on the non-focal page.

Vocabulary: Acuity, Field of View, Peripheral vision, Rods, Cones, Monocular Vision, Fovea

Activity Name: I'm Beat!

Abstract/Lab Description: In this activity, students will discover how some species of birds have a number of adaptations, both physical and behavioral, that make them more successful.

Age Range: Grades 1-4
Objectives/Standards:
1-LS1-1
2-LS4-1
3-LS2-1
3-LS3-1
3-LS4-2
3-LS4-3
4-LS1-1

Duration: 20 minutes

Materials:

Students
Timer

Procedure:

1. Ask students to name animals featured in the film *Incredible Predators* that they would describe as "fast". Ask them to describe the different adaptations these animals have that allow them to move at high speeds. Many animals have adaptations that enable them to move at great speeds whether it's running across the plains, soaring through the sky, or swimming through the ocean.
2. After discussing the different adaptations offered, ask students to consider some of the difficulties with being a "fast" animal. What would be hard about moving at great speeds? Students may say that they need to eat more food for more energy or that they may get tired. Explain that many animals are only able to sustain their speed for short periods of time, like the cheetah or mako shark. Their bodies are built to sustain short bursts of speed, but their muscles soon wear out.
3. Tell students that they're going to pretend to be a bird in this activity. Ask them to identify their "wings". How do their arms differ from a bird's wings? The students may not have thought of birds as "fast" animals, but Peregrine falcons can reach speeds of up to 200 miles per hour and are considered the fastest animal on earth. Birds come in all different shapes and sizes, which means that different types of birds move in different ways. Some birds can't fly at all, while others can fly at extremely high speeds. Amazingly, most birds can prevent muscle fatigue due to a combination of adaptations, such as those discussed later in step nine of the activity.
4. For this activity, the students are going to flap their "wings". Explain to students that for this activity one wingbeat is a full movement of their arms up above their shoulders and down below their waist with arms stretched out entirely. When birds bring their wings down, they descend. To keep "flying", arms need to be moving the entire time. Birds also do not retract their wings after each flap, so arms need to be extended the entire time. The Rufous Hummingbird has one of the fastest wingbeat speeds. It is able to move its wings at fifty-two to sixty-two wingbeats per second. It would be impossible for students to act like

the “fast” Rufous Hummingbird. Instead students are going to be “slow” Great Egrets. This bird moves at only two wingbeats per second.

5. Ask the students to stand up and move to a location where they can flap their “wings” without touching a neighbor. Clap your hands for the students at the rate of one clap per second. Students should try to complete two full wingbeats per clap to match the Great Egret. Complete a few practice rounds of several seconds each until students get the rhythm.
6. Begin the timer and clap along with each second for sixty seconds. While you are clapping, students should be flapping their “wings”. If students started complaining that they’re tired, encourage them to keep going!
7. At the end of sixty seconds, have students sit down and rest. Ask what they noticed about behaving like a bird. How are they feeling? They’ll immediately notice that they’re exhausted. They may comment that they’re out of breath, their arms hurt, or their heart is racing. Ask why. Explain that our muscles aren’t built to move at great speeds for long periods of time. Muscle fatigue sets in pretty quickly in humans.
8. Ask students to consider how birds are able to fly great distances. Why don’t they get tired? Have students provide examples of different adaptations birds have that allow them to fly for long periods of time. What adaptations do birds have that might prevent their muscles from quickly fatiguing the way they do in other animals like cheetahs and humans? Discuss the suggestions provided.
9. Explain to students that birds have a number of adaptations, both physical and behavioral, that prevent their muscles from getting tired when they are flying. Students will immediately think of feathers as an adaptation birds have that enable them to fly. While feathers are definitely an important feature, there are many other physical adaptations they use.
    - To counteract the increased activity associated with flapping wings, birds have two lungs and 9 air sacs that allow for quick movement of air within lungs. This also gives them a higher oxygen content.
    - Birds have hollow, pneumatic bones, which are bones that are hollow or contain air cells. This makes them much lighter than other vertebrates.
    - They have strong muscles in their wings. These muscles have to attach to something to give them their strength. Birds have a large sternum, or modified breastbone, for muscle attachment.
    - Birds that have long migrations may have more red muscle. This is muscle with more blood vessels to allow for better oxygen exchange, so they do not get tired.

    Frigate birds in particular, such as those seen in *Incredible Predators*, have amazing adaptations. They produce very little preening oil. This makes them much lighter than other birds their size, but it also means they are not waterproof and cannot land in the ocean. Frigate birds also are able to stay aloft for days at a time by taking advantage of air currents and their lighter forms. They rely on these currents to carry them with minimal effort and very little flapping thereby helping them to save their energy!
10. Now ask students if they’ve ever seen birds flying in a “V” formation. This is an example of a behavioral adaptation. Birds can use the currents created by the wingbeats of other birds in the formation to minimize their energy usage.
11. To assess for understanding, give students the following list of adaptations in birds and ask them to indicate if these adaptations are behavioral or physical.
    - Beak shape (physical adaptation)

- Feather color (behavioral adaptation)
- Migration (behavioral adaptation)
- Flight (physical adaptation)
- Good eyesight (physical adaptation)

Differentiated Strategies and Extensions:

- For students with limited mobility, have the students instead squeeze a tennis ball as hard as they can for thirty seconds. What do they notice? Their forearms will get tired quickly. This is another way to demonstrate muscle fatigue in humans. This motion is also similar to how hard the human heart has to work to pump blood. Ask students to consider why our heart doesn't get tired the way their arm muscles do. This is because cardiac muscle is structured differently from skeletal muscle. Have students consider why we have specially adapted muscles in our own body that serve different functions.

Vocabulary: Adaptation, Behavioral Adaptation, Physical Adaptation, Muscle Fatigue

Activity: Never Saw It Coming

Abstract/Lab Description: This activity will help students to locate their blind spot and understand how the blind spot affects both predators and prey.

Age Range: Grades 1 -12

Objectives/Standards:
1-LS1-1
2-LS4-1
3-LS2-1
MS-LS1-3
HS-LS4-4

Duration: 10 minutes

Materials:
Bold colored markers or crayons
LXR Handout – 1 per student or one per group

Procedure:
1. Before class begins, print out copies of the LXR handout.
2. To begin the activity, explain to students that inside their eye is something called the "blind spot". In this location the optic nerves cluster and there are no rods or cones. Therefore there is no image detection in that area, hence the "blind spot". Due to this "blind spot", the image sent to the brain from the eye has a hole in it. In animals with stereoscopic vision, such as the polar bear or the chameleon seen in *Incredible Predators*, the brain takes the images sent from each eye and interposes them to fill in the holes, similar to copy and paste functions on a computer. Now students will locate their own blind spots!
3. Hand out the LXR papers to students. Instruct students to hold the paper in their right hand at the bottom edge of the paper so that the L is to the left side of their hand and the R is on the right side. Extending their arm straight in front of them, students should close their left eye and while staring with their right eye at the X in the center of page, slowly pull the paper closer to their face. At approximately 18 inches from their face, they should notice that the R has disappeared from the paper. If students look directly at the R, it will still be there, but when they gaze at the X, it will disappear. Trouble-shooting for this activity includes shifting the paper slightly left or right from directly in front of the student so that the R completely disappears into the blind spot. Occasionally raising or lowering the paper slightly will also align the R into the blind spot completely.
4. Once students have succeeded in having the R disappear, ask them to repeat the experiment with the L by closing the right eye and repeating the process.
5. To illustrate that the brain is indeed copying the information from around the hole and pasting it over the blind spot, students should use a bold colored marker and color a thick-bordered box closely around the R, being careful to leave the R uncolored within a white box. As they repeat the experiment, the R will still disappear but what is visible with their peripheral vision will be a solid colored box. This can be done with the L as well but works best if the white space around the L is shaped like the L instead of a mainly white box. Let students experiment using multiple colors or by creating patterns around the R and describing what their brain thinks it sees.

6. Discuss with students how a blind spot might affect prey. Thompson's gazelle, like the one stalked by the cheetah in the film, can see farther to the sides than a human and have binocular vision down their nose but have a blind spot directly in front of their forehead. They are also unable to see directly behind them. The chances of the gazelle being hunted from the rear or the side by the cheetah is high. The chances of the gazelle being hunted by the cheetah from the front and directly above its head are very small. In this case, the small blind spot of the gazelle is an advantageous adaption because the payoff is a greater field of vision elsewhere. Gazelles also compensate for the blind spot by living in herds. More eyes pointed in more directions means that the gazelles can watch out for each other. For a large predator, like the leopard or the cheetah, the blind spot occurs directly behind them and slightly off to the sides. This is advantageous when hunting because it allows these big cats to focus on the hunt directly in front of them. It is disadvantageous after the kill is completed, when they must be wary of other predators, such as lions and hyenas, coming to steal their hard earned kill. To prevent this from happening, both the leopard and the cheetah will drag their prey to a safer location for consumption.

Vocabulary: Blind Spot, Stereoscopic Vision

Activity Name: Probability of a Successful Hunt

Abstract/Lab Description: Students will investigate probability with random samples. Students will determine the effect of larger or smaller sample size, probability of two simultaneous events, and draw inferences about a population based on small samples. The probability that a hunt will be successful tells us how often on average we would expect the predator to succeed, but it doesn't tell us whether any given hunt will be successful.

Age Range: Grades 6 - 12

Objectives/Standards:
MS-LS1-4
MS-LS1-5
MS-LS4-4
MS-LS4-6
MS-ETS1-4
HS-LS3-3
HS-LS4-3

Duration: 60 minutes

Materials:
- Small glass 'gems'/flat glass pieces in at least two colors. Examples are red and blue.
- Cloth drawstring bags or paper lunch bags
- Copies of Sampling without Replacement Data Log

Preparation:
1. Prepare sampling bags. Fill at least six bags with flat glass marbles in different ratios in each. Some of these ratios are meant to represent the probability that a hunt is successful for specific predator species. The following is a suggested set of bag contents.

Bag A:	48 red and 2 blue	(50 total)
Bag B:	45 red and 5 blue	(50 total)
Bag C:	25 red and 25 blue	(50 total)
Bag D:	10 red and 40 blue	(50 total)
Bag E:	7 red and 42 blue	(49 total)
Bag F:	2 red and 38 blue	(40 total)

Procedure:
1. Explain to the students that in today's lab we will model the likelihood that a hunt will be successful for certain predators through a process called sampling. The probability of a certain event is the likelihood that it will happen.. A population is a group of individuals or items or events (for example, the population of all coin flips before sporting events). A sample is a smaller subset of that population used to represent the whole. We can discuss all hunts by cheetahs as our 'population' of hunts and we then can look at a sample of some of those hunts. Ideally, the sample will be random, which means that each item we choose should have an equal chance of being selected.
2. Put the students into groups with no more than 5 students per group.

3. Demonstrate the following step to the entire class before you pass out the sampling bags. Without looking in the bag, remove one item and place it on the table. Note the color to the students. Ask the class if they know what other colors might be in the bag from only one item? Is the entire bag red (or blue, or purple)? It might be, or it might be a mix. How can we get more information? (Do it again!)
4. Ask the students to predict what color the next item you pull out might be. Without looking in the bag, remove another item and place it on the table. Note the color to the students. Did they guess correctly? Repeat this step and the subsequent discussion several more times until students start seeing a pattern develop.
5. Give one of the sampling bags you prepared earlier to each group. Tell the students not to look inside the bags, but tell them that each bag contains 40 to 50 items in two colors. Each of the bags has a mix of colored items and no two bags are alike.
6. Have groups remove one item at a time, inferring the possible contents of the bag each time as you have demonstrated. They should record their results on the "Sampling without Replacement Data Log". The first colored item that is pulled out will be considered "Color 1" and they should write that color on the log in the box with the one so they remember. Students should also make a guess about the remaining population of items after each item is removed. Just as in your demonstration, the more they know about the population (the more items that have been removed) the more accurate their guess should be.
7. Once groups have removed at least 20 of the items, ask them make a guess about the how many of the remaining items are each color. If they have removed 20 items and 19 of those items are blue and 1 is red, the students might assume differently than if they had pulled equal numbers of each.
8. Next, ask students to open the bag all the way and see if they were correct. Did their inferences get better as they had more information (more samples)? How did their last guess align with the actual population?
9. Explain to students that what they just did is called **sampling without replacement,** which means they did not return the samples to the bag before removing the next item.

Example charts for Sample Size Part 1

Sample #	Color 1 BLUE	Color 2 RED	Population of the remaining glass pieces might be…
1	X		All Blue or Mostly Blue?
2		X	Half Blue, Half Red?
3	X		Difficult to say
4	X		
5	X		Mostly Blue, Some Red?

Sampling Without Replacement Data Log

BAG #___________

Sample #	Color 1	Color 2	Population of the remaining glass pieces might be…
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

10. Ask which group had Bag C. In this bag, the probability of drawing a red pieces was equal to the probability of a cheetah's hunt being successful. What did this group conclude was the probability of drawing a red piece in this bag? (Should be 1 in 2). How else can we represent this probability? ½, 0.5, or 50% are equivalent ways to express the same thing! Did they ever have a 'run' of two blue pieces (failed hunts) in a row? Three? Five? So does a probability of ½ guarantee that we will perfectly alternate successful and failed hunts? No! It just means that the expected result is success half the time.
11. Ask which group had Bag E. In this bag, the probability of drawing a red piece was equal to the probability of a leopard's hunt being successful. What did this group conclude was the probability of drawing a red piece in this bag? (Should be 1 in 7). How else can we represent this probability? 1/7, 0.143, 14.3%, etc. Again, these are equivalent ways to express the same thing! Did this group ever have a 'run' of eight blue pieces (failed hunts) in a row? Ten? Fifteen? So does a probability of 1/7 guarantee that we will have a successful hunt every seventh time? No! We are looking at the expected, average result.
12. Ask which group had Bags D and F. In these bags, the probability of drawing a red piece was equal to the probability of a polar bear's seal hunt being successful. These groups should not agree! What was the probability of drawing a red piece in bag D? (Should be 1 in 5). How else can we represent this probability? What was the probability of drawing a red piece in bag F? (Should be 1 in 20). According to the film *Incredible Predators*, the likelihood of a polar bear seal hunt being successful was 1 in 5 in the late spring, but as ice melted and summer progressed, what happened? The probability dropped to 1 in 20 instead!
13. The chance that a kill is stolen before a predator gets to eat it is represented by the red pieces in Bag A or Bag B. The probability of this occurring varies by species, but is generally low. Students can research to see how often this actually affects various predators.
14. After all the samplings are completed, discuss sample size implications and conclusions with students:
    - Think about measuring people to find the average height of adult men who live in North America. If you measured just one person, it is unlikely that he would be precisely the average height of all North American men. It is reasonably likely that you might be able to find some to measure that are over 1.8 or 1.9 meters tall, though this is definitely above average. The same can be applied to the animals in this activity. If you study a single leopard, you may get different results than if you study all leopard. You need a bigger sample size than one to accurately find the average.
    - If you measured two people, how likely is it that both would be over 1.9 meters? Three people? Four people? The more people you measure, the less likely it is that all of them will be unusually tall. The larger sample size is making your data more accurate.
    - Students will start to get the idea that <u>in general</u> the more people you measure, the closer their average height will get to the average height of the whole population. Assuming the samples are random and therefore representative of the population, we expect a larger sample size to give more accurate information. If your sampling technique is flawed, though, a larger sample will not solve the problem – if I want to know the average educational level of American adults but I only survey people I find in one particular coffee shop on a university campus, my results won't be very **representative** whether I ask 10 people or 200 in that same shop.
    - Why wouldn't we just ask every single adult male in North American what their height is? That would be very time consuming, and a large enough sample will give us an extremely good approximation of the true average. Because it is impractical to observe every cheetah

hunt in every location, for example, a representative sample of those hunts can be used to draw conclusions about their average success, for example.

- Returning to our sample bag activity, how accurate would our assessment of the probability of drawing a certain color be after one or two samples? After ten? After twenty? Generally, the larger our sample, the more accurate our conclusions about the entire population (but this assumes our sampling is truly random and therefore representative)
- How does this lab show that animals with advantageous adaptations will be more successful? If the average leopard successfully completes a hunt 14.3% of the time, than a single leopard that hunts successfully 20% of the time is either better adapted to its environment, is more physically fit, is in an area with higher prey density, or some combination of these factors.
- How would repeated success from a population of animals skew the data over time? If one population of leopards was 30% successful on their hunts, it would raise the average for the entire group. The amount of change would be dependent on the proportion of the overall group that this smaller successful population comprised.
- How would repeated success from a population of animals alter the population of animals over time? If a population of animals is more successful than the whole at hunting over time, that population may increase.. The adaptations or inherited traits of the successful population will be passed off to more surviving offspring. However, an increase in predators in an area may lead to a decrease in prey so fluctuations in populations are expected.

Differentiated Strategies and Extensions:

- Group students who have difficulty writing with other students who can record group results. For visually impaired students, differently textured objects could be used instead of the flat glass playing pieces.

Vocabulary:

Population, sample, fair, expected result, event, trial, probability, inference, predator, prey, probability, chance, likelihood

Activity: Species Specifics

Abstract/Lab Description: Students will learn about roots, prefixes and suffixes and how they are scientific names used in binomial nomenclature and why they are important to science.

Age Range: Grades 3 to 12

Objectives/Standards:
Not Applicable

Duration: 30 minutes

Materials:

- List of roots, prefixes and suffixes from Greek and Latin - 1 per student
- A picture of a cheetah, a leopard and a mountain lion
- Modeling clay in various colors
- Index cards
- Pencils
- Paper

Procedure:

1. Before beginning this activity, print out a picture of a cheetah, a leopard and a mountain lion.
2. Begin the activity by showing students the picture of a leopard. Ask students to physically describe the animal. They will probably give you words like cat, large, spotted, predator.
3. Now show students the picture of the cheetah. Ask students if these two animals are the same? They will say no, but ask them how they can be sure. The descriptive words the offered for the leopard all apply to the cheetah as well!
4. Explain to students that all living things have a scientific name in addition to the common names they may know. For example, a *Canis lupus familiaris* is more commonly known as a dog. The scientific name is intended to keep different animals straight even though they have similar features, just as in the leopard and the cheetah. Usually the scientific name comes from Greek and Latin roots, prefixes and suffixes, but it is also common for part of a scientific name to include the name of a person. A scientific name is comprised of two parts - the genus and species of an animal. The genus for a dog is *Canis,* but also included in that genus is wolves, dogs, jackals and coyotes. The species name *lupus familaris,* lets you know that you are specifically discussing a pet dog and that you should not confuse it with *Canis lupus* (a wolf), Canis latrans (a coyote) or *Canis aureus* (the golden jackal).
5. Now provide students an index card. Have the students number the index cards consecutively. You may wish to complete this step before class.
6. Next provide to each student a list of root words, prefixes, and suffixes from Greek and Latin.
7. Give students several minutes to pick two or three word parts from the list provided to create their own monster name. They will need to choose carefully because they will have to make their monsters in a moment. Students should not share their creation or scientific name of their creations. They will need two root names, one for genus and one for species. For example, a *Bicaput osteophage* would be a two headed, bone eater.
8. On the side that is not numbered, ask students to write down the "scientific name" of their creature on their index card. This name should be comprised of the word parts they selected

from the list. They should also record a "common name" for their creature on the same index card. This name will be more descriptive and of the student's choosing.

9. Next, explain that students will create their monsters using the modeling clay. Their monsters should reflect the meanings of the word parts they selected for their scientific name.
10. After all of the students have finished creating their monster, ask students to place the monsters in a central location with the associated index card face down next to the monster.
11. Ask students to number a piece of paper with one number corresponding to each monster. Next, student will view the monsters and write down what they think is the scientific name of each monster. They can use the list you provided to help determine which roots, prefixes and suffixes were used in the name. Depending on the size of the class, this part can be done as pairs or in small groups.
12. After all of the students have written down their guesses, have students sit down.
13. With the students seated, turn over the index cards and reveal the "scientific" names of the monsters. How well do the descriptions and the monsters match up?
14. Next, collect the index cards and shuffle them. Read out the "common names" to the class. Ask the students to guess which common name belongs to which monster.
15. After the activity, discuss with students the strengths and weaknesses of using common names and scientific names when describing animals. Does the common name reflect the same information as the scientific name? Do the roots, suffixes and prefixes of the scientific name reflect the animal accurately? When would you use the scientific name over the common name? Which was easier to figure out – common names or scientific names?
16. For additional practice, ask students to try and decipher the scientific names of these animals from the film, *Incredible Predators*. These will be trickier because the word parts are not listed on the handout!
    - Panthera pardus (Leopard. Means "male panther")
    - Balaenoptera musculus (Blue whale. Means "whale-fin mouse")
    - Caerostris darwini (Darwin's Bark Spider. Named after Charles Darwin on the 150th anniversary of *On the Origin of Species*)
    - Calumma parsonii (Parson's chameleon. Parsonii references a British physician James Parsons)
    - Ursus maritimus (Polar Bear. Means "sea bear")

Differentiated Strategies and Extensions:

- If resources do not allow for students to use modelling clay for this activity, students may illustrate their monster instead.

Vocabulary:

- Species, Genus

Example Greek and Latin Roots, Prefixes and Suffixes

Prefix	**Meaning**	**Example**
Ambi-	Both	Ambidextrous – both hands
Ante-	Before	Antecedent – going before in time
Bi-	Two	Bisect- to divide
Circum-	Around	Circumscribe – to draw a circle around
Derma-	Skin	Dermatology – study and treatment of skin disorders
Endo-	Inside	Endoskeleton – internal skeleton
Exo-	Outside	Exoskeleton – external skeleton
Hyper-	Over, above	Hyperactive – over the normal activity level
Hypo-	Under, below	Hypodermic- parts beneath the skin
Intra-	Within	Intravenous – within a vein
Macro-	large	Macrofossil – a fossil large enough to be seen without a microscope
Mono-	One	Monotone – a single, unvaried tone
Multi-	Many	Multiple – many parts
Non-	No, not	Nonsense – lack of sense
Penta-	Five	Pentagon- a figure with five straight sides and five angles
Pre-	Before	Prefix – a word, letter or number placed before another
Semi-	Half	Semi-circle – half a circle
Root	**Meaning**	**Example**
Alb	White	Albino – abnormally white animal or plant
Am, ami	Love, friend	Amiable – worthy of affection
Aqua	Water	Aquarium – tank of water for animals and plants
Bell	War	Belligerent – a party taking part in war
Bio	Life	Biology – the science of life
Brach	Arm	Brachial – relating to the arm
Capit, cap	Head	Captain – the head or chief
Chron	Time	Chonology – the science of dealing with historical dates
Cogn	To know	Recognize – to know again
Corpus	Body	Corpse – dead body
Dactyl	Finger	Polydactyl – having many digits
Dendro	Tree	Dendrochronology – the study of tree rings
Gastro	Stomach	Gastrolith – a stone swallowed by an animal to aid in digestion
Homo	Same	Homogenous – same throughout
Hydro	Water	Hydrophobic – repel or fail to mix with water
Mana	Hand	Manacles – metal chain or shackle confining ones hands
Osteo	Bone	Osteoplasty – branch of surgery concerned with bone repair or grafting
Pod	Food	Myriapod – group of arthropods having many legs
Ptero	Wing	Pterosaur – a prehistoric reptile with membranous wings
Stoma	Mouth	Stomata – opening used for gas exchange in plants
Suffix	**Meaning**	**Example**
-able	Capable of	Legible – capable of being read
-ate	To make	Consecrate – to dedicate
-chrom	Color	Achromatic – having no hue
-ile	Pertaining to	Docile – capable of being managed easily
-ism	Belief, ideal	Sensationalism – matter, language designed to excite
-ist	Doer	Artist – one who creates art
-ose	Full of	Verbose- full of words
-osis	Condition	Neurosis – nervous condition
-phage	Eater	Esophagus – conveys food from the mouth to the stomach
-tude	State	Multitude – state of quantity

Activity Name: Sprinting Toward Lunch

Abstract/Lab Description: Students explore speed and distance and compare predators to their own top speed!

Age Range: 10-16 (younger with modifications)

Objectives/Standards:

Duration: 30 – 75 minutes (*30 minutes if calculation only; 45-75 if some or all students are running*)

Materials:

Copies of student data sheets (Version A for older students, Version B for younger students)
Calculators
Stopwatch (one per group)
Safe area to run at least 100 meters in a straight line
Long measuring tape or measuring wheel OR a running track with marked distances
Pencils

Procedure:

1. Ask students what is speed? What is speed a measure of? Take input and then condense answers to clarify that speed is distance traveled over time. For example, miles per hour (mph or miles/h), kilometers per hour (kph or km/h), or meters per second (m/s) are all measures of distance traveled in a given time. Miles/h, km/h, and m/s are all examples of units of speed. Different units may be chosen based on how well they fit a situation or for convenience, but they are important. We don't give speeds as "10" for example, because it doesn't mean anything without units! 10 miles per hour is very different than 10 meters per second.
2. Explain that students will explore distance, speed, and some related concepts in this activity. Make sure that students have access to pencils and paper before beginning.
3. As a class, work through this example: In the *Incredible Predators* film, we saw a leopard hunt that was over in less than 6 seconds of sprinting, and we learned that the leopard can sprint at 40 miles per hour (64 kph). How could we figure out how far the leopard traveled in 6 seconds if it was running 40 miles per hour the whole time?
   Students may notice that the units don't match – we know how many seconds the leopard was running, but we have its speed in miles per hour. So we need to convert the speed so our units of time match – we need them both expressed in terms of either seconds or hours. For this example, seconds will be more convenient.
4. Help the class work through the conversion from 64 kilometers/h to meters per second, showing them how to cancel units as appropriate. How many seconds are in an hour? There are 60 seconds in a minute, and 60 minutes in an hour, so there are 60*60 = 3600 seconds in an hour. This can be expressed as:

$$\frac{64 \text{ km}}{\text{hour}} \times \frac{1 \text{ hour}}{3600 \text{ sec}} = \frac{64 \text{ km}}{3600 \text{ sec}}$$

But we are asking students to provide meters per second, so a second set of conversions are required. How many meters are in a kilometer? Right! 1000 meters in 1 kilometer, so:

$$\frac{64\text{ km}}{3600} \times \frac{1000\text{ m}}{1\text{ km}} = \frac{17.8\text{ m}}{\text{sec}}$$ (also commonly written as 17.8 m/s)

So, if the leopard ran for 6 seconds at a rate of 17.8 m/s, how far did it travel in those six seconds?

$$6\text{ seconds} \times \frac{17.8\text{ m}}{\text{seconds}} = \text{about 107 meters}$$

This is also an opportunity to reinforce rounding. In the example above, we rounded 17.777777777 m/s (etc.) to 17.8 m/s, and we rounded 106.8 meters up to 107 meters.

5. Pass out the student worksheets provided as appropriate for your group. Shortly, students will complete some independent calculations, similar to those above, but for now they need this sheet to record data.
6. Now tell students that they are going to test their top student sprinting speed! They will use a sprint of 100 meters because it is a convenient and familiar distance. Students may work in groups to time each other sprinting this the 100 meters. You can also select one example student if time is short. Students should record their time on the worksheet.
7. Move to a suitable space for the sprints and allow all participants to run while another student times them.
8. Record results then return to your workspace or classroom to discuss results. Have students compare their fastest group member or the student you selected to the cheetah in our example. As a basis for comparison you may wish to provide the following information to the students:
   - It is very fast for a 13-year-old to run 100 meters in 12 seconds. More often your fastest runner at that age will take 13-15 seconds to cover the distance.
   - A very fast ten-year-old might run it in 13 seconds but more often your fastest runner at that age will take 14-16 seconds to cover that distance.
   - A very fast 16-year-old might cover the distance in 11.5 seconds, but 12.5 to 14.5 seconds is still fast for this age group.
9. Discuss the results of the sprints. Did our human runners run at a constant speed the entire sprint? Why or why not? The runners should not have had a constant speed, because they started from rest, increased to their top sprinting speed, and then tried to maintain it.
   At this point you may need to clarify terms for students. We often use the word acceleration to mean increasing speed, but it actually refers to a change in speed or direction. If you were chasing your prey, you want to not only run quickly, but accelerate up to your maximum speed quickly as well! The speeds being discussed are average speeds over a short time period.
10. Students should use the data they recorded and the other data on the chart to calculate:
    a. How long would it take our example cheetah to run 100 meters?
    b. How long would it take our example leopard to run 100 meters?

c. Students should also calculate how much faster these animals' sprint speeds are than their own time.
d. The current men's world record is 9.58 seconds, set by Jamaica's Usain Bolt in 2009. How does this time compare to our predators?

Differentiated Strategies or Extensions:

- For less advanced students, walk them through the calculations as a class or simplify calculations by giving them some intermediate steps such as providing them the converted speeds.
- For very young students, measure how far a student can run in ten seconds, then show them how much farther a leopard or cheetah could have run in the same amount of time by walking off this distance together.
- For students with motor difficulties, you can shorten the distance traveled by a student or ask the student to act as a timer for other students.
- To extend the activity, ask students to recalculate the conversions in this activity without rounding the numbers. Does it significantly change the final answer? Why or why not?

Vocabulary: Unit, Speed, Distance, Acceleration, Kilometer, Meter, Mile, Average, Rounding, Sprint

Sprinting Toward Lunch Student Data Sheet
(Version A)

1. In the film *Incredible Predators*, we learned that a cheetah has a top speed around 56 miles per hour, which is equivalent to 90 kilometers per hour, but it can only maintain that speed for around 10 seconds.
    a. What is the speed in meters per second?

    b. How far could that cheetah go at top speed? Record this distance in the chart below.

2. Time yourself or a fellow student running a 100m sprint. Record this time in the chart below.

3. Use the data you recorded and the other data included on the chart to calculate the following:
    a. How long would it take our example cheetah to run 100 meters?
    b. How long would it take our example leopard to run 100 meters? How far would the leopard go in 10 seconds at this speed?
    c. What was your student's speed in m/s? In km/h? How far did the student run in 10 seconds at this average speed?
    d. Calculate how much faster these animals' sprint speeds are that your human example. Provide this number as a percentage.

    Use the space below the chart for calculations if necessary.

	Speed in km/h	**Speed in m/s**	**Distance covered in 10 seconds**	**Time to run 100 meters at top speed**
Student				
Cheetah	**90 km/h**	**25 m/s**		
Leopard	**64 km/h**	**18 m/s**		
World record holder?				**9.58s**

Sprinting Toward Lunch Student Data Sheet
(Version B)

1. In the film *Incredible Predators*, we learned that a cheetah has a top speed around 56 miles per hour, which is equivalent to 90 kilometers per hour or 25 meters per second, but it can only maintain that speed for around 10 seconds. How far could that cheetah travel at top speed? Record this on the chart below.

   $\frac{\text{25 meters}}{\text{seconds}}$ x 10 seconds = ________________ meters

2. Time yourself or a fellow student running a 100m sprint. Record this time in the chart below.

3. Use the data you recorded and the other data provided on the chart to calculate how far the leopard would travel in 10 seconds at its top speed? Record this in the chart below.

4. Determine your student speed from his or her time for the 100 meter sprint using the following equation:

   100 meters ÷ __________________ = ________________meters per second
   {Your time in seconds}

5. How far did the student run in 10 seconds at this average speed? Record this in the chart below.

6. Determine your student speed in km/h from the speed in meters per second using the following equation:

_____________ $\frac{\text{meters}}{\text{second}}$ x $\frac{\text{3600 seconds}}{\text{hour}}$ x $\frac{\text{1 kilometer}}{\text{1000 meters}}$ = ________ kilometers per hour (km/h)
{Your speed in m/s}

	Speed in kilometers per hour (km/h)	**Speed in meters per second (m/s)**	**Distance covered in 10 seconds**	**Time to run 100 meters at top speed**
Student				
Cheetah	**90 km/h**	**25 m/s**		**4 seconds**
Leopard	**64 km/h**	**18 m/s**		**5.6 seconds**

Activity: The Eyes Have It

Abstract/Lab Description: Students will learn about basic eye structure and function. Knowing the structures of the eye make it easier to talk about differences in animal eyes and visual perception. Pair this activity with one or all of the following activities – "I Didn't See You There", "Never Saw It Coming", "I See What You Did There" and "What Happened to Your Whole Hand?"

Age Range: Grades 3 - 12

Objectives/Standards:
3-LS2-1
3-LS3-1
3-LS3-2
3-LS4-2
3-LS4-3
3-LS4-4
4-PS4-2.
MS-LS1-4
MS-LS1-5
MS-LS4-4
HS-LS4-4
HS-LS4-5

Duration: 35 minutes

Materials:
Blank Basic Anatomy of the Eye - Teacher Copy
Pencils, pens, or colored pencils

Procedure:
1. Ask students to tell you what they believe the function of the eye is. The most common answer will be that the eye sees, but actually the brain "sees". The eye functions to collect, focus and convert light into electrical signals your brain interprets.
2. Ask students to observe the eyes of fellow students, describing what they see. They might say, for example, they see the whites of the eye, or the colored part or ring, or the black dot. If students are unfamiliar with the names for the parts they are describing, tell students the correct term for each part as it is introduced by the students. See the Basic Anatomy of the Eye - Teacher Copy for reference.
3. Ask students the following questions, but before beginning remind students not to actually stick their fingers in their eyes.
    a. If you were to touch your eye, what is the first part your finger would touch? The answer depends on whether you are touching the side or front of the eye. The whites of the eye are called the sclera, but if you touch your eye while you were looking at your finger, you would touch the cornea, a clear part of the sclera. Students often guess you would poke the pupil or the lens but those are contained inside the eye.
    b. Where does light enter into the eye, through the sclera or the cornea? The cornea is transparent and focuses the light as it passes into the eye.

c. Why can't light enter the eye through the sclera? This answer is a bit obvious but it leads to the discussion of eye function, in that the eye cannot function properly if clear structures become cloudy, as seen in the eyes of aging people and animals.

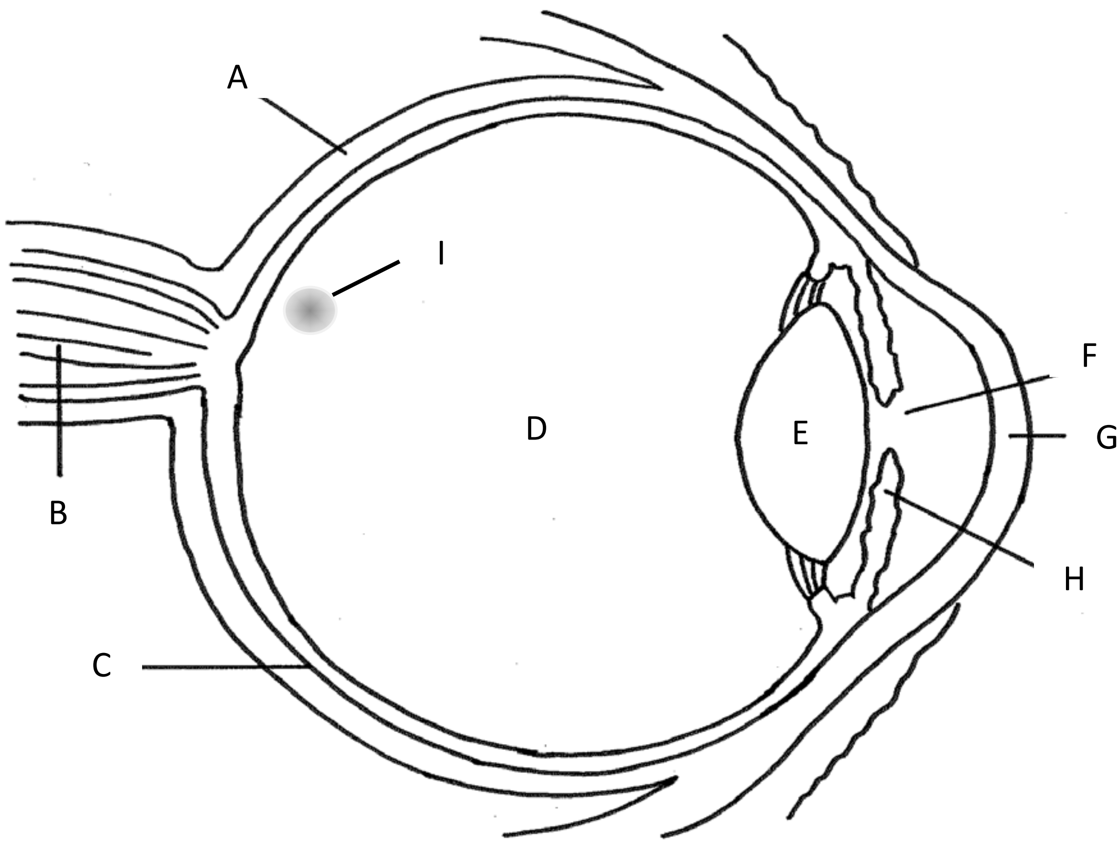
4. Hand out the diagram of the human eye and have students label each part, discuss the function of the parts as you work. When finished, discuss eyes in the animal world with students. Do all animal eyes look alike? Can they provide specific examples of how the eyes are different? Eyes have evolved over the last 500 million years in a surprising number of variations, from the compound eyes of the praying mantis to the independently moving eyes of the chameleon. Animals with eyes, even those with primitive vision, have a distinct advantage to blind animals as they have the ability to better understand the environment around them. In most animals, the eye has evolved to be specifically adapted to a particular environment, how the animal moves and how the animal eats. In vertebrate mammals, the physical structures of the eye vary depending on whether you are the hunter or the hunted. For example, nocturnal and ambush hunters, such as owls or the house cat have vertical pupils. The cheetah, leopard and polar bear seen in the film *Incredible Predators*, are all big predators that hunt during the day and so they have round eyes and circular pupils. Grazing herd animals, like the Thompson's gazelle and the puku, have horizontally elongated pupils that can rotate to stay level with the horizon. This allows the animal to keep a level eye on its surroundings while feeding to watch for predators and provides them information about escape routes in the case of attack.

Differentiated Strategies and Extensions:

- For older students, if time and space allow, dissect a mammal eye.

Vocabulary: Sclera, Cornea, Iris, Pupil, Lens, Vitreous Humor, Retina, Optic Nerve, Nocturnal

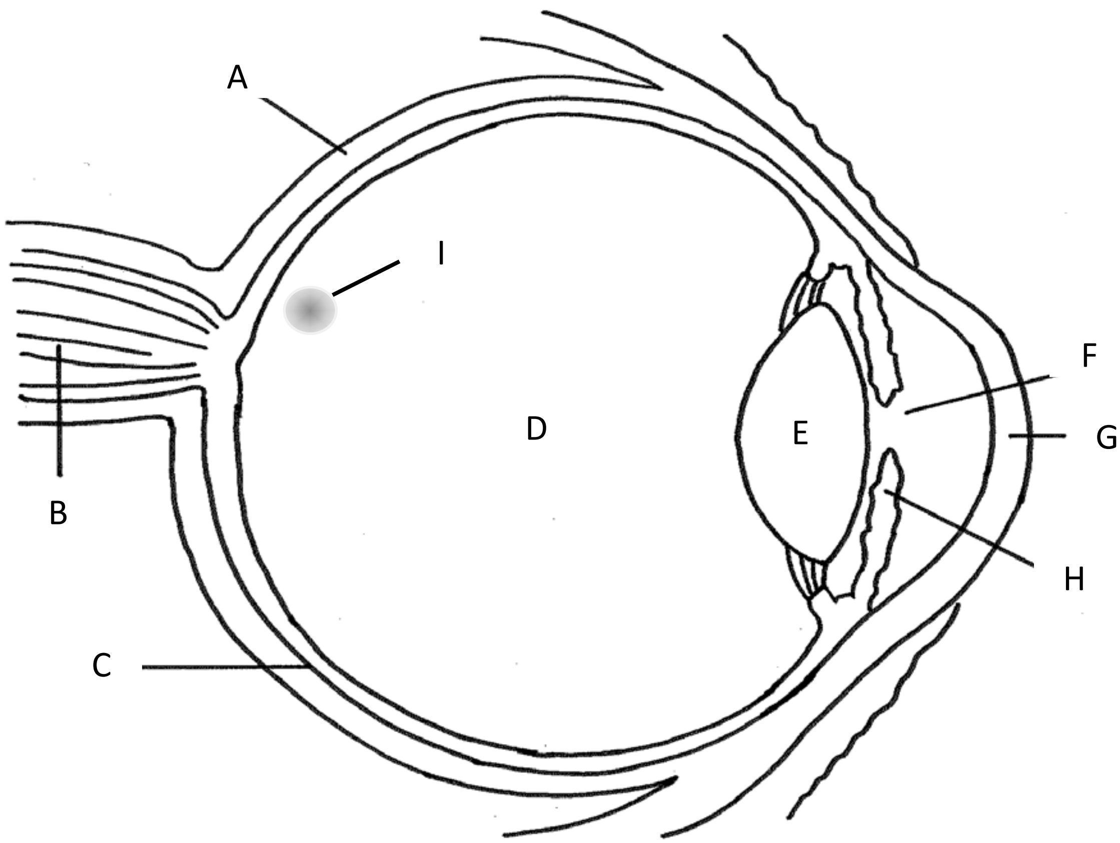
Basic Anatomy of the Eye - Teacher Copy



Use the diagram above and your teacher's help to fill out the information below.

Letter	Name	Description of part's function in the eye
A	Sclera	The "whites" of the eye; Provides structure to the eye and allows tendons to attach to the eye for proper movement
B	Optic Nerve	Bundle of nerve in the back of the eye that transmits impulses to the brain from the retina; The spot where all the nerves converge is called the "blind spot"
C	Retina	The part of the eye made of rods and cones, which transmit light into images for the brain to interpret; It is connected to the optic nerve and contains the fovea.
D	Vitreous humor	- Gel located inside the eye which helps the eye keep its shape
E	Lens	Located directly behind the pupil; Contraction of the pupil allows changes the amount of light the lens lets in and changes shape of the lens for proper focus
F	Cornea	Dome shaped outer covering that protects the eye; Helps the eye focus light more effectively
G	Pupil	Hole in the middle of the eye which appears as a black dot; Takes in light and focuses it
H	Iris	The colored part of the eye; Contains muscles that expand or contract to control the amount of light the eye allows in
I	Fovea	An indentation in the middle of the retina; Spot in the eye where the highest visual acuity is possible.

Basic Anatomy of the Eye



Use the diagram above and your teacher's help to fill out the information below.

Letter Name Description of part's function in the eye

A

B

C

D

E

F

G

H

I

Activity: The Shape of Things

Abstract/Lab Description: Students will explore how various physical characteristics, such as coloration, size, and shape, are adaptations that allow them to survive in their varied environments and play a crucial role in predator-prey dynamics unique to each unique habitat.

Age Range: K-12

Objectives/Standards:
K-2-ETS1-2
K-2-ETS1-3
2-LS4-1
3-PS2-2
3-LS2-1
3-LS4-2
3-LS4-3
3-LS4-4
4-LS1-1
MS-LS1-4
MS-ETS1-3
MS-ETS1-4
HS-LS2-8
HS-LS4-4

Materials:
- Pictures of the following fish: pacu , butterfly fish, flounder, moray eel, frogfish, tuna fish, tuatog, skate, pipe fish
- Access to craft materials or clean recyclables for creating models of fish
- Basic tools for assembly such as but not necessarily:
    - Scissors
    - Needle nose pliers
    - Philips screwdriver
    - Glue gun
    - Glue
- Paper
- Pencils

Duration: 30 to 60 minutes

Procedure:
1. Before the activity complete the following:
    - Find pictures of the fish from the materials list on the internet and print them. Make sure they are large enough pictures for the entire class to be able to see clearly. Sort them into two sets. In set one, place the pacu , butterfly fish, flounder, moray eel. In set two, place the frogfish, tuna fish, tuatog, skate, pipe fish.
    - Label each picture with the name of the fish

- Write the following words on the board for reference later: fusiform, compressiform, depressiform, or filiform
- Gather tools for general use by the class
- Gather craft materials or clean recyclables for use by the class

2. To begin the activity, display the pictures of the various fish from set one. Ask students what characteristic makes these fish look most different from one another? The most obvious characteristic is the shape of their bodies.
3. Explain to the students that the physical characteristics of a fish can tell us about the environment from which it came. Fish live in a wide range of aquatic habitats and come in many sizes, shapes, and colors. Each of these physical characteristics provides clues to where the fish lives, what it eats, and its style of locomotion.
4. Now invite students to draw comparisons between the shapes of the different fish and items that are manmade. For example, the shape of the pacu is similar to a torpedo. Encourage them to make correlations. Does the shape of the body of a fish give any clue to how fast they can swim, how they avoid predators, or catch food? Pacu are shaped like a torpedo and torpedoes are fast, using this speed to catch their prey. Continue this process with all of the different shapes.
5. Draw the attention of the class to the picture of the pacu. Tell the class that the majority of fish, are fusiform, or tapered at both ends. Explain that this streamlined shape allows them to move through open water with little resistance drag. Many predatory fish have this body shape as this shape, combined with a deeply forked tail, enables them to swim incredibly fast and catch prey.
6. Next, explain to the class that not all fish are fusiform in shape. Fish can come in a wide variety of shaped depending on their environment and the specific adaptations the fish have to be successful in that environment. Compression, depression and elongation, also known as filiform, are other common fish body types.
7. Draw the attention of the class to the picture of the butterfly fish. Explain to the class that a body compressed laterally, or from side-to-side, creates a disk-like shape and that many fish found in reef environments have this shape. Tell the class that this shape allows the fish to swim quickly, in short bursts, allowing it to evade being eaten by predatory fish.
8. Now show students the picture of the flounder. Explain that this is a depressiform fish and is compressed dorsoventrally, or from top to bottom. Explain that fish with this shape, also called flatfish, are typically bottom dwelling and can be scavengers or predators. Explain that these fish propel themselves by flapping their fins, much like a bird.
9. Draw the attention of the class to the picture of the moray eel. Explain that this is a filiform fish and has an elongated shape. Point out that the moray eel has a long slender body that helps it to swim against current and move with ease through water. Tell them that other elongated fish may be ribbon-shaped or thread-like, which makes them slower swimmers, but allows them to hide from predators in crevasses.
10. Lastly, draw attention to the picture of the frogfish. Explain that this is a globiform fish that has a rounded shape and that they are typically bottom dwellers. Tell the class that globiform fish are typically slow swimmers and may have specialized camouflage, sharp barbs, or poison to defend themselves from predation.
11. Show the class pictures of the various fish from set two, one at a time, and invite students to try to discern shape type of each fish, the environment the fish may live in, and what adaptations they have developed in order to avoid predation or catch prey.
12. Next, separate the students into working groups of three to four members. Explain that each team will be tasked with modeling how one of the different shapes moves through water. Secretly assign each team one of the following shapes: fusiform, compressiform, depressiform,

filiform or globiform. Remind students that a fusiform fish would have a tapered shape that creates little resistance in the water, a compressiform fish would be a thin upright disc for short burst of speed, a depressiform fish would be a bottom-dweller and flat like a pancake, a filiform fish would be shaped like a long tube and a globiform fish have special adaptations for defense because they are not particularly fast.

13. Show the teams the materials they have to work with for this activity, and the show the location you have provided to test the models. Provide the teams with paper and pencils and ask groups time to brainstorm ideas for their models. Encourage them to sketch ideas and write notes on the paper provided.
14. After a short time for brainstorming, give the groups a specific amount of time to construct their model fish. Encourage students to test the models as they go to see what works well and what needs. Provide guidance as necessary to groups that are stuck or struggling. When time is up, instruct students to clean up their work areas in order to prepare to present their models and afterwards a class discussion.
15. One at a time, ask each group to stand and show their models. Let the other students guess which of the five fish shapes is represented. How could they tell what fish body shape was represented in the model?
16. After each group reveals the fish form they were assigned, allow them time to demonstrate the features of their models work and describe how they were engineered. Encourage groups to share the specific characteristics they were trying to achieve that reflected the assigned body shape, the problems they encountered in assembling the models, and how they overcame these obstacles.
17. When all groups have presented, compare the models with similar body types. Which model do the students deem to be the best example of a particular body shape. How would students amend their design after seeing all the presentations?
18. Now ask students to think back to the film *Incredible Predators.* What body shape did the dorado fish exhibit? What about the flying fish? Both of these fish were fusiform in shape – the dorado for speed to catch prey and the flying fish to evade predators. Both of these fish are specifically adapted for their environment and any change to the environment or animal would have drastic consequences. Discuss with students how the interaction between the dorado and flying fish might be different if they exhibited different body shapes. What if the dorado was globiform and the flying fish was compressiform? Does the fusiform body shape present an advantage to the flying fish as it travels in a school? What would happen to these two sleek fish if they suddenly lived near a coral reef?

Differentiated Strategies and Extensions:

- Position the pool so that students with special physical needs can be accommodated.
- If you have limited time, models can be created by the teacher for use as a demonstration only.

Vocabulary:

- Environment, Fusiform, Compressiform, Depressiform, Filiform, Globiform, Predator, Prey, Camouflage, Adaptation, School

Activity Name: What Happened to Your Whole Hand?

Abstract/Lab Description: This activity illustrates how stereoscopic vision works, providing predators better depth perception and the ability to more accurately judge distance.

Age Range: Grades 1 -12

Objectives/Standards:
1-LS1-1
3-LS4-2
3-LS4-3
MS-LS1-3
HS-LS4-3
HS-LS4-4

Duration: 10 minutes

Materials:
Paper towel tubes or sheet of computer paper rolled into a tube

Procedure:
1. Hand out the tubes, one for each student. Students should hold the tube in their right hand, close to one end of the tube.
2. Have students select something on the opposite side of the room to view, a large poster or object for example. Have students hold the tube close to their right eye without touching their face. Next, they should close their left and pay attention to what they can see. Students should note that they can see clearly out the end of the tube, but can also the walls of the tube itself. Typically, they can also see out of the right corner of their eye, so if someone were to walk past they would still be able to see the motion in the gap.
3. Now ask students to open their left eye and, with both eyes open, pay attention to what they can see. In addition to seeing left side of the room, they should also see the left side exterior wall of the tube, the image through the tube, and the interior walls of the tube.
4. Have students set their tubes down while you demonstrate the following: hold the tube in your right hand place the tube to your right eye, as before. Extend your left hand, with the palm facing outward in front of the tube. Look at the same object on the far side of the room with both eyes open. The result will be that a hole appears in the palm of your hand. What's happening? Humans, like most other predators, have eyes that face forward. Normally, the images seen by the right and left eyes are very similar, but slightly different, and the images overlap. The brain processes these images in a way that allows an animal to slightly see around an obstacle without having to physically move. This is called stereoscopic vision. In this experiment, the tube restricts the vision of both eyes. The right eye sees the tube and the left eye sees your hand, so the image your brain sees is the overlap of the two images: a picture of your hand with a hole in it. Most predators, such as the chameleon, polar bear, praying mantis and leopard in *Incredible Predators*, have stereoscopic vision. Stereoscopic vision is an evolutionary adaptation that significantly improves depth perception and enhances an animal's ability to judge distance – both of which allow predators a higher degree of accuracy when stalking prey. This is particularly useful to a predator when trying to conceal itself behind trees or tall grasses, which may partially obstruct its view of the prey it is stalking.

Vocabulary: Stereoscopic vision

Activity Name: You Ate How Much for Lunch?!?

Abstract/Lab Description: Students explore the calorie needs of polar bears and calculate the calorie content of their common prey.

Age Range: Grades 5 - 12

Objectives/Standards:
5-LS2-1
MS-LS2-1
MS-LS2-2
MS-LS2-4
HS-LS2-1
HS-LS2-2

Duration: 30-75 minutes

Materials:
Copies of "You Ate How Much for Lunch?!?" worksheets
(Version A for younger students, Version B for older students)
Calculators
Pencils
Cheetah Energy Use worksheet

Procedure:
1. Remind students that energy can change from one form to another, for example, electrical energy can turn into light, or heat, or sound. Where does the energy your body uses come from? The food you eat! Food is stored, chemical energy, and we process that food in order to use the energy for different functions with our body.
2. According to the film *Incredible Predators*, polar bear hunts are more successful during the late spring than during mid-summer. Why? Because as the ice melts, the bears are less likely to capture a seal before it escapes off the ice, into the water, and polar bears almost never succeed in catching prey once it is off the ice.
3. Explain to students that the energy in food is typically given in kilocalories (kcal). This can be confusing, because on nutrition labels for human food, kilocalories are usually listed as Calories instead. A kilocalorie AND an upper-case-"C" Calorie are both equivalent to 1000 lower-case-"c" calories.
   1 kilocalorie = 1000 calories
   1 Calorie = 1000 calories
4. Using the appropriate version of the worksheet on the following pages, have students calculate a polar bear's energy intake based on the following. For younger students, adapt by working through the calculations as a class, and checking in step by step to make sure students understand each answer.
   a. Assume that the female polar bear we saw in the film weighs 180 kilograms (400 lbs.)
   b. Assume that the average daily energy requirement for this bear is around 140 kcal per kilogram of body weight.

How many calories does our female polar bear need, on average, each day? Show your work. (180 kg * 140 kcal/kg = 25,200 kcal per day, on average)

c. Assume that she catches a 55 kg (120 lbs.) seal. Polar bears often eat only the blubber of the seal. Assuming 40% of the seal's weight is blubber, how many kilograms of blubber did our polar bear eat? (22 kg of blubber)
d. Seal blubber contains roughly 7500 kcal/kg (kilocalories per kilogram) – how many kcal did she eat from this kill? (165000 kcal – Now THAT'S a big meal!)
e. About how many days' energy requirements were met by this meal? (165000 kcal divided by 25200 kcal/day = 6.5 days – Almost a week!)
f. Extension for advanced students: As the weather warms up and ice melts, polar bears are far less successful – according to Incredible Predators, only 1 in 20 hunts are successful in mid-summer, compared to 1 in 5 in late spring. More hunting uses additional energy. Assuming the bear's energy use in mid-summer is now 170 kcal/kg of body weight each day, how many days would the same size meal provide the bear's energy requirements?
170 kcal/kg * 180 kg = 30,600 calories required per day (on average)
165000 kcal / 30600 kcal/day = 5.4 days

5. Discuss calculations as a class and also ask students how the polar bear's consumption and energy use might change from the average numbers. Polar bears' weights fluctuate widely by season, as food availability and hunting success change. Also, female polar bears may spend many months without hunting or eating at all while caring for new cubs. They have an unusual metabolism this way; most animals cannot go that long without food! When food is plentiful and hunting is easy, they may consume far more than their average daily requirement, and this ensures that they will have enough energy stored in their bodies as fat to make it through weeks or months when food is scarce and they are consuming less than their average daily requirement.
6. Blue whales also undergo seasonal weight fluctuations; when food is abundant, excess consumed energy is stored as fat and some of this energy will be used in the 'leaner' season. The blue whale's feeding strategy results in a very large capture of krill all at once. The amount of krill in a single giant mouthful varies widely, depending on the density of krill in the area and the volume of the mouthful the whale engulfs during a particular lunge. Calculate with the class:
    a. Assume one particular blue whale weighs 140 tonnes (154 'short' tons or 310,000 lbs) and that blue whales are very energy efficient due to their large size and body composition, requiring just 10 kcal/kg of body mass per day on average. How many total kcal does this whale need on average?

       140 000 kg * 10 kcal/kg = 1.4 million kcal per day

    b. If this whale encounters a moderately dense patch of krill and lunges, engulfing a large mouthful, it might consume 130 kg of krill in that single gulp. Krill contain roughly 1100 kcal/kg (4600 kJ/kg). How many kcal did the whale consume in that gulp?

       1100 kcal/kg*130 kg =143000 kcal

c. If our whale makes 20 similar lunges in one day, how many kilocalories did the whale consume, and what percent of its average daily energy requirement was that?

143000 kcal/lunge *20 lunges = 2860000 kcal

2860000 kcal (obtained) /1400000 kcal (needed) = 2.04 times the average daily requirement (over 200% of the average daily requirement)

d. If on another day our whale encountered very dense krill fields and could consume 300 kg of krill per lunge, but only lunged 12 times, how many kilocalories did the whale consume that day, and what percent of its average daily energy requirement was that?

1100 kcal/kg * 300 kg = 330000 kcal in one lunge

330000 kcal/lunge * 12 lunges = 3960000 kcal consumed that day

3960000 kcal obtained / 1400000 kcal needed * 100 = over 280% of the daily requirement

On this day, our whale will store a LOT of excess energy for future use!

e. Extension: Have students research how much energy (in kilocalories) is stored in each kilogram of whale blubber (fat) and then calculate, assuming perfect efficiency, how many kg of fat the whale should have gained from its 4.95 million calorie day?
3960000 kcal obtained minus 1400000 kcal needed = 2560000 surplus kcal

Student-researched estimates may vary, but assuming 8000 kcal of stored energy per kilogram of blubber, the whale could gain (store) 2560000 kcal ÷ 8000 kcal/kg = over 320 kg (700 lbs) from that day's krill.

7. Now discuss with students that different predators employ different hunting strategies. Some, like African wild dogs, may hunt opportunistically and may attempt several pursuits each day, many of which fail. Others, like cheetahs, spend most of their time at rest and have very short and infrequent, but high intensity hunting efforts. Locomotion, such as walking, running, jumping, swimming, etc., requires more energy than resting, so because they spend much of their time resting instead of just walking around, they reduce their energy expenditure or how many calories they 'burn'. For all predators, energy balance must be maintained over time or the predator will eventually starve. Additionally, it is important for students to understand that predators play an important role in the ecosystems they interact with by reducing prey populations. If the prey populations are left unchecked they will deplete energy sources which may result in wild fluctuations in populations of plants and animals.
8. For additional practice, have students calculate an example cheetah's energy use over a day, filling in the missing values in the table provided.

Differentiated Strategies and Extensions:

- Complete calculations as a class for younger students, or use the simpler handout.

Vocabulary: Energy, Kilocalorie, Intensity, Energy Balance, Metabolism

You Ate What for Lunch?!?
(Version A)

Food is stored, chemical energy, and we process that food in order to use it for different functions within our body. The energy in food is typically given in kilocalories and abbreviated as kcal (pronounced kay-cal).

Calculate a polar bear's energy intake in kilocalories (kcal) based on the following:

1. If the female polar bear we saw in *Incredible Predators* weighs 180 kilograms (400 lbs.) and the average daily energy requirement for this bear is around 140 kcal per kilogram of body weight. How many calories does our female polar bear need, on average, each day?

   =___________ days

2. Assume that the polar bear catches a 55 kg (120 lbs.) seal. Polar bears often eat only the blubber of the seal. Assuming 40% of the seal's weight is blubber, how many kilograms of blubber did our polar bear eat?

   55 kg * 0.40 = __________ kg of blubber

3. Seal blubber contains roughly 7500 kcal/kg (kilocalories per kilogram) – how many kcal did she eat from this kill?

   7500 kcal/kg * ____________kg of blubber = __________________ kcal

4. About how many days should this meal sustain the bear?

You Ate What for Lunch?!?
(Version B)

Food is stored, chemical energy, and we process that food in order to use it for different functions within our body. The energy in food is typically given in kilocalories and abbreviated as kcal (pronounced kay-cal).

Calculate a polar bear's energy intake in kcal based on the following:

1. Assume that the female polar bear we saw in *Incredible Predators* weighs 180 kilograms (400 lbs.) and the average daily energy requirement for this bear is around 140 kcal per kilogram of body weight. How many calories does our female polar bear need, on average, each day? Show your work.

2. Assume that she catches a 55 kg (120 lbs.) seal. Polar bears often eat only the blubber of the seal. Assuming 40% of the seal's weight is blubber, how many kilograms of blubber did our polar bear eat?

3. Seal blubber contains roughly 7500 kcal/kg (kilocalories per kilogram) – how many kcal did she eat from this kill?

4. About how many days' energy requirements were met by this meal?

5. As the weather warms up and ice melts, polar bears are far less successful – according to *Incredible Predators*, only 1 in 20 hunts are successful in mid-summer, compared to 1 in 5 in late spring. More hunting uses additional energy. Assuming the bear's energy use in mid-summer is now 170 kcal/kg of body weight, how many days would the same size meal provide the bear's energy requirements?

6. How many seals, at a minimum, are required to feed 1 female polar bear in the course of a year? What does the proportion of seals to bears tell you? If the female polar bear had cubs, how do you expect the ratio of seals to bears to change?

Cheetah Energy Use

In *Incredible Predators*, a female cheetah hunts to get food for herself and her four cubs. Using the information given below, calculate the missing values and fill in the blanks.

Activity	**Energy use in kilocalories (kcal/hour or kcal/second)**	**Time spent on activity per day**	**Kcal expended during that time**
Resting/sleeping	50 kcal/hour	21 hours	
Locomotion (walking, looking for prey, etc.)		3 hours	800 kcal
Sprint/attack phase of hunt	2.4 kcal/second	Assume 2 hunting attempts per day, each with a 25 second sprint phase = 50 seconds	
			TOTAL kcal used in one day: