



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Welcome to STEAM FORWARD!

Animals Have Diets, Too!

Career: Nutritionist

Episode: Energetics

Imagine being in charge of feeding an entire town where everyone has different likes and dislikes, a variety of dietary needs and appetites ranging from slightly hungry to ravenous. It sounds like a challenging job. How do you choose, prepare and serve all that food?

It all starts with one person, our nutritionist, Dr. Lisa Hoopes, who works with the zoological operations team to calculate the dietary needs of our animals.

During this episode, hosted by Dr. Meisa Salaita, we will take a deep dive into what we feed the animals, how we feed them and the science behind calculating how much we feed them.

Following Dr. Lisa Hoopes's lead, your students will research, calculate and design a diet for one of our animals! Students are encouraged to think beyond the scope of an aquarium setting to imagine other situations where understanding energetics and nutrition is important.

OBJECTIVES: Why are my students learning this?

At the completion of this mini-unit, your students will be able to:

- Explain the factors that impact an animal's metabolism.
- Compare and contrast five species of animals to identify the factors that influence their diets.
- Calculate the percent of its body weight an animal consumes.
- Evaluate which animals have the highest and lowest metabolic rates based on the data collected.
- Calculate the metabolic rate of a penguin.
- Develop a diet for a penguin that meets its metabolic needs.

THE ESSENTIALS: ASK & ANSWER

- 🐟 How does an organization like Georgia Aquarium design diets that meet the energy needs of its animals?
- 🐟 What factors influence metabolic rates in animals?
- 🐟 Why do animals have different metabolic rates?



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Using STEAM FORWARD

For this project, you will need to print copies of the Student Activity pages. Students will benefit from having calculators and access to the internet for background research, although **internet availability is not necessary**.

Students should work in small groups (2-4) to facilitate collaborative problem solving. Allow students to express their creativity throughout the activities.

To begin STEAM Forward, show your class the video hosted by marine biologist Dr. Meisa Salaita. At the conclusion of the first video segment, groups can work together to complete **Metabolism Mania!**. Then, the class will reassemble to review the answers or watch the next video segment showing how we determine what to feed an animal in **Who's the Biggest Eater?**. The final activity, **Designing Diets!**, is a diet design challenge.

All three written activities can be completed over one or two typical class periods depending on the level of your students. Each activity can be used as a stand-alone lesson or as part of a wider unit.

A variety of classroom extensions, outlined in **Beneath the Waves**, are available for you to use and share. As each STEAM Forward video is interdisciplinary in nature, Georgia Aquarium encourages you to **Splash It Around!** within your grade level teams to collaborate on project-based learning.

Your students will meet Georgia Aquarium experts in a career-focused Q&A called **In the Field**. For your planning needs, national and local **Middle School Curriculum Standards** are listed by activity and content at the end of these Teacher Instructions.

If you would like to share how you implemented STEAM Forward in your classroom, we want to hear about it! Please contact Georgia Aquarium's Education Department at education@georgiaaquarium.org to share your best practices and offer constructive feedback.



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Activity 1 – Metabolism Mania!

Video segment: 00:00–03:30

OBJECTIVES: Why are my students learning this?

At the end of this lesson, students will be able to:

- Explain the factors that impact an animal’s metabolism.
- Compare and contrast five species of animals to identify the factors that influence their diets.

Introduction

Did you know that **warm-blooded** animals use energy to keep their body at a constant temperature and **cold-blooded** animals depend on the surrounding environment to regulate their body temperature? This is why you might observe a turtle or garter snake basking in the sun in your backyard during the winter months! The way an animal regulates its body temperature directly impacts its **metabolism**, or the chemical process for turning food into energy.

What other factors besides being warm or cold blooded do you think might impact an animal’s metabolic rate and, therefore, how much an animal needs to eat? Use the information on the following pages to develop hypotheses about how other factors (environment, growth stage, activity level, gender) influence an animal’s diet!

Answer Key

1. Based on the information gathered above, which animal do you think eats the most food? The least? For what reasons? Write your answer in 3-4 sentences below and be sure to back up your answer with data! Then, discuss with a peer.

Answers will vary. Key points that students should look at in drawing their conclusion:

- What the animals eat.
- The type of habitat they live in.
- The amount of work it takes to find food.

2. Now that you’ve discussed the factors that influence how much an animal eats, select **one** of the factors (environment, growth stage, activity level, gender) and **one** of the animals (African penguin, emerald tree boa, beluga whale, southern sea otter, black blotched fantail ray) you read about to dive deeper into how complex animal diets really are!

I am choosing to investigate how _____ (environment, growth stage, activity level, gender) affects a _____’s (African penguin, emerald tree boa, beluga whale, southern sea otter, black blotched fantail ray) diet.

Answers will vary.





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

3. Based on your selections above, develop a **hypothesis**, or an idea that could be tested for validity using data and/or experimentation.

Answers will vary.

African Penguin:

- ✓ Diet consists of twenty-five species of fish (which make up 42 percent of its diet), eighteen species of crustaceans, three species of squid, and one species of polychaete (worms).
- ✓ A layer of blubber under the skin helps to keep the penguins warm. If they become overheated, blood vessels in the skin fill with blood, bringing heat from within the body to the surface where it is radiated into the air.
- ✓ Featherless patches on face and feet also allow excess heat to escape.
- ✓ The penguin often *porpoises*, plunging in and out of the water, as it swims in order to renew air inside its lungs without interrupting forward progress.
- ✓ Feeds at sea, frequently foraging 9 miles (14.5 km) from its rookery area, and occasionally as far as 60 miles (96.6 km) offshore in search of food.
- ✓ African penguins are found on the southernmost coast of Africa in water that is between 40 to 70 degrees F (5-20 degrees C).
- ✓ Male and female African penguins are the same size standing 18 to 25 inches (46-64 cm) tall and weighs 6 to 7 lbs. (2.7-3.2 kg).
- ✓ Two (sometimes 3 or 4) whitish eggs are laid and incubated for 38-42 days. Both parents sit on the nest and tend to their young, relieving each other daily.
- ✓ After hatching, chicks are fed by the parents for up to 3 months, until they molt their down layer and grow their juvenile feathers. This process is called *fledging*.

Emerald Tree Boa:

- ✓ Occurs in parts of Northern South America from Brazil to Bolivia and Surinam.
- ✓ Found in wet lowland rain forests with heavy precipitation.
- ✓ This boa is an arboreal species that spends most of its life in trees and bushes.
- ✓ Adults generally range from about 4 to 6 feet (122-183 cm) in length.
- ✓ Emerald tree boa is carnivorous and nocturnal. Its diet consists of arboreal rodents, squirrels, monkeys, lizards and bats. It will also consume birds.
- ✓ Emerald tree boa is an ambush predator, meaning it sits and waits for its prey. It spends the day coiled into a ball on top of a horizontal branch with its head poking out of the center of the coil. At night, it extends its neck and head downward, waiting for a prey animal to move within range below. It strikes quickly, grasping and holding the prey with its long, curved teeth and then drawing it up to its body. The boa then suffocates its prey by constriction.
- ✓ In its natural habitat, it may go as long as two months between meals.
- ✓ This boa is ovoviviparous with the female giving birth to 10 to 12 young at a time. The gestation period is 6 to 7 months. The young are about one foot (30 cm) long at birth and weigh about 1.5 ounces (43 grams). Females do not provide care after birth.





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Beluga Whale

- ✓ Belugas can be found in a wide variety of environments in the Arctic and some subarctic waters, from deep offshore waters to shallow bays and estuaries; even ranging far upriver.
- ✓ Very thick layer of blubber, thick skin, relatively small tail flukes and pectoral flippers, and absence of a dorsal fin are adaptations for life in cold water.
- ✓ Average weight and length of an adult ranges between 1100-2500 lbs. (499-1143 kg) and 11-15 feet (3.4-4.6 m).
- ✓ Average calf birth weight is 119-145 lbs. (54-66 kg) and length is 4.5-5.1 feet (137-155 cm).
- ✓ Belugas show sexual dimorphism, with males being approximately 25% larger than females.
- ✓ They are opportunistic feeders, and will consume over 100 species of marine and freshwater fish, mollusks, crustaceans, and zooplankton.
- ✓ Belugas can hunt cooperatively to conserve energy.
- ✓ Gestation period of 15-16 months and nurse calves until the age of approximately two years.
- ✓ Most dives range between 9-18 minutes with feeding dives last 18-20 minutes.

Southern Sea Otter

- ✓ Southern sea otters are found along the central California coast. They are frequently associated with kelp forests. They rarely venture onto land.
- ✓ Adult southern sea otters are approximately 4 feet (1.2 m) in length. Adult males average 65 lbs. (29.5 kg) and adult females average 45 lbs. (20 kg) in weight. A newborn southern sea otter pup is 22 to 24 inches (55-60 cm) in length and 4 to 5 lbs. (1.8-2.3 kg).
- ✓ The sea otter's body is covered in a dense fur that constantly must be groomed to maintain its insulating properties and cleanliness; therefore, a sea otter will spend up to 10% of its time grooming. The sea otter's fur also is designed to trap air to further insulate it from the cold water and to provide additional buoyancy.
- ✓ The southern sea otter consumes many types of prey including sea urchins, snails, clams, abalone, mussels, crabs, scallops, fish, barnacles, octopus, worms and squid, which it captures with its clawed paws, not its jaws.
- ✓ The southern sea otter has a high metabolic rate that is about 2.5 times greater than that of terrestrial animals. The hind feet and front paws lose the most heat because fur is sparse or absent, so the sea otter often can be seen holding them out of water to conserve body heat while it floats on its back at the surface.
- ✓ The female sea otter is pregnant for four-and-a-half months. The pup is nursed by its mother for 6 months to a year.





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Black Blotched Fantail Ray

- ✓ The black blotched fantail ray occurs in the Indo-West Pacific from the Red Sea and East Africa to Southern Japan, Micronesia and tropical Australia. It is usually associated with reefs and occurs in a wide variety of habitats from shallow lagoons to outer reef slopes.
- ✓ Feeds on bottom fishes, bivalves, crabs and shrimp. To find prey, this ray often excavates large holes into the sand by blowing water from its mouth.
- ✓ Its length from snout to tail can reach almost 11 feet (330 cm). Disc widths of about 10 feet (3 m) and weights of 330 lbs. (150 kg) have been reported.
- ✓ This ray is ovoviviparous meaning pups hatch from eggs carried inside of the female; therefore, they are born alive. Each pup is about 13 inches (33 cm) in disc width.
- ✓ This ray is considered bottom dwelling, often resting on coral reefs or sandy bottoms for extended periods of time.





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Activity 2 – Who’s The Biggest Eater?

Video segment: 03:32-04:42

OBJECTIVES: Why are my students learning this?

At the end of this lesson, students will be able to:

- Calculate the percent of its body weight an animal consumes.
- Evaluate which animals have the highest and lowest metabolic rates based on the data collected.

Introduction

Now let’s test your hypothesis about which factors affect the amount of food an animal needs to eat! First, calculate the percentage of the animal’s body weight consumed per day, based on the information provided in the table.

How do I calculate % body weight consumed per day?

Step 1: Calculate the ratio of how many pounds of food per day an animal eats compared to its body weight:

Weight of food per day / animal weight = ratio of food consumption to body weight

For example: whale shark = 40 lbs. of food eaten per day / 2,000 lbs. = .02

**Note:* Experts in the research community estimate that whale sharks can weigh in excess of 2,000 pounds. The 2,000 pound number is approximate based on that data and does not reflect a specific whale shark at Georgia Aquarium.

Step 2: Multiply that figure by 100 to calculate a percentage!

Ratio of food consumption to body weight x 100 = percent of body weight consumed daily = 2%

The higher the percentage of body weight consumed per day, the higher an animal’s energetic requirements!

One more thing: our nutritionist Dr. Lisa Hoopes calculates her numbers on the **metric system**, which is an internationally agreed decimal system of measurement. Don’t forget to pay attention to whether or not you’re working with grams or kilograms – when making the calculations, your units of measurement need to be the same!

Hint:

1 grams (g) is equal to 0.001 kilograms (kg)

The animal weight in kilograms (kg) is equal to the weight in grams (g) divided by 1,000





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Answer Key

Animal	Animal Weight	Food/Day (grams)	% Body Weight Consumed Per Day	Warm / Cold Blooded?	Natural Habitat	Activity Level
Adult African Penguin	3.2 kg	350 g/day	10.9% BW/day	Warm	Coastal areas of South Africa and Namibia	High
African Penguin Chick (2-3 days old, hand-reared)	100 g (0.1 kg)	60 g/day	60% BW/day	Warm	Coastal areas of South Africa and Namibia	High
Adult Emerald Tree Boa	1 kg	2.5 g/day	0.25% BW/day* (7.5% BW/month)	Cold	Tropical rainforests of South America	Low
Juvenile Emerald Tree Boa	50 g (0.05 kg)	0.6 g/day	1.2% BW/day* (36% BW/month)	Cold	Tropical rainforests of South America	Low
Adult Male Beluga Whale	1000 kg	30 kg/day	3% BW/day	Warm	Arctic and sub Arctic oceans	High
Adult Female Beluga Whale	700 kg	21 kg/day	3% BW/day	Warm	Arctic and sub Arctic oceans	High
Newborn Beluga Whale	80 kg	5 kg/day	6.25% BW/day	Warm	Arctic and sub Arctic oceans	High
Adult Male Southern Sea Otter	30 kg	6 kg/day	20% BW/day	Warm	Central California coast	High
Adult Female Southern Sea Otter	22 kg	4.4 kg/day	20% BW/day	Warm	Central California coast	High
Juvenile Southern Sea Otter (3-4 mo old)	12 kg	3 kg/day	25% BW/day	Warm	Central California coast	High
Adult Black Blotched Fantail Ray	200 kg	1.5 kg/day	0.75% BW/day** (5.25% BW/week)	Cold	Indo-Pacific region near reefs and lagoons	Low
Juvenile Black Blotched Fantail Ray	6 kg	102 g/day (0.102 kg/day)	1.7% BW/day ** (12% BW/week)	Cold	Indo-Pacific region near reefs and lagoons	Low

* This is a bit misleading since this animal does not eat every day. In order to compare with the other species on the list for this activity, the food intake is expressed as 2.5g/day when, in reality, an adult would consume a 75g mouse, once per month. $75g/30 \text{ days} = 2.5 \text{ g/day}$. Similarly, a juvenile Emerald Tree Boa would consume a 6 g pinkie mouse every 10 days. So 3 pinkie mice per month, or $18g/30 \text{ days} = 0.6 \text{ g/day}$.

** Black blotched fantail rays are usually fed 3 times per week. So $4.5 \text{ kg per week} / 3 \text{ days}$ is 1.5 kg/day.

- Next, use your researching skills to determine each animal's native habitat and whether they are warm-blooded or cold blooded. Take notes in the table above. *Remember:* using .edu and .gov sites are always best!

Answers should be added to the table above.



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

2. Graph the results for percentage of body weight consumed using the graph paper on the following page. Select the best type of graph (pie, bar, or line) to represent the data points you calculated for percentage of body weight consumed each day.
- Why did you select this type of graph?
Answers will vary; make sure that students justify their answer with type of data, audience, and purpose
 - Based on your graph, which animal needs the highest percentage of food? For what reasons?
Southern sea otters require a higher percentage of food than any other animals including beluga whales due to the sea otter's lack of blubber. Belugas have a nice layer of blubber that helps them maintain their body heat in their cold environment. Sea otters lack this blubber layer and instead rely on fur, which must be constantly groomed. Their MR (metabolic rate) is the highest of the marine mammals!
 - Based on your graph, which animal needs the lowest percentage of food? For what reasons?
The emerald tree boa needs the lowest percentage of food. This type of boa is an ambush predator meaning it sits and waits to attack its food, so the amount of energy needed to capture prey is low. It is also nocturnal and hunts at night in the tropical rainforests, so it does not need a mechanism to help it stay cool.

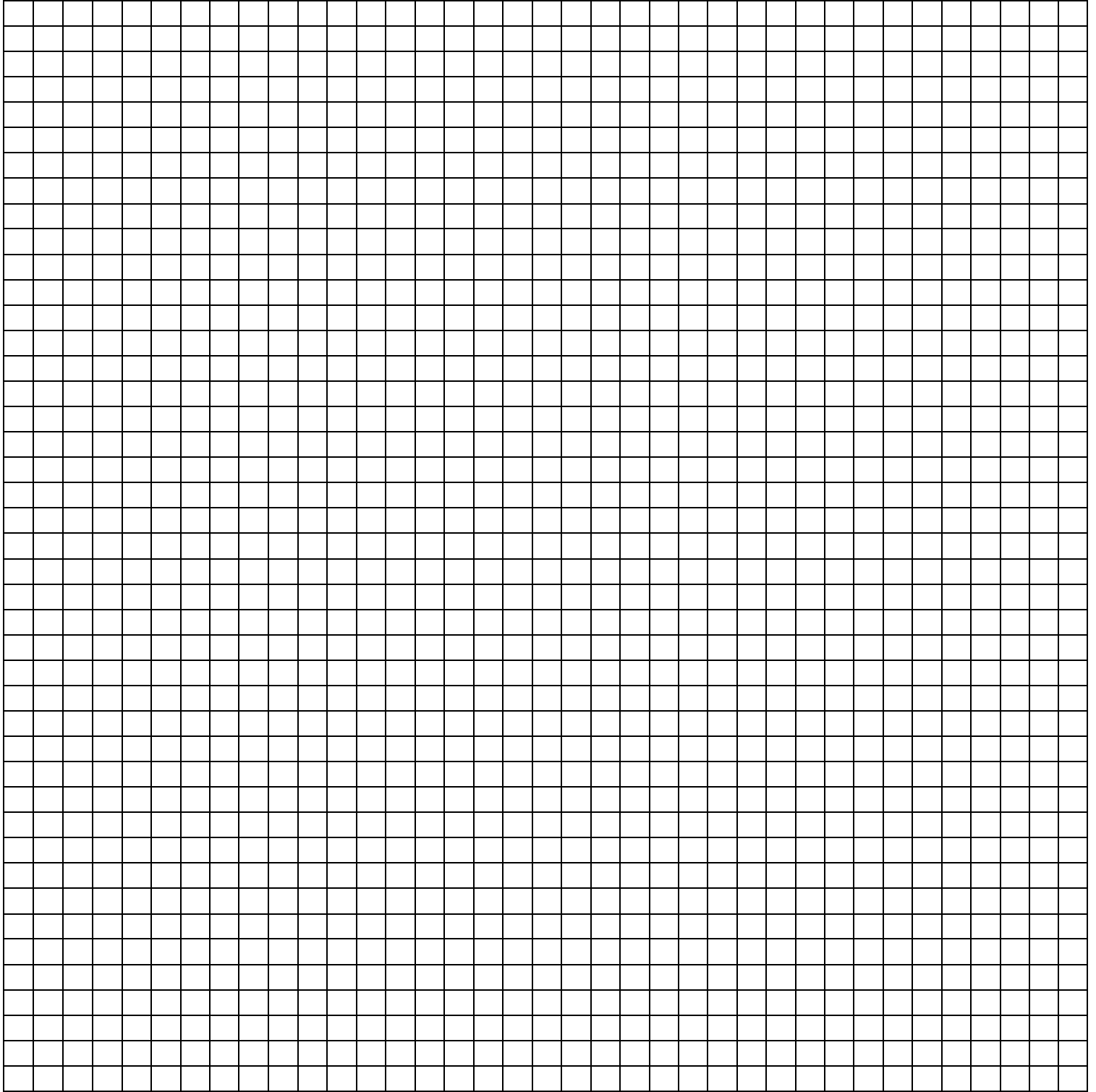




GEORGIA AQUARIUM

STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Activity 3 – Designing Diets!

Video Segment: 04:46-05:36

OBJECTIVES: Why are my students learning this?

At the end of this design challenge, students will be able to:

- Calculate the metabolic rate of an African penguin.
- Develop a diet for an African penguin that meets its metabolic needs.

Introduction:

Now it’s time for your students to design a diet of their own based on what they have learned! They are taking on the role of a nutritionist, just like Dr. Lisa Hoopes. They have a new adult female African penguin arriving at the Aquarium and need to calculate a daily diet for this bird. She weighs 2.5 kg. Scientific studies measuring oxygen consumption in a variety of bird species have determined the number of kilocalories that birds must eat on a daily basis to maintain their weight while at rest. Using that formula, we can calculate our new penguin’s metabolic rate and how much food she will need.

Resting metabolic rate (kilocalories/day) = $78 (BW^{0.75})$ where BW is the body weight of the bird in kg.

ANSWER KEY:

1. Calculate the number of kilocalories/day this bird requires while at rest.

$78 (2.5^{0.75}) = 155 \text{ kcals/day}$

2. This value is the amount of kilocalories the bird requires per day at rest. However, these are active birds! Scientists have found that African penguins have an activity level 1.5 times that above rest. Knowing this, how many kilocalories/day are required for an active African penguin?

$155 \text{ kcal/day} \times 1.5 = 232.5 \text{ kcal/day}$

3. Now that you know how many kilocalories this bird requires, let’s create a diet. African penguins at Georgia Aquarium are fed equal amounts of capelin, pacific herring, and silverside . Using the information provided below, how much of each species should you feed to this African penguin to meet her metabolic requirements?

Fish Species	Energy Value of Fish
Capelin	0.98 kcal/g
Pacific Herring	2.10 kcal/g
Silversides	1.50 kcal/g





GEORGIA AQUARIUM

STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

There are different ways to get this answer, but essentially $\frac{1}{3}$ of the 232.5 kcal/day needs to come from each species of fish. That is 77.5 kcal ($\frac{232.5}{3}$). For capelin, you would feed 79.1 grams (77.5 kcal/day divided by 0.98 kcal/g = 79.1 grams/day). For herring, you would feed 36.9 grams/day and for silversides, you would feed 51.7 grams/day.

- Circle back to your investigation statement in Activity 1. What did you learn about the animal you selected and what factors might influence its metabolic rate? Did anything surprise you? Write your answer in 3-4 sentences below.

Answers will vary.











STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Beneath the Waves: Classroom Extensions

-  Have students calculate their own metabolic requirements by using the same factors we did for our animals, and researching the government-approved guidelines for making healthy food choices.
-  Teach students that food is the equivalent of energy, and that calories are a unit for measuring that energy. You can also dive deeper by introducing Joules, which are used to measure the expenditure of energy.

Splash It Around! Use these inquiry-based interdisciplinary activities and project ideas to incorporate our video series into additional classes and content areas.

-  Environmental Science
 - Have students research other animals at Georgia Aquarium. What role does this organism play in its natural environment (predator, herbivore, producer, decomposer)? Based on the information found, what do you think its metabolic rate would be?
 - Calculate your own personal metabolic rate. What are some factors that increase and decrease your metabolic rate?
-  Language Arts
 - Revisit the Essential Questions for this episode. Have students write their answers in paragraph form and then discuss their responses in pairs or as a group.
-  Economics
 - How much does it cost to feed the animals at Georgia Aquarium? Using the diet for the African penguin in activity 3, research how much it costs to purchase enough fish for 30 penguins.
-  Art
 - Have students collect any packaging that comes with their food for one-two weeks, and then create a display of the animal they selected in the activities. Ask students how what they eat compares to what their selected animal eats. How might these packaging materials be detrimental to the animal you created if it were in its natural environment?



STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

In The Field

What better way to bring STEAM FORWARD alive for your students than to introduce them to experts at Georgia Aquarium? Here, they will learn more about the background and experience it takes to be a member of the STEAM TEAM. Let's get up close and personal!

MEET AN EXPERT

Meet: **DR. LISA HOOPEES, Nutritionist**
Texas A&M University
Major: **Wildlife and Fisheries Science**

What is the most exciting part of your job at Georgia Aquarium?

The most exciting part of my job is the challenge of maintaining the nutritional health of thousands of different species, from the smallest urchins to the largest of whale sharks.

What advice do you have for students interested in doing what you do?

Read, explore and volunteer! Follow your passion. From the academic end, stay strong in math, chemistry and science as they will have direct application to day-to-day operations in an aquarium.

What is something surprising or unexpected about your career path?

I had planned to stay in a university setting and become a research professor, but a twist of fate and a job at a major zoological institution changed my mind. Afterwards, I applied and accepted the job at Georgia Aquarium. I have the best of both worlds in that I get to help care for a unique collection of animals at the Aquarium, and I get to continue to follow my research interests. I am currently working on research projects across the globe regarding a variety of aquatic species.

What do you say to students who ask "Why am I learning this?"

To understand how the world around you works and provide you with some insight and possible inspiration on a career in science. Very little is known about the nutritional requirements of many of these aquatic species in their natural environments. You could be the next scientist to help discover these unknowns!





STEAM FORWARD – EPISODE 10

Energetics and Nutrition [Teacher Version]

Curriculum Standards Grades 6-8

We know how important it is to be able to document how you spend instructional time in your classroom. To that end, the activities in our STEAM FORWARD curriculum are directly connected to the Georgia Performance Standards and the Georgia Standards of Excellence, along with the Common Core State Standards for Mathematics and English Language Arts and the Next Generation Science Standards. To assist with your planning needs, these correlations are organized by activity and content. In the charts below, you can readily see how they fit into your required curriculum. Dive right in!

Georgia Performance Standards for Science	<p>S6/7/8CS3. Students will use computation and estimation skills necessary for analyzing data and following scientific explanations.</p> <p>S6/7/8CS6. Students will communicate scientific ideas and activities clearly.</p> <p>S7L2. Students will describe the structure and function of cells, tissues, organs, and organ systems.</p>
Georgia Standards of Excellence for Mathematics and Language Arts	<p>ELAGSEL6-8RST7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).</p> <p>ELAGSE8SL4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.</p> <p>MGSE6.NS.1. Interpret and compute quotients of fractions, and solve real-world problems involving division of fractions by fractions</p> <p>MGSE6.RP.3. Use ratio reasoning to solve real-world and mathematical problems utilizing strategies such as tables of equivalent ratios, tape diagrams, double number line diagram, and/or equations</p>
Common Core State Standards for Mathematics and Language Arts	<p>RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed through visuals (model, graph, diagram).</p> <p>SL.8.4: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence and sound valid reasoning.</p> <p>MP.2: Reason abstractly and quantitatively.</p>
Next Generation Science Standards	<p>MS.PS.3.1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.</p>

