Introduction

Jonathan narrates this educational segment about the biology of sharks. They represent a very diverse group of animals from the plankton grazing Whale and Basking sharks to some of the most formidable of predators in the sea, Great White and Tiger sharks. They are evolutionarily advanced animals and are incredibly well adapted for their place in ocean ecosystems.

In this video, differences between sharks and their bony cousins are highlighted and celebrated. One such difference is in each group’s ability to control their vertical position in the water. Bony fish have a swim bladder that they can inflate and deflate to control their buoyancy. Sharks on the other hand must swim and control their depth with their fins. It’s like the bony fish are hot air balloons with a propulsion system and sharks are airplanes, moving forward to stay aloft. So how does buoyancy work? Why can bony fish control buoyancy and why do sharks lack this ability? This lesson looks at the science behind the principle of buoyancy.
(1) PLANNING THE INVESTIGATION:
Focus Question (Teacher provided or student generated? Write in or glue in?)
Prediction (Whole group oral or written in notebook? I think/predict that________ because _______)
Planning (What should be changed? What should be kept the same? How will differences be measured? Teacher given? Written on board? Glue in sheet? Student generated?)

(2) DATA ACQUISITION & ORGANIZATION:
Data Collection Methods (How will students record data? Drawings, charts & tables, artifacts, graphs & organizers)
Data obtained (What is the expected outcome of the observations?)
Data display (Data re-organization, graphic organizers)

(3) MAKING MEANING:
Discussion/analysis Conference: Science Talk (Class graphic organizer, thinking maps, sharing data, claims and evidence as a whole group)

Claims & Evidence listing:

<table>
<thead>
<tr>
<th>Claim</th>
<th>Evidence</th>
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</thead>
<tbody>
<tr>
<td>(I claim that...)</td>
<td>(I know this because...)</td>
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</tbody>
</table>

Conclusion (Sentence Frames and Prompts to scaffold answering the focus question: How do claims and evidence related to the big idea? Were predictions supported by the evidence?)

(4) REFLECTION & SELF-ASSESSMENT:
Line of learning (What did you learn that was new?)
Reflection/Self-reflection (At first thought...now I think...I still need help understanding)
Next Step Strategies (Re-teaching strategies)

Reference: Bay Area Science Project/Lawrence Hall of Science - 2010
Background

The shark is a fascinating creature, surrounded by myth and misconception. To many, sharks symbolize the very essence of ruthlessness, representing the ultimate savages of the natural world. Sharks and their direct predecessors have been swimming in the world’s oceans for well over 300 million years, and were going about their business long before dinosaurs walked the Earth. The fact that sharks have survived for so long without changing very much is a real tribute to the effectiveness of their anatomy.

For more shark information see Wonders of the Sea:
http://www.oceanicresearch.org/education/wonders/sharks.html

** Scientific Vocabulary  Shark Biology **

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Density</td>
<td>The amount of material (mass) in a given space (volume). It is calculated by dividing a material’s mass by its volume. (Density = mass ÷ volume) Units are typically expressed in grams per milliliter (g/ml). ** Important Fact: The density of water is about 1 gram per milliter.**</td>
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<tr>
<td>Displacement</td>
<td>When an object pushes a material out of the way. An object displaces its volume when submerged in a fluid.</td>
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<tr>
<td>Fluid</td>
<td>A liquid or gas. A fluid has no definite shape... it flows. Air and water are fluids.</td>
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<tr>
<td>Force</td>
<td>A push or pull</td>
</tr>
<tr>
<td>Mass</td>
<td>A measure of the amount of matter. The basic unit of mass in the metric system is the gram. Mass is measured using an object’s weight on a balance.</td>
</tr>
<tr>
<td>Volume</td>
<td>The amount of space occupied by a quantity of material or object. The basic unit of volume in the metric system is the liter (l). Smaller volumes are measured in milliliters (ml) 1 ml = 0.001 liters, also known as 1 cubic centimeter (cc).</td>
</tr>
<tr>
<td>Weight</td>
<td>The force of gravity on an object</td>
</tr>
</tbody>
</table>
Directions: Find a picture or a synonym (similar word) for each of the Essential Vocabulary words. Use a dictionary, thesaurus, internet, or any other resource available to you. These are in alphabetical order. For an additional activity, pair words with opposite meanings.

ADAPT -
ALGAE -
BAIT –
BOTTOM DWELLING -
BUOYANCY -
CAMOUFLAGE -
CARTILAGE
COMPETE -
DECREASE -
DETECT -
DROWN -
ECOSYSTEM -
ELECTRICAL CURRENTS -
ELECTROSENSORY SYSTEM -
EVOLVE -
FEEDING FRENZY -
FORCE -
GENERATE -
HABITAT -
HOVER -
INCREASE -
IRONIC -
MIRROR -
MOTION -
MUSCLES –
NEUTRAL -
PELAGIC -
PLANKTON -
PREDATOR -
PREY -
REFINE -
REPRODUCE -
SENSES -
SKELETON -
SOPHISTICATED -
SPECIES -
SWIM BLADDER -
VULNERABLE -
THREAT -

AMPULLAE OF LORENZINI – special sensing organs called electoreceptors, forming a network of jelly-filled pores. They are mostly discussed as being found in cartilaginous fish (sharks, rays, and chimaeras)

EYELIDS= NICTITATING MEMBRANES – a whitish or translucent membrane that forms an inner eyelid in birds, reptiles, sharks and some mammals. It can be drawn across the eye to protect it

GILLS - the paired respiratory organ of fishes and some amphibians, by which oxygen is extracted from water flowing over surfaces within or attached to the walls of the pharynx

PECTORAL FINS - each of a pair of fins situated on either side just behind a fish’s head, helping to control the direction of movement during locomotion. They correspond to the forelimbs of other vertebrates

PORES - a minute opening in a surface, especially the skin or integument of an organism, through which gases, liquids, or microscopic particles can pass

SINK - go down below the surface of something, especially of a liquid; become submerged

SNOT - the projecting nose and mouth of an animal, especially a mammal

TAIL FIN - a fin at the posterior extremity of a fish’s body, typically continuous with the tail

TAPETUM LUCIDEM – a layer in the eye chiefly of nocturnal mammals that reflects light back causing the eyes to glow when light strikes them at night
EXTENDED VOCABULARY  Shark Biology

Directions: Find a picture or a synonym (similar word) for each of the Extended Vocabulary words. Use a dictionary, thesaurus, Internet, or any other resource available to you.

ANCIENT -
ENTIRE -
FLEXIBLE -
GULP -
PATIENT
PRIMITIVE -
RULE -
SOFT -
UNSUSPECTING –

IDIOMATIC LANGUAGE:
BACK AND FORTH -
COUNT FOR SOMETHING -
INTERESTED IN SOMEONE/ SOMETHING -
RUN OUT
LACK OF SOMETHING -
WEED OUT -
Word Search: Shark Biology

ADAPT  EVOLVE  MOTION  RULE
ALGAE   FLEXIBLE  NEUTRAL  SKELETON
ANCIENT GULP    PATIENT  SOPHISTICATED
CAMOUFLAGE HOVER  PRIMITIVE  UNSUSPECTING
ENTIRE   IRONIC   REFINISHING  VULNERABLE

Learn more at www.BlueWorldTV.com!
Crossword Puzzle: Shark Biology: Scientific Vocabulary

Across
2. A liquid or gas. A fluid has no definite shape... it flows.
6. A biological community of interacting organisms and their physical environment.
9. Of or relating to the open sea.
10. A group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.
12. The natural home or environment of an animal, plant, or other organism.

Down
1. The force of gravity on an object.
3. A push or pull
4. The amount of material (mass) in a given space (volume).
5. The amount of space occupied by a quantity of material or object.
7. A measure of the amount of matter.
8. When an object pushes a material out of the way.
11. An animal that naturally preys on others.

DENSITY      HABITAT      VOLUME
DISPLACEMENT  MASS       WEIGHT
ECOSYSTEM     PELAGIC    
FLUID         PREDATOR   
FORCE         SPECIES    

Learn more at www.BlueWorldTV.com!
Previewing Background Knowledge & Check In Questions

1. What is a shark? Is it a fish? How is it different from other fish?
2. Name some distinguishing characteristics of all sharks.
3. What does a shark look like? Are they all similar looking
4. Are sharks dangerous to people?

Viewing the Video

Watch the Shark Biology video webisode 45 - Length 10:06
http://www.blueworldtv.com/webisodes/watch/shark-biology

Post Viewing Questions and Writing Prompts

Post Viewing Questions:
1. When the sharks were fighting each other over the frozen chum ball, during the “feeding frenzy”, were you scared for Jonathan?
2. Do you think Jonathan was frightened? Why or why not?
3. Are you convinced that sharks are not crazy killers now? Why or why not?
4. What new information did you learn about a shark’s biology?
5. What surprised you the most about the shark?
6. How does the Ampullae of Lorenzini work?
7. How do you think the Ampullae of Lorenzini was discovered? (Guess first, then google it)

Writing Prompt

Writing (or speaking) activities to be used in conjunction with the two shark comparison diagrams at the end of the unit.
1. Write a list of the steps explaining the process of how a shark uses fins in order to glide through the water.
2. Using the transitions below, write 10 sentences using compare and contrast transitions to show how sharks and bony fish are alike.
3. Write ten sentences on how fish and sharks are different.
4. View the diagrams and write five comparison/contrast sentences of sharks to birds. (The idea may be repeated, but use a different transition)
5. Write five comparison /contrast sentences of fish to hot air balloons while viewing the diagram. (The idea may be repeated, but practice using different transitions)
5 W Questions

1. Q: Who is a close relative to the shark?
   A: 

2. Q: When would a Hammerhead shark drown?
   A: 

3. Q: Where are the Ampullae of Lorenzini located on a shark?
   A: 

4. Q: What do sharks have that no other fish has?
   A: 

5. Q: Why are sharks important in the ecosystem of the ocean?
   A: 

6. Q: How does a shark hunt at night?
   A: 

Shark Biology Listening Exercise

Before any animals existed on land, sharks __________the oceans. They have been around for over 250 million years. Many people think that because they are __________animals, they are in some way primitive.

But as it turns out, sharks are highly evolved sophisticated animals with some amazing ____________for survival!

The fact that sharks have survived for so long demonstrates the incredible effectiveness of their ____________. And let’s face it--250 million years’ worth of ____________has got to count for something!

Over 400 ___________of sharks live in the oceans across many habitats. Some, like the Caribbean Reef shark, live on shallow tropical coral reefs. Others, like the blue shark, are pelagic, living far from land in the ___________ocean. The Greenland shark lives in the ___________waters of the arctic, while the Tiger shark prefers the tropics. Sharks are everywhere, but what are they?

Sharks are fish, but there are ___________key things that differentiate them from other kinds of fish.

Sharks and their close ___________the rays differ from the bony fishes in several ways.
Shark Biology Listening Exercise

First, sharks and rays have a soft flexible ____________ made of cartilage. The cartilaginous skeleton makes the shark more flexible than similarly-sized bony fishes.

Also, sharks and rays have no swim___________.

A bony fish uses an ____________ called a swim bladder to maintain neutral buoyancy, so it can hover like a hot air balloon. The fish adds or removes ____________ from its swim bladder through its bloodstream to increase or decrease its buoyancy.

The shark’s lack of a swim bladder means that, unlike bony fishes, the shark ______________ to sink. To stay off the bottom, sharks have to keep moving.

While the shark uses its tail fin in a back and forth ____________ to provide forward thrust, its pectoral fins work like airplane wings to provide lift. Like an airplane wing, as long as the fins move ____________ through the water, they provide lift to keep the shark up.

Not too long ago, scientists thought all sharks had to swim at all times, not just to stay off the bottom, but to keep water ____________ over their gills. For some species like the hammerhead, this is true. Hammerheads must keep swimming at all times to ____________ water through their gills. Ironically, if they stop swimming they’ll drown.

But many species of sharks sometimes stop swimming and rest on the bottom, ____________ water to ventilate their gills. This is a Lemon shark, common in the Caribbean, taking a break resting on the sand. It gulps water to___________.

Nurse sharks also spend a lot of time ____________ on the bottom.

Bottom-dwelling species of sharks like the Wobbegong actually live their ____________ lives on the bottom. They are ____________ to look like a rock covered in algae, and they hunt by being very ____________ and waiting for an unsuspecting fish to come close.
Activity: Understanding Buoyant Force

**Introduction:** When an object is at rest on a table, the table pushes up on the object with a force equal to the downward force of gravity on the object. **When the same object is in a fluid, the fluid pushes up on the object with a force called buoyancy.**

**Materials:**
- Inflated ball, such as a basketball and a 5 gallon bucket of water

**Procedure:**
1. Place an inflated ball into a 5 gallon bucket filled about two-thirds with water.
2. Slowly push the ball down into the water. **It might take two hands.** Notice that there is an upward force of the water against the ball.
3. Keep pushing the ball SLOWLY deeper into the water. The upward force increases as more of the ball is pushed below the surface of the water. **It's important to note that the water level in the bucket is rising… is there a relationship?**

4. Keep pushing SLOWLY. Once the ball is **totally submerged** the upward force pushing back does not increase and remains constant, no matter how much deeper you push the ball into the water.

**Discussion:**
This upward force that the water exerts on the basketball is called **buoyancy or buoyant force.**

**But where does this force come from?**
It was important to see that as the ball was pushed further into the water the **buoyant force** increased. At the same time more water was being displaced by the ball. Once the ball was completely submerged and no more water was being displaced, the buoyant force stayed the same.

**Conclusion:** Buoyant force is due to the displacement of the water.
Simply put… if you push water out of the way… it pushes back. This push back is the **buoyant force.**

**But why does water push back when it has been displaced?**
If you let go of the ball submerged in the water, the ball goes back to the surface quickly. At the same time the water level in the bucket returns to back to its original level. Gravity pulled the water back into its original position. Thus, when you push a ball into the water, the water pushes back with its weight.

**Conclusion:** Buoyant force is the weight of displaced water.

*The principle of buoyancy was discovered by the Greek scientist Archimedes around 250 B.C.*

*Secondary Unit Lesson 7 - Shark Biology: Student Resources - Page 12*

Learn more at [www.BlueWorldTV.com](http://www.BlueWorldTV.com)!
Follow up:
If the buoyant force on the object is equal to the weight of the fluid the object displaces…

**The weight that an object loses when placed in a liquid is equal to the weight of the liquid that the object displaces.**

*For convenience, let’s use gram force for the measurement of weight.*
- For example, a 25 gram weight is placed in water. When in water the object weighs 15 grams (*it lost 10 g of weight*).
- Water must be pushing back with a force of 10 grams; the buoyant force = 10 grams.
- Since water has a density of 1 g per ml, then the *volume* of the displaced water must be 10 ml, thus the volume of the object is 10 ml.

---

**When an object floats: the buoyant force = the object’s weight**

This means that the weight of the water displaced must equal the weight of the object. If an object weighs 20 g and floats in water, it must displace 20 g of water... or a volume of 20 ml.
If an object sinks: the weight of the object is greater than the buoyant force.

This means that the weight of the object is greater than the weight of the displaced liquid.

- Let’s say we have a 50 ml object that weighs 100 g and sinks to the bottom.
- It can only displace 50 ml of water, which is 50 grams of water.
- Water can only exert a buoyant force of 50 grams on this object.
- Thus the object sinks, but it lost 50 g of weight when submerged.

This last example shows why something more dense than the fluid that it is in will sink in that fluid. This object would have had a density of 2 grams per ml whereas water is 1 g/ml.

**Buoyancy Activity: Floating a Submerged Weight**

In this activity you will calculate the amount of buoyant force needed to lift a sunken weight in an aquarium off the bottom. Then you will put together a float arrangement that can exert that amount of buoyant force. Attach the float to your sunken weight to see if it brings your weight off of the bottom.

**Materials:**

- For floats:
  - Small empty plastic bottles
  - Small pieces of styrofoam, corks, etc.
  - Wire hooks (bent paper clips) for attaching to the sunken weight
- Graduated cylinders, beakers of water, and droppers.
- Teriyaki sticks / skewers for pushing floats into graduated cylinders of water.
- Gram scale or balance. 500 g and 1000 g spring scales.
- At least ten gallon aquarium or 5 gallon bucket filled with water. With an a aquarium you can see the lift of the weight off the bottom; better visual learning.
- Weights. 250 – 1000 grams. (could be anything from lab weights to rocks with a way to hook a float on to it, such as being wrapped with string.)
Buoyancy Activity: Floating a Submerged Weight (cont’d)

Procedure:

Step 1: How to Calculate the Maximum Buoyant Force of a Float.

**Buoyant force is the weight of displaced water.**

Floats work by displacing a lot of water without adding much mass or weight. So they expand volume without adding much mass... thus floats decrease the density of the object to which they are attached.

Think of a life preserver… it increases volume without adding much mass to a person. Thus they displace more water and increase buoyant force without really increasing their weight.

To determine the maximum buoyant force that a float can exert on a weight underwater you need to know two measurements.

1. You need to know the amount of water a float can displace which means that you need to know the volume of the float.
2. You have to take into consideration the weight or mass of the float. This will take away from the maximum buoyant force that a float can have.

So: **Buoyant force = the weight of displaced water minus the weight of the float**

For example:

- A float displaces 100 ml of water... so the weight of the displaced water is 100 grams.
- The mass of this float out of water is 10 grams weighed on a scale.

\[
\text{Buoyant Force} = \text{weight of displaced water} - \text{weight of the float}
\]

\[
\text{Buoyant Force} = 100 \text{ grams} - 10 \text{ grams}
\]

\[
\text{Buoyant Force of the Float} = 90 \text{ grams... which means that it is capable of lifting an object that weighs 90 grams underwater}
\]
Step 2: The weight to be raised.
- Select a weight for this experiment.
- Hang the weight from a spring scale and lower it totally underwater.
- Measure the weight in grams of its weight underwater and record it on the next page in the data section.

- Next, lower the weight to the bottom of an aquarium or a tall bucket.

We will now try to raise the weight off the bottom using an assortment of floats made from small empty plastic bottles, small pieces of styrofoam, corks, etc. Each float will have a wire hook (such as large bent paper clip) for attaching to the sunken weight.

Step 3: Buoyant Force of Floats.

*As explained earlier...*

To determine the buoyant force of a float push it with a stick into a graduated cylinder with water and measure the amount of water it displaces. *Since water is 1 gram for every ml of water... the number of ml displaced water is also the grams of displaced water.*
Next, you must get the weight or mass of the float (with its hook) on a balance or scale and subtract that from the weight of the water displaced by the float.

So....

Maximum Buoyant force of a float = Weight of displaced water - Weight of the float

Record this information in the data table for each float.

DATA TABLE

Weight underwater of the sunken object on the bottom of the aquarium? ________ g

Buoyant Force of Floats that You’re Testing

<table>
<thead>
<tr>
<th>Float</th>
<th>Volume of Displaced water (ml)</th>
<th>Weight of Displaced water (g)</th>
<th>Mass of the Float (g)</th>
<th>Buoyant Force of the float (g)</th>
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Buoyancy Activity: Floating a Submerged Weight (cont’d)

Step 4: Raising the weight off of the bottom.

What is the weight underwater of the sunken object on the bottom of the aquarium? __________ g

How much buoyant force would be needed to lift the weight off the bottom of the aquarium? __________ g

From your data on the floats you have, describe the number and type of floats that you could attach to the sunken object to lift it off the bottom of an aquarium.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

Hook your floats on to your weight and see if you are correct.
Buoyancy Activity: Neutral Buoyancy Challenge

When a fish hovers motionless in the water, it is not sinking or floating. It is neutrally buoyant. For this to happen, the amount of buoyant force must be exactly equal to the underwater weight of the fish.

Bony fish control their buoyancy by increasing or decreasing the amount of water that they displace. This is done by inflating or deflating their swim bladder by exchanging gas with their bloodstream. It’s a very sophisticated system and one that is not present in sharks.

Since the gas molecules are “undissolved” from the bloodstream to inflate the bladder the volume of the bladder and the fish increase without adding any mass to the animal. Thus the fish displaces more water, increasing its buoyancy. The opposite effect happens to reduce their buoyancy and drop to a lower depth. Gases from the bladder are reabsorbed by the blood, lowering the volume of the swim bladder. The fish displaces less water and buoyant force is reduced.

We can repeat the previous activity, but to incorporate the challenge of getting a weight neutrally buoyant. Basically the lift from a float(s) must be exactly equal to the underwater weight of a sunken object.

Getting Neutral Buoyancy (same materials and procedure as previous activity)

1) Underwater weight of sunken object with spring scale: ____________ g

2) The buoyant force needed to be exerted by float(s) for neutral buoyancy = ____________ g*

3) Prepare a float or floats to hook on to your sunken object whose weight of:
   displaced water - weight of the float(s) = buoyant force that you need .

   Total Buoyant Force of the Floats : ____________ g - ____________ g = ____________ g *
   weight of displaced water weight of floats buoyant force of floats

It isn’t easy, but if you’re successful the floats and sunken object will be suspended in the water; not sinking or floating.

NEUTRALLY BUOYANT!

Atlantic salmon fry, photo by Bill Andrake
Add the following parts:
1. Eyelids (what is the other name for these?)
2. Retina
3. Teeth
4. Ampullae of Lorenzini
Compare and Contrast Illustration #1: Shark & Bird
Compare and Contrast Illustration #2: Fish and a hot air balloon