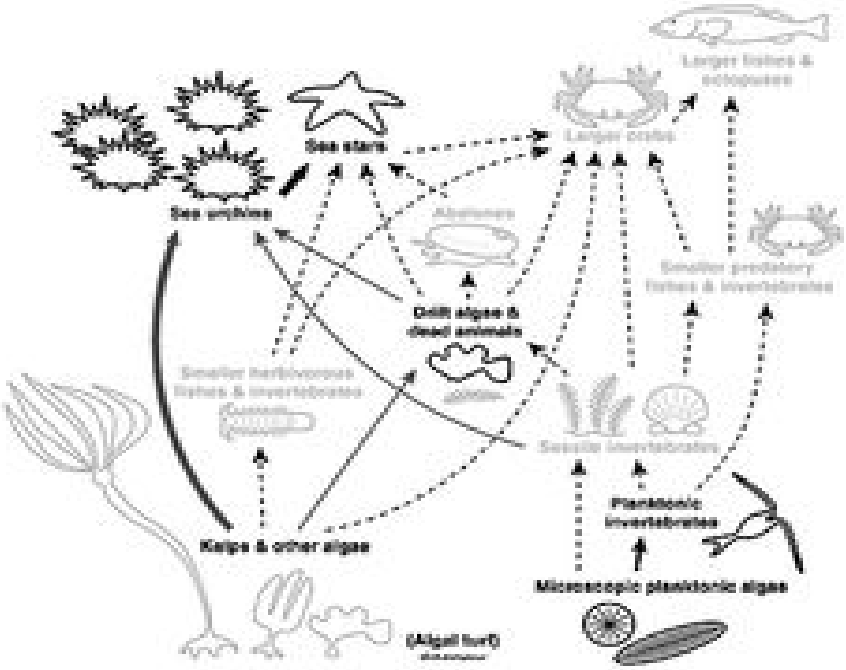
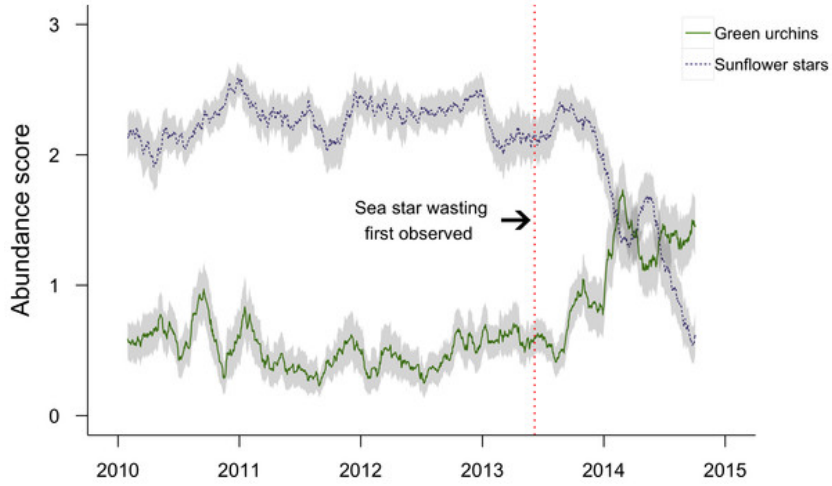
B. Without sea otters, urchin barren food web





Question 2 : How do we analyze and model the amount of energy moving through the biosphere?

Ecological Pyramids

- **ecological pyramid** is a way of representing energy flow in food chains and food webs

- there are 3 types of ecological pyramids
  1. pyramid of **numbers**
  2. pyramid of **biomass**
  3. pyramid of **energy**

Why is this way of representing energy flow shaped like a pyramid??

Pyramid of numbers

- created by counting the number of individuals at each trophic level

- sometimes, an ecosystems pyramid of numbers will not have the shape of a pyramid due to the size of the organisms

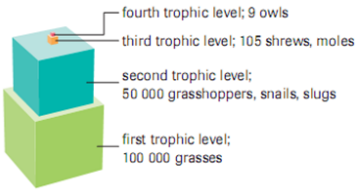


Figure 1
A pyramid of numbers for a grassland ecosystem. In this ecosystem, the number of producers is greater than the number of primary consumers.

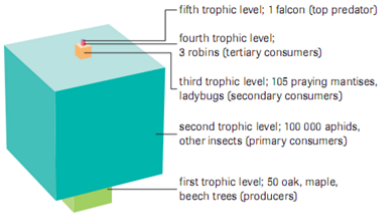


Figure 2
A pyramid of numbers for a deciduous forest ecosystem. Because an aphid is much smaller than a tree, a single plant may provide food for thousands of aphids.

Pyramid of Biomass

- Biomass is the total dry mass of living material in an ecosystem

- a pyramid of biomass is made by finding the biomass of each trophic level

- typically they are reported in units like grams per square meter (g/m^2)

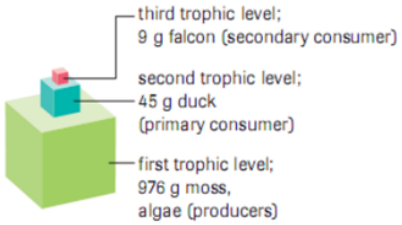


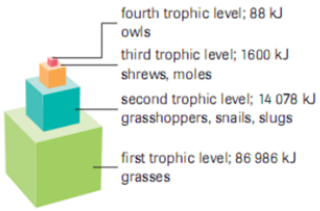
Figure 3
A pyramid of biomass for a Newfoundland peat bog. The numbers represent the dry mass (g) for all organisms at that trophic level found in 1 m^2. As you can see, there is less biomass at each trophic level.

Pyramid of Energy

- A pyramid of energy is created by measuring the amount of energy available at each trophic level

- We will use the approximation that 10% of the energy from each trophic level gets passed on

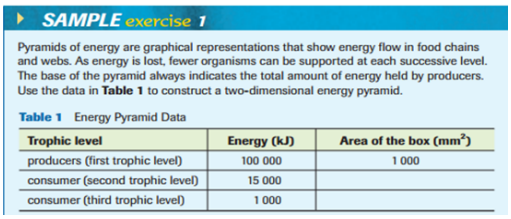
- energy is measured in kilojoules (kJ)



How to draw an ecological pyramid

1. Establish a ratio between the area of the box and the amount of energy held by the producers. For two-dimensional pyramids, the amount of energy held by producers is displayed as a ratio of the area of the box at the base of the pyramid.

energy = area of the box at the base of the pyramid
100 000 kJ = 1000 mm²



SAMPLE exercise 1

Pyramids of energy are graphical representations that show energy flow in food chains and webs. As energy is lost, fewer organisms can be supported at each successive level. The base of the pyramid always indicates the total amount of energy held by producers. Use the data in **Table 1** to construct a two-dimensional energy pyramid.

Table 1 Energy Pyramid Data

Trophic level	Energy (kJ)	Area of the box (mm^2)
producers (first trophic level)	100 000	1 000
consumer (second trophic level)	15 000	
consumer (third trophic level)	1 000	

2. Determine length and width of the producer box.
1000 mm² = width x length
1000 mm² = 20 mm x 50 mm

Draw the box with these dimensions

3. Use the ratio for producers to establish the size of the box for second-level consumers.

$$\frac{100000\ kJ}{1000\ mm^2} = \frac{15000\ kJ}{?\ mm^2} \qquad ?: 150\ mm^2$$

4. Determine the length and width of the second-level consumer box.

? mm² = width x length $\qquad 150\ mm^2 : 15\ mm \times 10\ mm$

Draw the box

5. Repeat for the third-level consumer box.

$$\frac{100000\ kJ}{1000\ mm^2} : \frac{1000\ kJ}{?\ mm^2} \qquad ?\ mm^2 : 10\ mm^2$$

6. Determine the length and width of the third-level consumer box.

? mm² = width x length $\qquad 10\ mm^2 : 5\ mm \times 2\ mm$

Draw the box

Practice Questions

1. As shown below, phytoplankton are at the base of an ocean food chain.
phytoplankton → zooplankton → herring → salmon

2,000 000 200000 20000

(a) If the phytoplankton in an ecosystem produce 20 000 000 kJ of energy per day, how much energy is available for the salmon?

(b) Suppose each herring requires 1000 kJ of energy per day to survive. How many herring can this ecosystem support?

200 herring

(c) Draw a two-dimensional energy pyramid for the above food chain

100000 kJ : foxes

10 000 000 kJ = producers 1 000 000 kJ = rabbits

2. An ecosystem contains 1000 bushes and grasses. Each produces about 10 000 kJ of energy per day.
(a) How many rabbits can be supported by this ecosystem, if each rabbit requires 5 000 kJ of energy per day?

200 rabbits

(b) How many foxes can be supported by this ecosystem, if each fox requires 10 000 kJ of energy per day?

10 foxes

(c) Draw a pyramid of numbers for this ecosystem.

$\frac{1000 \text{ bushes}}{2000 \text{ m}^2} : \frac{200 \text{ rabbits}}{x \text{ m}^2}$

Outcome 1 – Concept 2 – Question 2 Review Questions

1. What problem might you encounter if you tried to show energy flow through an ecosystem using a pyramid of numbers?

2. How might a pyramid of energy for a grassland community differ between summer and winter? Think about the effects the different abioc condions of each season might have on the ecosystem. Use your conclusions to draw a pyramid of energy for each season. Explain any differences between the two pyramids.

3. Figure 9 shows pyramids of biomass and numbers for a deciduous forest. Explain why the two pyramids are different shapes.

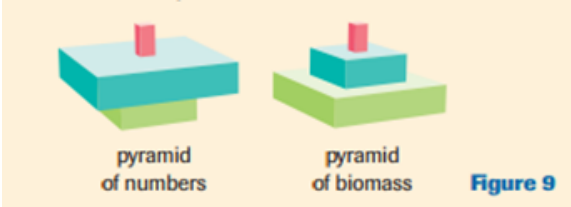


Figure 9

4. Why do energy pyramids have their specific shape?

5. A field mouse eats 10 000 g of leaves each year, among other things. If each gram of leaves has absorbed 150 kJ of energy from the Sun, about how much energy is available for the mouse?

6. The producers in a closed ecosystem capture 1.5 x10^9 kJ of energy from the Sun each year. The main food chain in the ecosystem has four levels. (a) How much energy is available for the consumers at the top level? (b) Draw a pyramid of energy for the food chain.