**Ecological Pyramids**

How does energy flow through an ecosystem?

**Why?**

Every organism in an ecosystem is either eating or being eaten. When cows eat grass, they obtain some of the energy that the grass transferred from the sunlight it absorbed. If cows could carry out photosynthesis, would they have access to more energy than they get as herbivores? Which organisms in an ecosystem require the most energy to sustain life?

**Model 1 – Pyramid of Energy**

1. Label the pyramid levels in Model 1 with the following: primary producers, primary consumers, secondary consumers, and tertiary consumers.

2. The arrows in Model 1 represent the energy available to the next level of the pyramid.
   
   a. What percentage of the source energy from Question 1a is absorbed by the oak leaves in Model 1?
      
      \[
      \frac{25,000}{3,190,000} \times 100 \approx 0.8\% 
      \]
      
   b. By what process do the oak leaves harness this energy?
      
      Photosynthesis

3. Describe how the consumers in one level of the pyramid obtain energy from the organisms at the previous level of the pyramid.
   
   They eat them to obtain the energy.

4. Refer to Model 1.
   
   a. How much energy per year do the caterpillars in Model 1 obtain from eating the leaves in a square meter of the oak tree?
      
      4,000 kcal

   b. What percentage of the energy that was originally absorbed by the oak leaves is passed
on to the caterpillars?
\[
\frac{4,000}{25,000} \times 100 = 15.7\%
\]

c. What percentage of the energy absorbed by the oak leaves is not passed on to the caterpillars?
\[
100 - 15.7 = 84.3\%
\]

5. Calculate the percentage of energy that is transferred from one level of the pyramid in Model 1 to another for all of the levels.

a. Caterpillars to blue jays.
\[
\frac{470}{4000} \times 100 = 11.75\%
\]

b. Blue jays to hawk.
\[
\frac{24}{470} \times 100 = 5.1\%
\]

6. Calculate the average percentage of energy that is transferred from one level to another using your answers in Questions 4b and 5. Note that this average percentage transfer is similar for many different types of energy pyramids in nature.
\[
15.7 + 11.75 + 5.1 = 32.55 \div 3 = 10.85\%
\]

7. Explain why an energy pyramid in any ecosystem typically is limited to four or five levels only.
Since only ~10% gets passed on from level to level, there isn’t enough available energy to sustain life at the top of the pyramid if there are more than 4-5 levels.

8. Propose an explanation for why populations of top carnivores, such as hawks, are always smaller than the populations of herbivores, such as caterpillars.
Because only ~10% of the energy gets transferred up the pyramid, it takes a lot of the previous level to sustain the next higher level. If the top level’s population were to grow, the levels below it would also have to grow in order for the higher levels to get enough energy.

Read This!
Each level in the pyramid in Model 1 is a **trophic level**. The word ‘trophic’ refers to feeding or nutrition. Model 1 shows one example of one organism that would be included in each level, but each level in an ecosystem includes many species of organisms.

**Model 2 – Pyramid of Numbers**

<table>
<thead>
<tr>
<th>Pyramid A</th>
<th>Pyramid B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hawk</td>
<td>1 hawk</td>
</tr>
<tr>
<td>20 blue jays</td>
<td>20 blue jays</td>
</tr>
<tr>
<td>1000 caterpillars</td>
<td>1000 caterpillars</td>
</tr>
<tr>
<td>2 oak trees</td>
<td>100,000 oak leaves</td>
</tr>
</tbody>
</table>

9. Are the ‘producers’ levels in the two pyramids in Model 2 referring to the same organisms or different organisms? Explain.
They are referring to the same organism. The leaves are a part of the tree. The difference is that pyramid B is just focusing on the energy producing part of the organism as a whole.

10. Which of the two pyramids in Model 2 gives a more accurate account of what occurs in this ecosystem? Use complete sentences to explain your reasoning.
   Pyramid A because the tree is the organism (producer) not the individual leaves.

Model 3 – Pyramid of Biomass

<table>
<thead>
<tr>
<th>Pyramid X</th>
<th>Pyramid Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak trees (11,000 g/m²)</td>
<td>Phytoplankton (40 g/m²)</td>
</tr>
<tr>
<td>Caterpillars (800 g/m²)</td>
<td>Zooplankton (210 g/m²)</td>
</tr>
<tr>
<td>Blue jays (400 g/m²)</td>
<td>Perch (100 g/m²)</td>
</tr>
<tr>
<td>Hawk (80 g/m²)</td>
<td>Heron (20 g/m²)</td>
</tr>
</tbody>
</table>

11. Refer to Model 3.
   a. Identify the trend in biomass as you move up the trophic levels in Pyramid X.
      The biomass in pyramid X decreases as you move up the trophic level.
   b. Is the trend in biomass in Pyramid X the same as seen in Pyramid Y? Explain your answer.
      The biomass initially increases but then decreases after that. This is because the producers are very small and therefore do not make up a large biomass as a whole.

Read This!
Phytoplankton are microscopic aquatic organisms that are quickly consumed by microscopic animals (zooplankton). Because they are eaten so quickly there is a need for the phytoplankton to reproduce rapidly for survival.

12. Explain why the Pyramid Y ecosystem can exist with a smaller biomass at the producer level.
   It can exist because the biomass reproduces quickly, therefore there is always new producers to replace the ones that get eaten. This quick reproduction can provide enough energy to sustain the other trophic levels.

13. What type of organisms are missing from all of the trophic pyramids shown in Models 1–3?
   The pyramids are all missing decomposers that help to return the energy back to the producer level.

14. Explain why a vegetarian diet is considered a more energy-efficient diet for humans than one based on beef, chicken or pork.
   A vegetarian diet is considered more energy-efficient because there is more of the original energy from the sun available at the producers’ level and therefore more energy is transferred to the consumer than if you were to go higher up the tropic levels for a source of food. For example, if you consumed a cow for energy, only 0.1% of the original energy from the sun reaches you, whereas if you eat vegetables, 10% of the original energy from the sun reaches you.