EDUCATION
GEORGIA AQUARIUM

Lesson Plan
8 FIN-TASTIC FORCES

Essential Questions:

1. How do different adaptations or traits improve an animal's ability to survive?
2. How do marine animals use magnetic, electric, and gravitational forces or fields for survival?

GSE Standards:

- **S8P5**: Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.
- **S8P5.a**: Construct an argument using evidence to support the claim that fields (i.e., magnetic fields, gravitational fields, and electric fields) exist between objects exerting forces on each other even when the objects are not in contact.

NGSS Standards:

- **MS-LS4-4:** Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Materials:

- Boxes
- Assorted magnets
- Paperclips, metal strips, or other assorted magnetic items
- Printed cards
- Tape
- Paper and pencils

Vocabulary:

- Magnetic field
- Electrical field
- Gravitational force
- Ampullae of Lorenzini
- Force

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Background:

- There are a variety of forces acting on the Earth at all times, including magnetic forces, electrical forces, and gravitational forces.
- Magnetic force is the attraction or repulsion between electrically charged particles. It is present as magnetic fields around the Earth and on the ocean floor.
- Electrical force is a non-contact force occurring between two or more charged objects.
- Gravity is the force that is constantly pushing down on objects on Earth, usually defined as the mutual attraction between all things that have mass.
- As these forces act on the Earth, they impact the animals living here. Many animals have adaptations that allow them to use these forces to their advantage or simply survive despite their presence.
- Some species of animals have magnetite in their skulls or beaks, which is believed to help them navigate using the Earth's magnetic field. Turtles, salmon, humpback whales, and even birds, are able to migrate using this force. Turtles are able to return the exact beach they hatched on, and humpback whales follow the same migration paths year after year.
- The magnetic field of the Earth is much like a bar magnet. At the magnetic North Pole, the magnetic field lines are perpendicular to the surface, near the Equator, they are parallel. Animals can detect these changes.
- The ocean floor also shows evidence of the changing polarity of Earth's magnetic field, creating invisible magnetic stripes on the ocean floor.
- Water is a better conductor of electricity than air is, so many animals have adapted to use electrical currents and forces to help them hunt or defend themselves.
- Many animals can be either **electroreceptive** (detects electric pulses) or **electrogenic** (generates electric pulses). Some animals can do both.

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Background:

- Living organisms produce electromagnetic fields, which electroreceptive animals can detect, determining size and location.
- Land animals have a harder time dealing with gravity than animals in the ocean, who have the force of buoyancy pushing up on them. Their skeletal and muscular systems have to be able to support their weight, limiting the size land animals can get.
- Animals who are larger or taller, also need special adaptations to ensure their blood is able to be pumped throughout their body.
- Sharks specifically use all three of these forces to survive.
- They have special jelly-filled pores on their rostrum that allow them to detect the electrical currents of their prey. These pores are called Ampullae of Lorenzini.
- These organs detect the electrical impulses generated by the muscle contractions of nearby fish, seals, or other creatures.
- They’re so sensitive that they can even detect a beating heart, but they only work at close range. It even helps the shark find fish that have buried themselves in the sand.
- These pores may also help sharks follow water currents. They may also serve as an internal compass, helping sharks navigate across hundreds or thousands of miles of open water by following Earth’s magnetic field.

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Lesson Structure:

1. Ask students to name the various forces they know of and how they show up in nature.
2. Using the animal forces cards, challenge students to organize the organism's adaptations into categories based on which force they most commonly use. Review correct answers.
3. Review the background information on sharks with students. Explain that they will be creating a shark maze to demonstrate how sharks hunt their prey.
4. Split students into groups and pass out boxes, paper clips and assorted metal items, magnets, and tape. Instruct groups to create a maze on the underside of the box. Once created, swap boxes with another group.
5. Using the shark magnet, map the path to find the hidden magnet, representing where the prey is hiding. Have students draw the path of the shark on the maps, then flip the box over and compare the path.

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Evaluate:

1. After sorting the cards, have students compare and contrast the different forces of nature, and how different animals utilize them.
2. Discuss with students how these adaptations help an animal survive in their distinctive habitats.
3. Ask students to identify where the pull of the magnets was the strongest, and to highlight any differences between the path and their map.

Extend:

1. Have students further research animals that make use of nature's forces to aid in their survival, presenting their findings to the class.
2. Using the cards, students can play a Go Fish or a "I Have, Who Has" style game where the goal is to get a set of animals that all utilize the same force.
3. To explore magnetic fields, offer students a variety of magnet and iron shavings, allowing them to observe and draw the magnetic field present for each type of magnet.
4. To continue exploring how sharks use magnetic forces, use the shark maze boxes to hide other magnets and instruct students to find where the strongest pull is, exploring north and south poles of magnets and their strength.

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ELECTRICAL

MAGNETIC

GRAVITATIONAL

SALMON

Salmon inherit a magnetic map and are able to migrate using the Earth's magnetic field, returning to where they were hatched in order to spawn.

TURTLE MIGRATION

Sea turtles lay their eggs on the same beach they hatched on. They are able to find their way back by using their internal compass to navigate Earth's magnetic field.

RED FOX

When hunting, red foxes align the angle of sound with the slope of Earth's magnetic field, consistently pouncing in a north-easterly direction. This increases their success.

HUMPBACK WHALE

These whales are thought to have a bit of magnetite in their skull. They use Earth's magnetic field to migrate in near-straight lines, usually the same route every year.

PLATYPUS

40,000 specialized electroreceptor skin cells on their bill. It detects changes in pressure and motion, and tracks electrical signals produced by muscular contractions of small prey.

ELECTRIC EEL

Electric eels contain hundreds of thousands of modified muscle cells called electrocytes. These animals can both produce an electrical current and detect it.

STARGAZERS

These fish have a modified eye muscle that can give off an electric current, shocking and immobilizing their prey or fending off predators.

ELEPHANTNOSE FISH

Elephantnose fish can generate an electric field and then use its electroreceptors to locate nearby objects by the distortions they cause in the electric field.

AMPULLAE OF LORENZINI

These jelly-filled pores along a shark's rostrum form their main sensory system, allowing them to detect electrical currents from their prey.

ELECTRIC RAYS

These rays have a kidney-shaped organ capable of generating electric shocks. They can control the intensity of their shocks as well, using this skill to hunt for their prey.

BEES

Bees are able to beat their wings very fast to create lift. They are able to navigate using gravity and sunlight, but have trouble figuring out where they're going without gravity.

GECKOS

Geckos can climb smooth surfaces because of the electrostatic forces on the gecko's toe pads. The difference in charge helps keep the gecko anchored to the wall.

LAND ANIMAL SIZE

While there are large land animals, they are limited by the force of gravity. The larger an animal on land, the stronger skeletal and muscular system they will need to support their weight.

BIRDS

Birds counteract gravity by using lift, with the front of their wing slightly higher than the back. They also have hollow bones that allow their lungs to fill with air, making their bodies lighter.

GIRAFFES

Due to constant gravitational stress, tall species like giraffes have special adaptations, such as natural hypertension, that allow them to pump blood from their heart to the brain.

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ANSWER KEY

1. Magnetic
    - Turtles
    - Humpback Whale
    - Salmon
    - Red Fox
2. Electrical
    - Electric Eel
    - Elephantnose fish
    - Platapus
    - Stargazer
    - Electric Ray
    - Geckos
    - Ampullae of Lorenzini
3. Gravitational
    - Birds
    - Bees
    - Giraffes
    - Land Animal Size