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Aquarium 101

Teachers' Guide

Grades 9-12

Program Description: How does the world's largest aquarium operate? Through an exploration of the aquarium's exhibits and behind the scene areas, students will be exposed to aquarium related careers, research efforts, conservation programs and how the aquarium meets the diverse needs of our animals.

Enduring Understandings for Aquarium 101:

- Aquariums are facilities that replicate the natural environment through a variety of processes for resident flora and fauna.
- Aquariums are responsible for maintaining animal health, educating public on environmental issues, and promoting conservation of aquatic biodiversity.
- It takes a team of people doing a variety of jobs to fulfill the vision and mission of the Georgia Aquarium.

Objectives:

Students will;

- Have a basic understanding of some of the career opportunities available in aquariums.
- Recognize how the filtration system of an aquarium is an artificial model of processes that occur in the natural environment.
- Explore some functions of the water quality and diagnostic laboratories at the Georgia Aquarium.
- Recognize how research can improve our knowledge and understanding of animals in and outside the Aquarium.

Georgia Performance Standards

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

b. Recognize that different explanations often can be given for the same evidence.

SCSh6. Students will communicate scientific investigations and information clearly.

d. Participate in group discussions of scientific investigations and current scientific issues.

SB4: Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.

d. Assess and explain human activities that influence and modify the environment such as global warming, population growth, pesticide use, and water and power consumption.
f. Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions.

SZ5 Students will evaluate the relationships between humans and other animals.

c. Explain how humans can preserve animal diversity in captive environments with regard to habitat creation, research, animal enrichment, diet, medical, and captive breeding programs.

SEV5: Students will recognize that human beings are part of the global ecosystem and will evaluate the effects of human activities and technology on ecosystems.

e. Describe the effects and potential implications of pollution and resource depletion on the environment on the local and global levels (e.g. air and water pollution, solid waste disposal, depletion of the stratospheric ozone, global warming, and land uses).

Before coming to the aquarium, the student should:

- Understand the importance of biodiversity.
- Understand the basic needs and homeostatic requirements of aquatic animals.
- Understand the concepts and importance of scientific inquiry, research and conservation.

Activities:

1. **Something's Fishy -** Students will study some of the common diseases affecting aquarium fishes, and recognize the complexity of diagnosing and treating fish diseases.
2. **Beluga Cuisine** - Students will examine the challenges involved in providing an appropriate, cost-effective diet for marine animals in an aquarium setting.

Something's Fishy

Grade: 9th – 12th grade

Objective: Students will study some of the common diseases affecting aquarium fishes, and recognize the complexity of diagnosing and treating fish diseases.

Duration: 45 minutes

Vocabulary: bacteria, protozoan, nematode, crustacean, antibiotic, systemic infection, nitrification

Materials: A single copy of each problem card
A single copy of each solution card
Copies of "Table of Common Aquarium Treatments and Their Properties" for each student
Copies of "Common Fish Diseases" for each student

Background:

Fish diseases can be caused by a number of factors which generally fall under three categories: biological, chemical, and physical. Many common diseases, such as "ich" or white spot disease, finrot, and fish lice have biological causes. Biological fish pathogens can include bacteria, protozoans, fungus, worms, flukes and crustaceans. The chemical environment of each fish is extremely important, as most fish are adapted to live within a narrow range of salinity, water hardness, pH, and temperature parameters. Fish are constantly excreting wastes, which can also quickly build up in a closed ecosystem and become toxic to the fish. Physical causes of disease may include poor handling or fighting. If fish are not handled properly during shipping or removal from an aquarium, their sensitive mucus covering can easily be damaged.

Diseases in fish are often caused by multiple factors. Many potential fish pathogens are actually a natural part of the environment. When a fish becomes stressed, this opens the door for these pathogens to attack. For example, a fish that becomes stressed by a sudden change in water quality may become susceptible to illnesses caused by a small population of protozoans normally present. Or, an injury caused by rough handling or fighting may become secondarily infected with bacteria. Thus, disease often occurs as a result of several factors.

It is important to note that disease in aquarium fish is rare when husbandry is good and management of the aquarium is of a high-quality. Disease usually occurs when there is poor control of water quality or overcrowding. Introduction of diseases may also occur with newly imported fish or plants. Fish that are contained in a stable, low-stress environment are much less likely to become diseased.

Procedure:

1. Review Common Fish Diseases attachment with class.

2. Divide the class into ten groups of 2-3 students and give each group a disease problem card.

3. Give each student a copy of the Table of Common Aquarium Treatments and Their Properties documents.

4. Have the students work in groups to answer the following questions. Students should use the disease descriptions and their knowledge from the Georgia Aquarium to help them. Books or Internet may also be used if available.
    a. Diagnose your fish according the given description. What is the problem?
    b. What was the original source or cause of the problem?
    c. How might you confirm your diagnosis if you had access to an aquatic veterinary lab?
    d. What treatment would you use to cure them problem? Consider feasibility, cost, and extent of the problem. Will you quarantine the affected fish or treat the aquarium as a whole?

5. Have students present their results orally to the class or in a written format handed in to the teacher.

Extension

The teacher may want students to do further research on the disease or condition, its transmission and treatment. Students may present the life cycles of parasitic diseases.

Assessment:

- Check that students correctly diagnosed their fish.
- Check that students used an appropriate treatment according to their diagnosis.

Resources:

Andrews, Dr. Chris, Arian Exell and Dr. Neville Carrington. 2003. The Manual of Fish Health. Morris Plains, NJ: Tetra Press.

Untergasser, Dieter. 1989. Handbook of Fish Diseases. Neptune City, NJ: T.F.H. Publications, Inc.

Gratzek, Dr. John B., 1992. Aquariology: The Science of Fish Health Management. Morris Plains, NJ: Tetra Press.

Common Fish Diseases

Fungus (*Saprolegnia spp.*)
This disease is usually seen in freshwater species. Fungal growth is most often a secondary infection that occurs after another health problem has affected the fish. Fish normally produce a mucus layer that covers the skin. If this layer is damaged, it may provide the opportunity for fungus to attack.

Symptoms:

- Tufts of dirty, cotton-like growth on the skin
- If left untreated, may cover entire body

Slime Diseases *(Chilodinella spp.)*
This is a protozoan parasite that causes the fish to overproduce skin mucus. Eventually, the protozoan may also attack the gills. The condition occurs in fish that are in poor condition and may affect coldwater fish in spring when temperatures are rising.

Symptoms:

- Dulling of colors due to mucus over-production
- Weakness
- Swollen gills and rapid gill movements

Hemorrhagic Septicemia (*Aeromonas, Pseudomonas and Vibrio spp.*)
The bacteria responsible for this disease are common in the aquarium as latent infections in otherwise healthy fish, and outbreaks occur only in fish which are in poor condition. Bacteria enter the bloodstream and circulate through the tissue, causing inflammation and damage. Diseased fish release pathogenic bacteria into the water, which in turn affect other fish.

Symptoms:

- Reddening at the bases of the fins
- Small hemorrhages around the eyes
- Lesions, ulcers or sores on the body
- Very dull, listless behavior
- Lack of appetite

Gill Flukes *(Dactylogyrus spp.)*
These tiny, worm-like flukes are barely visible to the naked eye. They infect the fish's gill membranes. The condition occurs often in newly imported fish or in established tanks which are poorly maintained. Also, carrying out water changes with unconditioned tap water may irritate the delicate gill membranes and make them more susceptible to infections.

Symptoms:

- Rapid gill movement
- Fish gasps at the water's surface
- The gills are covered in mucus, and parts are eaten away
- The fish may scrape itself against objects

Physical Damage (from rough handling or fighting)
Physical damage may be the result of fighting, poor handling, or other infections. Damaged fish may become listless and hide in secluded areas. If left untreated, wounds may become infected with other parasites.

Symptoms:

- Missing scales or split or ragged fins
- Damage to the body or mouth

Finrot (*Aeromonas spp., Pseudomonas spp.*)
Fishes with long, trailing fins are most susceptible to this bacterial disease. Usually the condition is caused by poor hygiene in the aquarium or other factors such as fin-nipping or vitamin deficiencies.

Symptoms:

- Short or ragged fins
- Fins clamped against the body

Fish Louse (*Argulus spp.*)
This is a small crustacean that looks somewhat like a crab. The parasite moves from host to host, anchoring itself with strong suckers. Once attached, the louse inserts its sharp mouthparts into the body of the fish to feed on its blood. Lesions may develop at the point of attachment and secondary bacterial infections may take hold.

Symptoms:

- Fish scrapes itself against objects
- Small parasites are visible (up to ¼ inch)

Worms in the Intestine (Cestode and nematode worms)
Obvious symptoms of this disease are often unnoticeable. The parasites are most common in wild-caught and newly imported fish. In heavy infestations, the fish may appear thin or grossly distended.

Symptoms:

- Fish may appear very thin or distended

"Ich" (*Ichthyophthirius multifiliis*)
This small ciliate protozoan parasite is extremely common in freshwater aquariums. The parasites are just visible to the naked eye as small white spots (up to 1mm) on the fish's skin.

Symptoms:

- The fish's skins and fins are covered in tiny white spots
- A badly affected fish may make rapid gill movements
- Heavily affected fish look like they have been sprinkled with salt grains

Water Quality Problems (pH, ammonia, temperature abnormalities)
Water quality problems can cause fish to exhibit abnormal behavior and, in severe cases, can cause death. Usually all the fish in the tank will exhibit unusual behavior suddenly.

Symptoms:

- Peculiar swimming behavior
- Rapid gill movements
- Gaping at the water's surface
- Cloudy eyes

Table of Common Aquarium Treatments and Their Properties

Chemical	Dosage	To Treat	Effect of N cycle
Copper	0.2 mg / liter	Skin and gill protozoans, flukes	Known to affect cycle in saltwater.
Malachite green	0.1 mg / liter	External protozoans and fungus	May affect nitrogen cycle in freshwater.
Metriphonate	0.3 mg/ liter	Skin and gill flukes, leeches	None.
Potassium permanganate	10 mg/ liter	Parasitic crustaceans	Compound is easily deactivated by organic matter.
Salt	1 gm / liter	Preventative treatment for freshwater fish with physical damage	No effect in low concentrations.
Methylene blue	2 mg/liter	External protozoans	Can cause severe and prolonged interruption in fresh and salt water.
Nifurpirinol	0.2 mg/liter	External bacterial infections	No effect in freshwater; may affect nitrification in saltwater.
Oxytetracycline	10 mg per 1 kg fish (injection)	Systemic bacterial infections	Known to affect nitrogen cycle in freshwater.
Chlorotetracycline	10 mg/ liter	Systemic bacterial infections	Known to affect nitrogen cycle in freshwater.
Mebendazole	25 mg/ kg fish (with feed)	Intestinal tapeworms	No effect on nitrogen cycle; administered with feed.

PROBLEM CARDS

Problem 1: At home you have a 30-gallon tropical aquarium with 15 cichlids of different species. You go on vacation for a week and so you buy a feed timer that will release the correct amount of food for your cichlids while you are gone. When you come back, the fish seem to be fine and the feeder has been functioning properly. Upon closer inspection of your fish, you discover that about five of the cichlids are covered with some tiny white spots.

Problem 2: You have a 20-gallon goldfish aquarium and you are trying to build your stock of goldfish. Recently you bought a fancy goldfish from a pet store. There were a few dead goldfish in the tank from which your fancy goldfish came, but your goldfish looked perfectly healthy. You keep it quarantined for a week at home. After one week it looks perfectly healthy, and so you introduce it to your 20-gallon tank with your seven other goldfish. After a few days, you notice its behavior change. It stops swimming around actively and becomes listless. You don't notice any other symptoms, except that the bases of its fins are reddish.

Problem 3: You are starting a new 20-gallon freshwater tetra tank and have just added five new fish. You have been carefully monitoring ammonia levels on a daily basis. Two days after adding the new fish, you notice a dramatic spike in ammonia levels. You quickly take out over half the water in the tank and replace it with new water. Because you were not expecting the spike in ammonia, you don't have any conditioned water available and have to use water directly from the tap. About a week later, you notice a few of the new tetras are breathing rapidly and gasping at the surface.

Problem 4: You have a koi pond in your backyard. The winter temperatures are warm enough and your fish are hardy enough that you do not need to heat the water in the pond. One day you notice that a few of your koi are behaving differently. Their colors seem to be duller and they are not as active as usual.

Problem 5: One day you notice one of your tropical freshwater fish exhibiting strange behavior. It is frequently darting across the bottom of the aquarium on its side and rubbing itself on the gravel. A few days later, you notice a small brown spot on one of the gill covers. After a few days the spot becomes bigger and more visible.

Problem 6: You have an aquarium of fancy veiltail goldfishes and you would like to breed them. They are excellent specimens with long, well-developed fins and you would like to produce some offspring with similar qualities. You set up a special breeding tank and put in the pair of fish. During the mating process, the male veiltail goldfish chases the female around the tank and her fins get somewhat damaged and torn apart. You put both fish back into the aquarium. After a few days, you notice the female veiltail has become a bit less active and that her fins have a whitish edge to them where they were damaged.

Problem 7: You are cleaning your 50-gallon tropical freshwater aquarium. One of the gouramis jumps out of the tank and lands on the carpet. Even worse, you can't find a net to pick it up and so you have to grab it with your hands and throw it back in. It survives, but three days later you notice a whitish tuft growing on the side of the gourami's body.

Problem 8: You started a new coral reef tank about three weeks ago, and you are gradually adding new fish. Last week you added a few yellow tangs to the aquarium. You wake up this morning and turn on the light in the aquarium, and notice that all of the fish, including the tangs, are gasping at the water's surface.

Problem 9: You have an established freshwater aquarium and you decide that you'd like to stock it with some local fish. You go to the stream near your house and carefully collect some darters to add to your aquarium. After a week, you notice that the new fish are looking weak and thin, although they are still eating normally.

Problem 10: You have a well-established 20-gallon coral reef aquarium with some anemonefishes and a damselfish. Last week you bought another damselfish, and you quarantine it for a week. After one week it appears to have no problems, and you introduce it to your aquarium. The next day you find that the new damselfish is missing some scales and that some of its fins are ragged and torn.

SOLUTION CARDS

Answer 1: Your fish are most likely affected with "Ich," or White Spot Disease. This is a common protozoan in all aquariums. While you were gone, the temperature of the aquarium may have fluctuated or a filter may have malfunctioned, and the fish may have become stressed enough to allow a few of the parasites to attack. One very effective remedy against "Ich" is methylene blue. However, this chemical causes severe disruption of the nitrogen cycle. If a few fish are severely affected, it would be best to take them out of the aquarium and treat them separately in a hospital tank. In your case, five of the fifteen cichlids are infected, but you might expect an outbreak in the entire aquarium. In this case it is probably best to treat the entire aquarium with copper, a treatment that has little effect on the nitrogen cycle.

Answer 2: The reddening at the bases of the fins is a sign of hemorrhagic septicemia. This is a serious bacterial disease. The bacteria are usually in low levels in an aquarium, but do not become a problem unless the fish are in poor condition and are stressed. You might assume that your new goldfish was already infested with the disease in the pet store, where there were other dead fish in the tank. After being put through the stress of moving and introduction to the new aquarium, your new fish may have undergone enough stress that its immune system was compromised and bacteria were given the opportunity to attack.

Diseased fish will rapidly release pathogenic bacteria in the water which will soon attack other healthy fish. Your course of treatment should be to immediately remove the sick fish from the aquarium and treat it with an antibiotic such as chlorotetracycline. You may want to give the healthy goldfish preventative treatment as well. However, beware that the antibiotic will affect the nitrogen cycle and so you will want to check ammonia and nitrite levels every day during treatment. Injection of oxytetracycline will be too difficult and expensive for a small goldfish. However, if the fish was very costly and is very sick, injection may be the best choice.

Answer 3: It sounds like your new fish are infested with gill flukes. The gills may have been damaged by chlorine and other chemicals when you added such a great quantity of tap water to the aquarium. This may have made the gills more susceptible to infection by flukes. Your best option for treatment here would probably be metriphonate. You can treat all the fish together in the 20-gallon aquarium because the treatment has no effect on the nitrogen cycle. If fishes are badly affected it may be wise to separate them so that others don't pick on them and stress them further. Make sure that the tank is well oxygenated and that ammonia levels are carefully monitored.

Answer 4: The temperature fluctuations in your unheated pond may have left an opportunity for slime disease-causing protozoans to attack. The protozoans cause the fish to over-produce skin mucus, and they may eventually attack the gills. Prompt treatment is necessary. If only a few select fish are affected, it may be best to take them out and isolate them, as treating the entire pond will be costly because of its size. Copper, malachite green and methylene blue may be used to treat external protozoans.

Answer 5: Your fish probably has a fish louse. This parasite is a rapidly growing crustacean. Eventually, the parasite would reach as size of up to ¼ inch, and the eyes and feathery legs would become visible. This parasite is not usually a great threat, but it is important to remove it before it leaves the host and lays eggs, which would hatch and cause a larger scale infestation.

Parasitic crustaceans can be removed manually if they are large enough to pick off with small tweezers. Adding potassium permanganate to the water will eventually kill the parasite and cause it to fall off. This treatment is best completed in a separate hospital tank, as the chemical is easily deactivated by organic matter. It must also be kept in mind that the site of attachment may become infected secondarily with bacteria or fungus. Affected fish should be closely monitored.

Answer 6: The female has likely contracted a case of bacterial finrot, which was given the opportunity to develop after the fins were damaged. Normally finrot does not develop in health fish, so you should also check to be sure that there are no water quality problems in the aquarium as well. The bacterial infection may be treated with nifurpirinol. This chemical will not affect the nitrogen cycle and may be put directly in the aquarium. However, since the finrot is an isolated infection, it may be better to remove the infected fish and treat it in a quarantine tank so that it does not become stressed.

Answer 7: The gourami was probably damaged when it jumped out of the tank. In addition, handling the fish with bare hands often damages the mucus covering over the fish's skin. The damaged mucus layer has given the opportunity for a fungal infection to take hold. The infection can be treated with malachite green, but this chemical will interrupt the nitrogen cycle. It is best to take the fish out and treat it in a separate quarantine tank.

Answer 8: Because the condition occurred very rapidly (overnight) and affects all of the fish in the aquarium, this is obviously a water quality problem. The most likely explanation is that the nitrogen cycle has not yet been established, and either ammonia or nitrite levels have become high enough to be toxic to the fish, causing them to gasp for air at the water's surface. If this problem is left untreated, it will quickly kill the fish.

At least one quarter to half of the water in the tank should be removed and replaced with conditioned saltwater, in order to reduce the concentration of the toxins. Ammonia and nitrite levels should be monitored daily and fish may need to be removed from the tank as the nitrogen cycle is still being established.

Answer 9: The wild-caught fish were probably already infected with intestinal worms, because worms are very rare in aquarium fish. This is because the life cycles of these worms usually involve other animals such as shrimps. Normally these intermediate hosts are absent in the aquarium, and the worm cannot reproduce because it cannot complete its life cycle.

Symptoms may go away without treatment as the parasites die off and are unable to reproduce. However, some nematodes may reproduce without intermediate hosts. In this case, a chemical such as mebendazole may be administered by adding it to the feed. This will have no affect on beneficial organisms in the aquarium.

Answer 10: Your damselfish is most likely the victim of physical damage from the other fish in your aquarium. Damselfishes are territorial and will take ownership of coral patches and drive others away. A 20-gallon aquarium may not provide enough space for a damselfish, as its territory will constantly be crowded by other fish. Your new damselfish may have been fighting over territory and has lost the battle.

Take the damselfish immediately out of the tank. The ragged fins and missing scales may develop secondary infections, so it is important to take preventative measures. You may want to treat the fish with an antibacterial such as nifurpirinol. It may be possible to reintroduce the damselfish to the aquarium by refurbishing the aquarium decorations. If you add more corals and provide more hiding places for the different fish, it may reduce the amount of aggression or at least provide safety zones for the weaker fish.

Beluga Cuisine

Grade: 9th – 12th

Objective: Students will examine the challenges involved in providing an appropriate, cost-effective diet for marine animals in an aquarium.

Duration: 1 hour

Vocabulary: Moisture, fat, protein, carbohydrate, vitamins, minerals, kilocalorie, amino acid

Materials: Beluga Cuisine worksheets (part 1, part 2, & part 3 (optional)), calculators, Answer key for parts 1 and 2 for teachers.

Background:

Having the appropriate diet for animals is important in maintaining good health and preventing disease. Animals not fed a proper diet may have poor or stunted growth, health problems due to deficiencies, or may be more susceptible to disease. Feeding animals in captivity can be especially challenging because the diets of many aquatic animals are unknown. In addition, obtaining the correct foods for aquatic diets can be difficult and expensive due to the inconsistent availability of different food sources.

Not only do the daily caloric needs of the animal need to be met, but the nutrient content within the diet must meet the nutrient requirements of the animal in question. One of the biggest concerns the husbandry department must address is the correct amount of moisture, protein, carbohydrates and fat in a diet. Vitamins and minerals may also be supplied as needed (too much will lead to toxicity and too little will lead to deficiency) based on nutrient analysis of the entire diet.

Proteins are important in the development of animals because they provide amino acids, the building blocks of many bodily tissues. Certain amino acids may be synthesized by the body, but others can only be acquired through the animals' diet. These are called essential amino acids and they must be supplied in proper quantity so that the body can make its proteins. Proteins can also provide energy in the absence of fats and carbohydrates. One gram of protein contains 4 Kcal of energy.

Carbohydrates provide energy and fiber for intestinal function. Most marine mammals feed on fish and other aquatic animals that contain little to no carbohydrates. Therefore the diet of marine mammals in aquariums usually contains few carbohydrates. One gram of carbohydrate contains 4 Kcal of energy.

Moisture is an important component of any diet, as it helps the animal to maintain a correct balance of water within the body. Both freshwater and marine fishes are able

to control water balance through the use of various cells in the body. However, most marine mammals obtain their freshwater through the foods they eat. Without enough moisture in the diet, marine mammals can become dehydrated, a serious health problem. In addition, water contains many of the vitamins and minerals needed in the body. Freshwater can actually act as a feeding stimulus in marine animals.

Fats provide the main energy source for animals, and also make food palatable. They are necessary building blocks for certain body parts such as cell membranes, and also control water loss from the animal's skin. Certain vitamins, called fat-soluble vitamins, can only be absorbed by fat in the body. One gram of fat contains 9 Kcal of energy.

In conclusion, biologists must look at quality of food, caloric intake, nutrient balance and expense when determining an appropriate diet for aquatic animals. Often there are conflicts between the cost of a diet and the quality of a diet. The cheapest diet may not meet all of an animal's nutritional needs. A high-quality diet is important to keep animals in good condition and to prevent disease.

Procedure:

1. Make copies of the student worksheets (1 per student).

2. Students may work in groups on this activity. However, each student should show his or her own work on the worksheet.

3. Review concepts that were introduced at the aquarium. Have the students recall how the food was prepared for animals at the aquarium, and the difficulties involved in preparing proper diets. Review the roles of moisture, fat, proteins, carbohydrates, vitamins and minerals in the function of the body.

4. Have students reread the Beluga Cuisine student worksheet. As a group, complete Part I of this activity.

5. Part two—Have students work in independent groups.
    - Students who are comfortable with Microsoft Excel may want to create an Excel spreadsheet to quickly calculate the beluga diets. The nutrition information may be entered into a table and students can enter Excel functions that will calculate the nutrient content and cost of a diet containing x pounds of each type of food. Students can then use trial and error to enter in different combinations of foods, to find the most cost-effective diet for the beluga.

Assessment:

- Check that the students have correctly completed math operations to find nutrient and caloric values of different diets.
- Check that the students found a proper diet that meets the needs of all of the constraints: moisture, fat, carbohydrates, and protein.
- Were the students able to compare the cheaper diet with the most nutrient balanced diet?
- Were the students able to find a cost-effective diet that was not too rich in any of the nutrients?

Extension

After completing part two, calculate a diet that will meet all of the nutritional needs and caloric needs of an adult sea lion. The amount of moisture, fat, protein and carbohydrates fed to the sea lion each day should be as close as possible to the actual required amounts. The table below shows the daily requirements.

Daily dietary needs of an adult sea lion:
14,200 Kcal per day
8.3 kg of water (moisture)
1.7 kg of protein
0.82 kg of fat
0.01 kg of carbohydrates

Resources:

Reeves, Randall R. et al. 2002. National Audubon Society Guide to Marine Mammals of the World. New York: Alfred A. Knopf, Inc.

Beluga Cuisine – Student Worksheet

One of the biggest challenges in the animal husbandry department at the Georgia Aquarium is finding an appropriate diet for each of the different animals. Certain animals can only eat certain types of food, and aquarists must be sure they are meeting the caloric and nutritional needs of each animal. Poor nutrition can cause a variety of health problems. To maintain animals at the correct weight, they must take in enough calories per day. However, the caloric value alone does not ensure an adequate diet. Moisture, fat, protein, carbohydrates, vitamins and minerals must also be in the correct proportions to ensure good development and growth and to prevent disease.

Because marine mammals live in saltwater, they obtain most of their freshwater supply through the food they eat. Without enough watery foods, they can become dehydrated and quickly die. Fats are the main energy source for animals. One gram of fat contains 9 Kilocalories. Keep in mind that the "calories" we often speak about when talking about diets or food consumption are actually Kilocalories, or Kcal. When we say a can of Coke has 200 "calories," this actually means it contains 200 Kcal of energy.

Proteins and carbohydrates are also important in bodily functions. Proteins contain amino acids, which are the building blocks for many tissues in the body. Carbohydrates are another energy source for animals. The diets of marine mammals typically contain very few carbohydrates, because these animals' stomachs are not well-adapted to digest carbohydrates. Most marine animals eat mainly fish and other aquatic organisms that contain very little carbohydrates. One gram of protein and one gram of carbohydrate each contain 4 Kcal.

In this activity, you will be working as a biologist to determine the proper diet for a beluga whale. The daily needs of a beluga whale are listed below, as well as the nutrient content of the three foods that are available for you to use. You will be determining several different diets, and will compare the most cost-effective diet with the diet that contains the best nutritional balance.

The daily caloric and nutritional needs of the average adult beluga whale are listed in the table below:

Daily dietary needs of an adult beluga:
30,000 Kcal per day
16.5 kg of water (moisture)
3.5 kg of protein
1.7 kg of fat
.03 kg of carbohydrates

The aquarium's commissary has herring, capelin, and squid available to use in the beluga's diet. However, you need to figure out what type of food to feed and calculate the weight of the food that should be fed to meet the animal's caloric and nutritional needs.

The table below shows the nutritional content and the cost of each type of food. The nutritional content is calculated by percentage weight. For example, if herring contains 70.9% moisture, this means that each 100 g of herring contains 70.9 g of water.

Herring	**Capelin**	**Squid**
Cost: $3.50 per kg	**Cost: $2 per kg**	**Cost: $8 per kg**
Moisture 70.9 %	Moisture 83.0 %	Moisture 77.3 %
Protein 17.1 %	Protein 13.6 %	Protein 17.7 %
Fat 11.3 %	Fat 2.5 %	Fat 1.3 %
Carbs 0.0 %	Carbs 0.0 %	Carbs 2.6 %

You may notice that the percentages do not add up to exactly 100%. The remaining weight that is not accounted for in this table is ash, or minerals.

Because the daily dietary needs of the adult beluga were given in kilograms in the previous table, it is simpler to convert the percentage values into grams.

Convert the percent nutritional content into grams of nutrient per kilogram of food, and enter the values into the following table for your own reference. Remember that 10% of a nutrient by weight is equal to 10 g of nutrient per 100 g of food, or 100 g of nutrient per 1000 g of food (which equals .1 kg of nutrient per 1 kg of food). Example: 1 kg = 1000g, therefore 70.9% of 1000g = 709 g or 0.709 kg.

Herring	**Amount of nutrient per 1 kg of fish**	**Capelin**	**Amount of nutrient per 1 kg of fish**	**Squid**	**Amount of nutrient per 1 kg of fish**
Moisture 70.9 %	709 g 0.709 kg	Moisture 83.0 %	g kg	Moisture 77.3 %	g kg
Protein 17.1 %	G kg	Protein 13.6 %	g kg	Protein 17.7 %	g kg
Fat 11.3 %	G kg	Fat 2.5 %	g kg	Fat 1.3 %	g kg
Carbs 0.0 %	G kg	Carbs 0.0 %	g kg	Carbs 2.6 %	g kg

Part I: Using the table on page two, answer the following questions.

1. Find the **cheapest method to meet the daily caloric needs (30,000 Kcal)** of a beluga using one or a combination of the three food sources. Remember that 1 gram of protein has 4 Kcal, 1 gram of carbohydrates has 4 Kcal, and 1 g of fat has 9 Kcal. (Hint: look at the relative fat and protein content of each of the food sources.)

2. What is the cost to feed the beluga daily with the diet you calculated?

3. Does this diet meet the **nutritional needs** of the beluga (enough fat, protein, and carbohydrates)?

4. What do you think would happen to the beluga if it were fed this diet for an extended period of time?

Part II –Guided Student Worksheet

5. Now calculate a diet that will meet all of the nutritional needs and caloric needs of the beluga whale. The amount of moisture, fat, protein and carbohydrates fed to the beluga each day should be as close as possible to the actual required amounts. (Hint: Since squid is the only food type containing carbohydrates, calculate the amount of squid to be fed first.)

Daily dietary needs of an adult beluga:
30,000 Kcal per day
16.5 kg of water (moisture)
3.5 kg of protein
1.7 kg of fat
.03 kg of carbohydrates

Because squid is the only food source with carbohydrates, so we need to calculate this first.

How many kg of carbohydrates does the beluga need each day? _____
How many kg of carbohydrates does one kg of squid supply? _____

_____ / _____
Kg of carbs needed / kg of carbs per 1 kg squid = _____ kg of squid needed

We've now met the beluga's daily needs for carbohydrates. However, the squid also contains moisture, protein and fat. Calculate how much moisture, protein and fat the squid is supplying to the beluga's daily diet.

Kg of squid needed		Kg nutrient per 1 kg of squid		Kg nutrient supplied by squid
kg	*	Kg water	=	Kg water
kg	*	Kg protein	=	Kg protein
kg	*	Kg fat	=	Kg fat

Then, subtract these amounts from the total daily needs of the beluga whale to find the kg of each nutrient that is still needed in the diet.

Total Beluga needs:		**Squid provides:**		**Nutrients still needed:**
16.5 kg of water	-	_____Kg water	=	_____Kg water
3.5 kg of protein	-	_____Kg protein	=	_____Kg protein
1.7 kg of fat	-	_____Kg fat	=	_____Kg fat

Next, we need to find a balance between herring and capelin to be put in the diet. If we use too much herring, there won't be enough moisture. If we use too much capelin, there won't be enough fat. Extra water can easily be excreted from the beluga during urination. However, a diet that is too high in fat content will not be healthy for the beluga. In addition, the oily food can leave a film on the surface of the water, clog the filtration system, or cause poor water quality. It is best to keep oily foods to a minimum.

Use trial and error to find a good balance of herring and capelin in the diet. Use the table below for your calculations. Take an estimated guess as to how many kg of herring and capelin will be needed in the diet. Once you have totaled the amount of nutrients available in your calculated diet, you can adjust by adding or subtracting a few kg of one or both fish in order to attain the correct nutrient values. Three tables are given below so that you may complete several different trials.

Capelin provides:		**Kg of capelin to be fed**		**Total kg of each nutrient**
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
Herring provides:		**Kg of herring to be fed**		+
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
		=		
		Total water		Kg water
		Total protein		Kg protein
		Total fish		Kg fat

Nutrients provided by squid:	Nutrients provided by capelin/herring:	Total nutrients provided by this diet:
_____Kg water	_____Kg water	_____Kg water
_____Kg protein	_____Kg protein	_____Kg protein
_____Kg fat	_____Kg fat	_____Kg fat

Capelin provides:		**Kg of capelin to be fed**		**Total kg of each nutrient**
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
Herring provides:		**Kg of herring to be fed**		**+**
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
		=		
		Total water		Kg water
		Total protein		Kg protein
		Total fish		Kg fat

Nutrients provided by squid:	Nutrients provided by capelin/herring:	Total nutrients provided by this diet:
_____Kg water	_____Kg water	_____Kg water
_____Kg protein	_____Kg protein	_____Kg protein
_____Kg fat	_____Kg fat	_____Kg fat

Capelin provides:		**Kg of capelin to be fed**		**Total kg of each nutrient**
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
Herring provides:		**Kg of herring to be fed**		**+**
Kg water/kg fish	x	Kg	=	Kg water
Kg protein/kg fish	x	Kg	=	Kg protein
Kg fat/kg fish	x	Kg	=	Kg fat
		=		
		Total water		Kg water
		Total protein		Kg protein
		Total fish		Kg fat

Answer Key

Beluga Cuisine – Student Worksheet

Herring	**Kg of nutrient per 1 kg of fish**	**Capelin**	**Kg of nutrient per 1 kg of fish**	**Squid**	**Kg of nutrient per 1 kg of fish**
Moisture 70.9 %	0.709 kg	Moisture 83 %	0.83 kg	Moisture 77.3 %	0.773 kg
Protein 17.1 %	0.171 kg	Protein 13.6 %	0.136 kg	Protein 17.7 %	0.177 kg
Fat 11.3 %	0.113 kg	Fat 2.5 %	0.025 kg	Fat 1.3 %	0.013 kg
Carbs 0 %	0 kg	Carbs 0 %	0 kg	Carbs 2.6 %	0.026 kg

Part I

1. Find the cheapest method to **meet the daily caloric needs (30,000 Kcal)** of a beluga using one or a combination of the three food sources. Remember that 1 gram of protein has 4 Kcal, 1 gram of carbohydrates has 4 Kcal, and 1 g of fat has 9 Kcal. (Hint: look at the relative fat and protein content of each of the food sources.)

The herring is the fattiest food and therefore it has the highest caloric content per kg of food. Although the capelin is cheaper, you would need about twice as much capelin as herring to meet the 30,000 Kcal requirement. Only 17.6 kg of herring would be needed.

The herring has 171 g of protein per kg, 113 g of fat per kg, and no carbohydrates. Thus the caloric value per kg is:

(171 g protein * 4 Kcal /g) + (113 g of fat * 9 Kcal / g) = 1701 Kcal /kg herring

The beluga needs 30,000 kcal per day:

30,000 Kcal / 1,701 Kcal per kg = 17.6 kg of herring needed

2. What is the cost to feed the beluga daily with the diet you calculated?

17.6 kg herring * $3.50 per kg = $ 61.73 daily

3. Does this diet meet the **nutritional needs** of the beluga (enough fat, protein, and carbohydrates)?

Nutrient content of herring	* 17.6 kg of herring	Needed by beluga	Comments
709 g water per kg	12.5 kg of water	16.5 kg of water	Not enough
171 g protein per kg	3 kg of protein	3.5 kg of protein	Not enough
113 g fat per kg	1.98 kg of fat	1.7 kg of fat	Too much
0 g carbs per kg	0 kg carbs	.03 kg of carbs	Not enough

The diet contains too much fat and not enough water, protein or carbohydrates.

4. What do you think would happen to the beluga if it were fed this diet for an extended period of time?

Over a short period of time, the beluga would become dehydrated. This would happen very quickly, as the beluga is missing 4 kg of water each day. If this was not corrected, the beluga could die of dehydration.

Part II

5. Now calculate a diet that will meet all of the nutritional needs and caloric needs of the beluga whale. The amount of moisture, fat, protein and carbohydrates fed to the beluga each day should be as close as possible to the actual required amounts. (Hint: Since squid is the only food type containing carbohydrates, calculate the amount of squid to be fed first.)

Squid is the only food source with carbohydrates, so we need to calculate this first.

The beluga needs .03 kg of carbs, and 1 kg of squid has 26 g or .026 kg
0.03 kg carbs needed / .026 kg carbs in 1 kg squid = **1.15 kg of squid needed**

Beluga needs:	**Squid provides per kg:**		**Still needed:**
16.5 kg of water	0.773 kg moisture	*1.15 kg=0.89 kg	15.61 kg water
3.5 kg of protein	0.177 kg protein	*1.15 kg=0.20 kg	3.3 kg protein
1.7 kg of fat	0.013 kg fat	*1.15 kg=0.014 kg	1.7 kg fat
.03 kg of carbs	0.026 kg carbs	*1.15 kg=0.03 kg	0 kg carbs

We still need to add 15.61 kg of water, 3.3 kg of protein, and 1.7 kg of fat to the diet by using various amounts of herring and capelin.

Use trial and error to find a good balance between herring and capelin that will provide the correct amount of nutrients to the beluga.

Students' answers will vary. A good balanced diet can be formed by using approximately 1.15 kg of squid, 12.7 kg of herring, and 10.0 kg of capelin.

6. Now calculate the daily cost of the diet you created.

Kg of food		Cost of food		Daily Cost
12.7 g herring	x	$3.50	=	$ 44.45
10.0 kg capelin	x	$2.00	=	$ 20.00
1.15 kg squid	x	$8.00	=	$ 9.20
		Total Daily Cost		**$ 73.65**

7. Compare your diet with the diets of the rest of your classmates.

   Whose diet was the most inexpensive?

(Answers will vary.)

   Which diet most closely met the actual nutritional needs of the beluga?

(Answers will vary.) Students should realize that the most inexpensive diet is not necessarily the best in terms of nutritional value. Students should also realize that it is difficult to meet the exact needs of the beluga when given only a few food choices.