Teacher Background Info - Station 3: Diet

To get a good indication of what an animal eats, you can dissect out the gut from a dead animal (roadkill, scientific samples), or, catch an animal and force it to regurgitate, or, look at its scat for any undigestible remains. We will focus on a variation of the scat method that is very popular as a science extension: owl pellets. Owls are nocturnal raptors, and they are predatory, eating small rodents and sometimes other birds, reptiles, even fish and crayfish (Cornell Lab of Ornithology, www.allaboutbirds.org). They generally eat their prey items whole, digest the muscle, fat, and skin, and regurgitate, in the form of a pellet, anything they can't digest (such as whole bones, or fur, or feathers). While you can sometimes find pellets in the wild (fresh ones are moist), it is easy to purchase sterilized dry pellets in a variety of sizes, from a variety of species, and from owls from different locations around the United States (North versus South, for example). These pellets often come from zoos or bird rehabilitation facilities where owls are fed small rodents.

At this station, students work in groups to dissect a pellet and identify and quantify the bones within one Barn Owl pellet (Figure 6).

Figure 6. Owl pellets are fun to dissect, and can teach about predator/prey relationships, energy flow, and trophic pyramids.

Ask: How are the bones alike? Different? Do any of the bones provide clues about the type of animal they came from (Carolina Biological Supply Company, teacher resources – owl pellet food webs)? Then, students calculate how many of each prey item the owls eat per week and year, and, given the number and mass of prey per year and the energy content of each prey type, they calculate the amount of energy per kilogram of prey (Table 3).

Prey	Number eaten per year (Y_T)	Mass (g) (=M)	Mass of Prey (g) (= PM = Y_T x M)	Mass of Prey (kg) (= PM/ 1000)	Mass (kg) of Producers eaten by Prey (= Prod)	Biomass (BM) of Producers (kg) (BM = PM(kg) x Prod)
Mouse/vole	900	20	18,000	18	**45.6 kg**	820.8
Mole	0	55	0	0	**365 kg**	0
Shrew	0	5	0	0	**1168 kg**	0
Rat	2730	240	655,200	655.2	**12.8 kg**	8386.56
Bird	0	20	0	0	**127 kg**	0
			Total PM_T (kg) = 673.2		**Total Biomass of Producers BM_T (kg) =** 9207.36	

Table 3. Sample data for the owl pellet investigation.

This can then be extended into a lesson on trophic pyramids and thermodynamics, where students are reminded that energy can't be created or destroyed (but can be transformed from one type to another, such as from food/chemical energy to heat). Because of the second law of thermodynamics (entropy), when an owl eats a mouse, some of the energy is lost as heat – and so less energy is available for whatever will eat the owl (Carolina Biological Supply Company, teacher resources – owl pellet food webs; Shertz, n.d.). Thus, if you stack your trophic levels one on top of the other, and the length of the level is equivalent to energy, the higher levels are shorter than the lower levels and you end up with a pyramid shape – the trophic pyramid. Students leave this station after calculating biomass of prey eaten by the owl, and the biomass of the producers eaten by the owl's prey, and after drawing a trophic biomass pyramid, and calculating energy loss between trophic levels. The energy loss from the prey to the owl often ends up being 99%, which leads to a discussion about the 10% transfer of energy and 90% loss of energy being averages, and, with the mass of the owl being so low (for a top predator) the math usually comes out at 99% loss (Carolina Biological Supply Company, teacher resources – owl pellet food webs; Shertz, n.d.). Students should question this number (it isn't 10%!) – this means they really understand the concept of energy loss, and aren't just plugging in numbers without understanding the concept.

Student Handout **Station 3: Diet**

To get a good indication of what an animal eats, you can dissect out the gut from a dead animal (roadkill, scientific samples), or, catch an animal and force it to regurgitate, or, look at its scat for any undigestible remains. Today, we will look at an owl pellet to determine both the diet of an owl and to calculate energy transfer through a trophic pyramid. An owl is approximately 43-50 cm (17-20 in) long with a wingspan of 99-110 cm (39-43 in) and has a mass of about **0.8** kg. Owls are nocturnal raptors that feed on small mammals, birds and reptiles. Owls swallow their food whole or if too big, may tear it into chunks. Owls are not able to digest hair, bones or feathers. The owl digestive system has a specialized section that presses the undigested portions together forming a **pellet**. Since the owls cannot pass the pellet through their digestive system, they must spit out (regurgitate) the pellet. Owls spit out 2.5 pellets per day on average.

Materials: owl pellets, dissecting tools, identification keys, skeleton diagram, paper plate.

Procedure:

1. One owl pellet per group of 2 students.
2. Over a paper plate, use dissecting tools and fingers to gently pry apart the pellet.

   NOTE: The bones you are looking for are small and easily broken.
3. Set aside any bones found – Place them into piles of bones that look alike.
4. Analyze the bones with the identifications key to identify prey items.
5. Repeat until you have completely dismantled the pellet.
6. The best way to count the number of prey is through skulls. If you can't find any skulls, try to count using bones.
7. Remember to wash hands at the end of the procedure. These pellets have been sterilized at 250°F for 204 hours, but still, wash your hands after lab!
8. Fill in the data chart (Table 1) as appropriate. You will not have data for every single species of prey. Remember, owls spit out 2.5 pellets/day on average.

Prey (Mass (g))	**Length (cm)**	**Number Found**	**Number eaten per day**	**Number eaten per week**	**Number eaten per year**
Mouse/Vole (20g)	6.5 to 9.8				
Mole (55 g)	12 to 14				
Shrew (5 g)	8				
Rat (240 g)	40				
Bird (20 g)	15				
Table 1. Owl Pellet Data				**Total =**	

Explain
Use your data to help analyze the amount of biomass (food) needed at lower trophic levels to support your owl.

A. Create a Numbers Pyramid for the owl based on the **number eaten per year** with one owl on the top with total annual number of all prey below. Use the assumption that an owl produces an average of 2.5 pellets per day.

B. Use the following facts about the prey to draw a food web that is representative of your pellet

Prey	**Diet**
Mouse/vole	Insects and other invertebrates, seeds, fruits, flowers, nuts, and other plant products.
Mole	Earthworms, centipedes, millipedes, snails, slugs, grubs, ants, sowbugs, termites, beetles, and crickets
Shrew	Beetles, grasshoppers, butterfly and moth larvae, wasps, crickets, spiders, snails, earthworms, slugs, centipedes, and millipedes. Shrews also eat small birds, mice, small snakes, plants
Rat	The rat's diet typically includes seeds, nuts, grains, vegetables, fruits, fungi, and insects.
Bird	Insects, arthropods, seeds, grains nuts, fruit

Draw your food web here. Include ALL possible prey items, not just what your owl ate.

- Arrows point the direction energy is flowing (toward the predator)
- Do NOT write "seed" or "flower, etc." Those are not organisms. Instead, write "plant".
- On the side, Label the trophic level and the type of consumer. Include the sun as the energy source for the plants.
- On the side – if the sun represents 100% of the energy, and plants can capture about 10% of the sun's energy, and herbivores can capture 10% of the plants energy, and primary carnivores can capture 10% of the herbivores energy … Label how much energy is left at each level.

C. Use this chart to calculate Biomass eaten. Transfer the last column of your data chart to the second column below. Then multiple that number times the third column (mass (g)). Then convert from g to kg. Next, multiple the mass of prey (kg) with the annual food (kg) eat/kg of prey to get the biomass eaten in kg. Add the two columns to get the two totals needed for part D.

Prey	**Number eaten per year**	**Mass (g)**	**Mass of Prey (g)**	**Mass of Prey (kg)**	**Annual Food (kg) Eaten/kg of prey**	**Biomass Eaten (kg)**
Mouse/vole		20			**45.6 kg**	
Mole		55			**365 kg**	
Shrew		5			**1168 kg**	
Rat		240			**12.8 kg**	
Bird		20			**127 kg**	
			Total		**Total**	

D. Use the chart above to create a **Trophic Biomass Pyramid**. For the **top carnivore level** you need to see the opening paragraph to find the mass of Barn Owl. For the **herbivore level** use the total Mass of Prey (kg). For the **producer level**, use the Total Biomass Eaten (kg).

Reflection:

1. Calculate about how many TIMES more energy is at the Producer level (1st trophic level) vs. Herbivore (2nd) level. To calculate, divide the 1st trophic level by the 2nd trophic level and then round up. **Show your work!**

   How much more energy is at the herbivore level (2nd) vs. the top carnivore (3rd) level?

2. Calculate how much energy is lost going from the 1st and 2nd trophic level. Use percent change to calculate.

   To find percent change: Starting amount - ending amount / starting amount X 100. **Show your work!**

   How much energy is lost from the 2nd to the 3rd trophic level?

3. The 10% rule says that 90% of the energy is lost as you go up a trophic level – only 10% is available to the level above. Are your results 90%? Why or why not? What can you infer?

4. According to the 1st law of thermodynamics, energy is never lost, it just changes form. We say that energy is "lost" as you go up a trophic level, but it's really not. Explain what we mean using the 2nd law of thermodynamics.

5. Predict what might happen to the owl if a disease wiped out a lot of the rat population. Be specific using information about populations.

6. Think of and describe another cause and effect situation that could occur using these organisms and populations.

7. While larger owls often make larger pellets, do you think you tell the size of an owl from the bones inside its pellet? Why or why not?

Teacher Notes:
Owl Pellets can be purchased from any biological supply company (i.e., Carolina Biological) or from the internet – I often get from Owl Brand Discovery Kits (https://obdk.com/buyowlpellets/) – they have Barn Owls and Horned owls, and pellets are about $2 each.

Carolina Biological has an on-line activity too that students can do for review: https://www.carolina.com/teacher-resources/Interactive/owl-pellet-food-webs-a-model-of-energy-and-mass-transfer/tr46115.tr

Students leave this station after calculating biomass of prey eaten by the owl, and the biomass of the producers eaten by the owl's prey, and after drawing a food web and a trophic biomass pyramid, and calculating energy loss between trophic levels. The energy loss from the prey to the owl often ends up being 99%, which leads to a discussion about the 10% transfer and 90% loss being averages, and, with the mass of the owl being so low (for a top predator) the math usually comes out at 99% loss.

Sample Data:

Prey	**Length (cm)**	**Number Found**	**Number eaten per day** (multiply by 2.5 pellets / day)	**Number eaten per week** (mult. by 7 days / week)	**Number eaten per year** (mult. by 52 weeks / year)
Mouse/Vole	6.5 to 9.8	1	2.5	17.3	900
Mole	12 to 14	0	0	0	0
Shrew	8	0	0	0	0
Rat	40	3	7.5	52.5	2730
Bird	15	0	0	0	0
Table 1. Owl Pellet Data				**Total**	3630

Prey	**Number eaten per year (Y_T)**	**Mass (g) (=M)**	**Mass of Prey (g) (= PM = Y_T x M)**	**Mass of Prey (kg) (= PM/ 1000)**	**Mass (kg) of Producers eaten by Prey (= Prod)**	**Biomass (BM) of Producers (kg) (BM = PM(kg) x Prod)**
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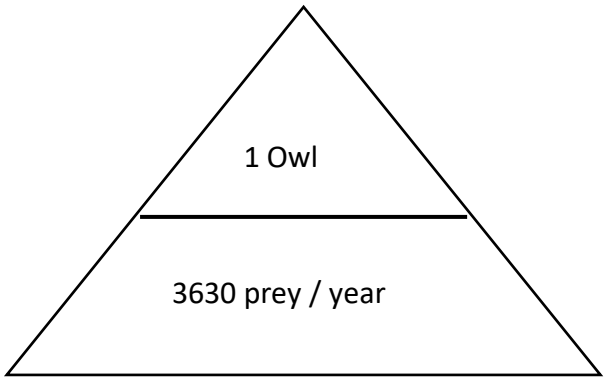
Bird	0	20	0	0	**127 kg**	0
			Total PM_T (kg) = 673.2		**Total Biomass of Producers BM_T (kg) =** 9207.36	

Table 2. Sample data for the owl pellet investigation.

A. Create a Numbers Pyramid for the owl based on the **number eaten per year** with one owl on the top with total annual number of all prey below. Use the assumption that an owl produces an average of 2.5 pellets per day.



B. Use the following facts about the prey to draw a food web that is representative of your pellet. On the side, Label the trophic level and the type of consumer. Include the sun as the energy source for the plants.

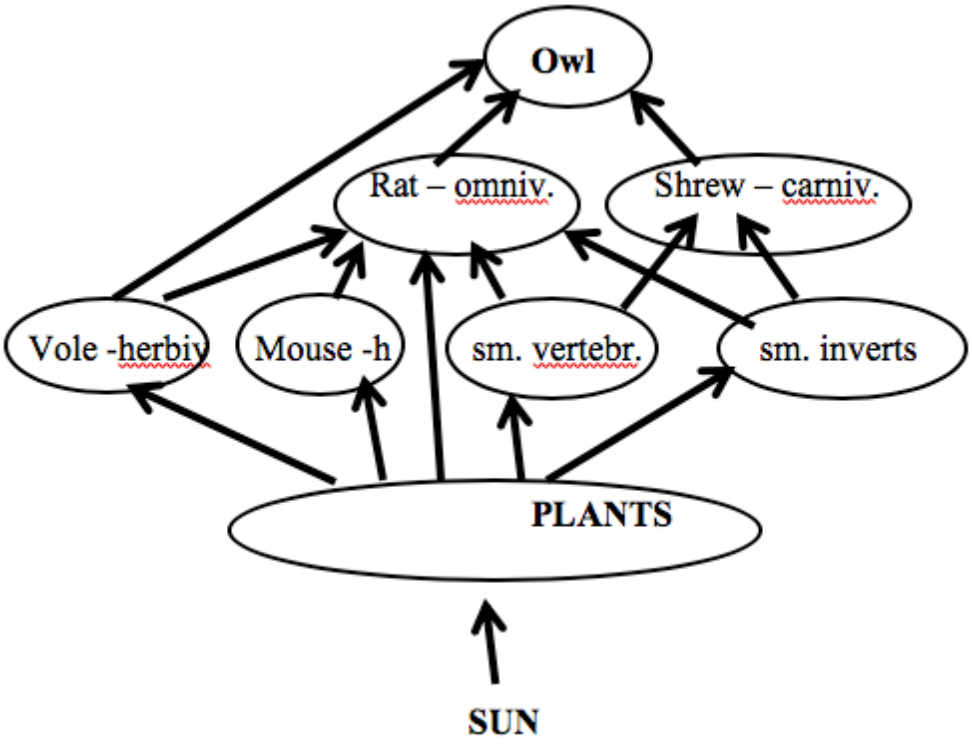
2º/3º Carnivore (0.01%)

Secondary consumer (0.1%)

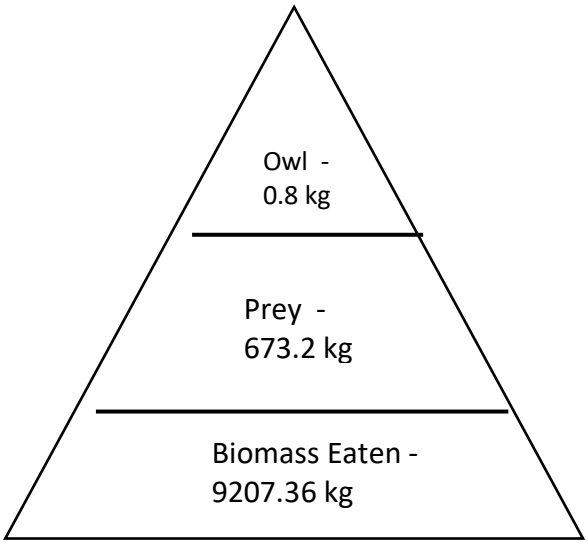
Primary consumer (1%)

Producers (10%)

Sunlight Energy (100%)



D. Use the chart above to create a **Trophic Biomass Pyramid**. For the **top carnivore level** you need to see the opening paragraph to find the mass of Barn Owl. For the **herbivore level** use the total Mass of Prey (kg). For the **producer level**, use the Total Biomass Eaten (kg).



Answers to Reflection Questions: (*Math answers will vary depending on what your owl pellets contain! This is just an example)

1. Calculate about how many TIMES more energy is at the Producer level (1st trophic level) vs. Herbivore (2nd) level. To calculate, divide the 1st trophic level by the 2nd trophic level and round. **Show your work!**

   9207.36 / 673.2 = 13.7 times more energy

   How much more energy is at the herbivore level (2nd) vs. the top carnivore (3rd) level?

   673.2 / 0.8 = 841.5 times more energy

2. Calculate how much energy is lost going from the 1st and 2nd trophic level. Use percent change to calculate. To find percent change: Starting amount - ending amount / starting amount X 100.
   Show your work! (9207.36 - 673.2) / 9207.36 = 0.9268

   0.93 x 100 = 93% energy loss

   How much energy is lost from the 2nd to the 3rd trophic level?

   ((673.2 - 0.8) / 673.2) x 100 = 99.88 % loss

3. The 10% rule says that 90% of the energy is lost as you go up a trophic level – only 10% is available to the level above. Are your results 90%? Why or why not? What can you infer?

It was more than 90% - this is because owls are birds, and so have lightweight ("hollow") bones – their weight is less so the calculation comes out higher

4. According to the 1st law of thermodynamics, energy is never lost, it just changes form. We say that energy is "lost" as you go up a trophic level, but it's really not. Explain what we mean using the 2nd law of thermodynamics.

The second law of thermodynamics says entropy always increases - so when you say energy is lost, it really means some is converted into heat and the heat dissipates into the air.

5. Predict what might happen to the owl if a disease wiped out a lot of the rat population. Be specific using information about populations.

Owls would probably switch diets to include more mice and other animals because rats will be hard to find.

6. Think of and describe another cause and effect situation that could occur using these organisms and populations.

What would happen if a disease wiped out the mouse population? I predict that with fewer mice, more rats would be eaten so the rat population would start to decrease.

7. While larger owls often make larger pellets, do you think you tell the size of an owl from the bones inside its pellet? Why or why not?

Since large owls do not always eat large prey, one cannot always determine the size of the owl that left a given pellet solely based on the size of the pellet. In addition, a startled owl may eject a pellet that is not fully compacted, thereby giving the pellet a larger appearance than normal. Other species of birds such as hawks and eagles produce pellets, but they are smaller and contain fewer animal parts than those produced by owls.

Assessment Ideas

1. Have students research and draw an aquatic food web – then discuss why aquatic BIOMASS food webs are often inverted (producers are very tiny!!)

2. Give students sample data and ask them to calculate energy loss.

3. Have students research and report out on food chains/webs in different biomes (Tundra, Tropics, Marine Deep Sea, etc).

4. Ask students what happens to the number of producers if there is plenty of sunshine and rain? What therefore happens to the number of consumers if there is plenty of sunshine and rain?

5. Ask students what would happen to the number of prey if the owl was removed due to something like habitat destruction? Why? Would this cause the collapse of the food web? Explain.

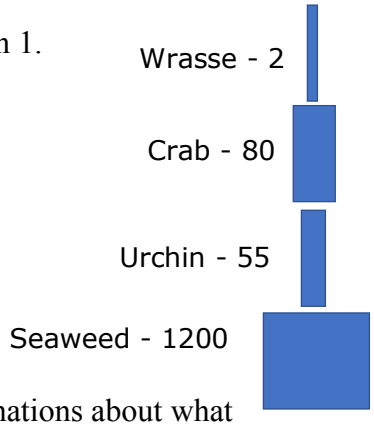
6. Go to https://www.carolina.com/teacher-resources/Interactive/owl-pellet-food-webs-a-model-of-energy-and-mass-transfer/tr46115.tr

Example test question:

1.Your food chain consists of the following data, calculate the biomass.

Organism	**Quantities**	**Average Mass (g)**	**Biomass (kg)** *(Q x AM ÷ 1000)*
Herring Gull	1	200	
Whelk	200	10	
Mussel	1000	20	
Plant Plankton	5,000,000	0.1	

2. Draw the pyramid of numbers and the pyramid of biomass for question 1.



3. The pyramid above and to the right is not sustainable. Give two explanations about what might occur as a result.

Resources:

- Carolina Biological Supply Company (Owl Pellet Food Webs activity). n.d. https://www.carolina.com/teacher-resources/Interactive/owl-pellet-food-webs-a-model-of-energy-and-mass-transfer/tr46115.tr
- Owl brand discovery kits. 2017. https://obdk.com/

References:

Cornell University, n.d., Cornell Lab of Ornithology https://www.allaboutbirds.org/ Accessed 4/11/19.

Shertz, K. n.d. Teaching A.P. Science – Owl Pellet Dissection – Trophic Pyramid and Energy Loss. https://teachingapscience.com accessed 4/11/19.