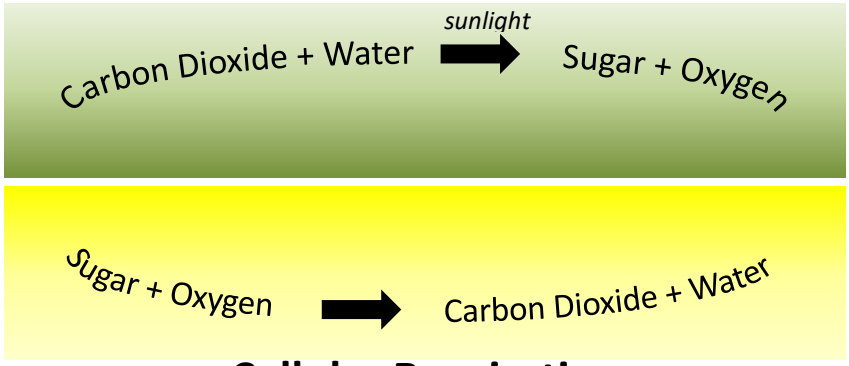
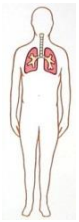
Energy in Ecosystems

All living things need energy. Where does it come from?

Energy cannot be created or destroyed. This means that a source of energy is required to fuel all life. For almost all life on Earth, that source is the sun. All living things derive their energy either directly, or indirectly from the sun.

Photosynthesis





Cellular Respiration

Energy from the sun is captured in the process of **PHOTOSYNTHESIS**. It is stored as **CHEMICAL ENERGY** in the chemical bonds of sugars. Organisms that make their own food in this way are called **autotrophs**. Autotrophs form the basis of energy for an ecosystem.

A herbivore can derive its energy by eating autotrophs or products produced by them (eg. nectar from flowers). Some organisms can derive their energy by consuming the bodies of herbivores or other consumers. Any organism that cannot make its own food is called a **heterotroph**.

FOOD CHAINS:

Grass → Grasshopper → Frog → Snake → Hawk

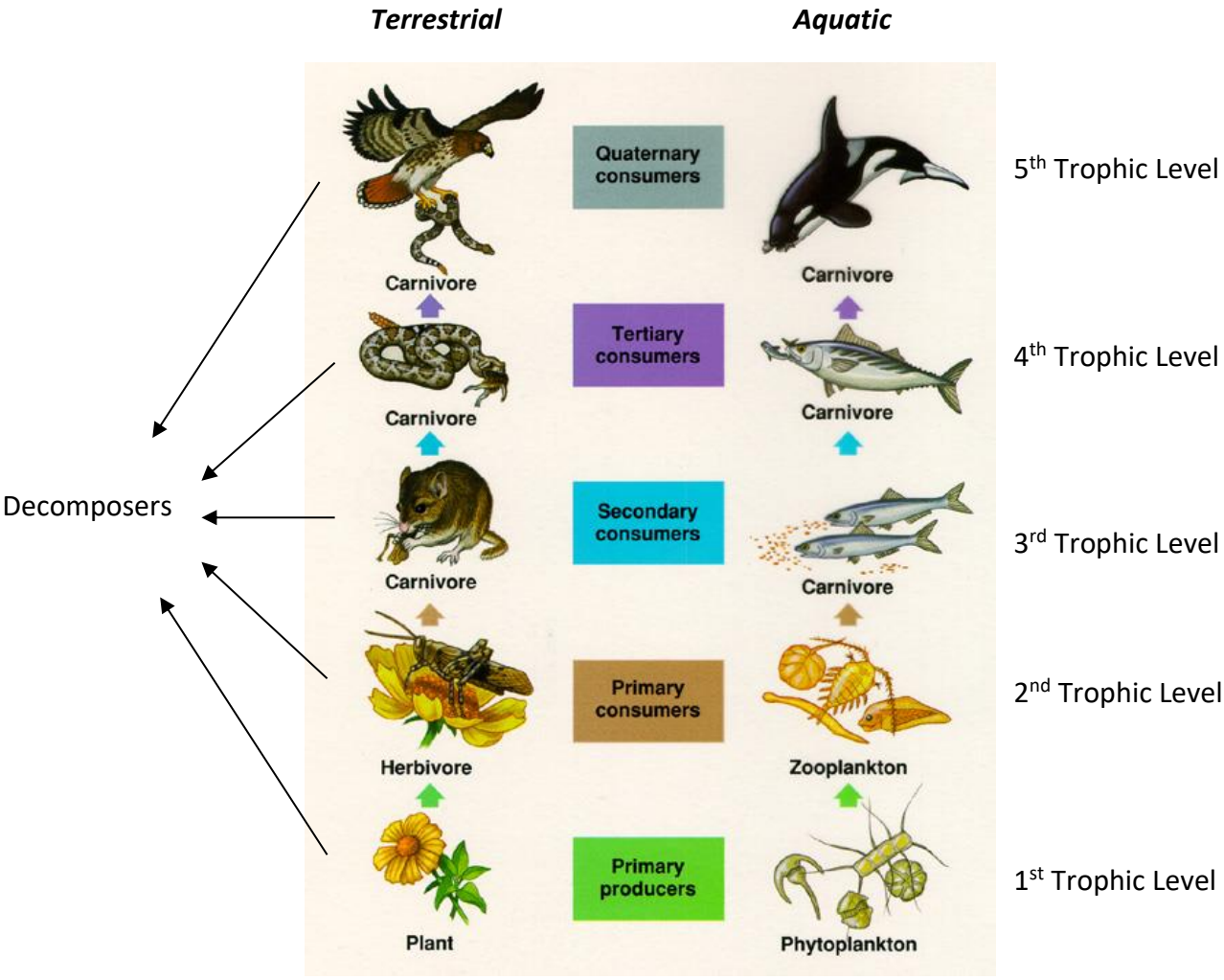
Ecologists find it useful to group organisms in an ecosystem based on where they derive their energy from. In other words, they arrange organisms according to "who eats who". A food chain lists a series of organisms in an ecosystem in order of their eating relationships.

All food chains begin with an autotroph. The autotroph for a food chain is referred to as the **producer**. All successive organisms in a food chain are referred to as **consumers**. This includes **herbivores** (plant eaters), **carnivores** (meat eaters) and **omnivores** (both meat and plant eaters).

Each feeding level is referred to as a **trophic level**.

Decomposers, like snails, bacteria and fungi, act on each stage of the food chain to break down dead and decaying matter. This returns their nutrients into the soil.

Examples of Food Chains:



THE "10% RULE"

Only a very small amount of energy from one trophic level is available for use at the next higher level. Most of the energy derived by an organism is either used by the organism, or lost to the environment as heat. Organisms use energy to grow, move, warm their bodies, reproduce, think and to perform a host of other metabolic functions. Even during the process of digestion some of the energy in food is inevitably lost and still further, some parts of food are indigestible.

The amount of energy which is actually available to the next trophic level is highly variable depending on which organisms are involved. As a reminder that it is only a very small amount, some ecologists loosely estimate that only about **10% of the energy at one trophic level is available to the next higher level**.

UPPER LIMITS

According to the 10% rule, less and less energy is available as we move up to higher trophic levels. The producers in most ecosystems only fix enough energy to support 3 to 5 trophic levels, however extremely productive environments like the oceans or tropical rain forests may support 7 or 8 trophic levels.

Practice Questions

Frog	Turtle	Snake	Rabbit	Grasshopper	Phytoplankton
Red-tailed Hawk	Blue Jay	Ant	Leaves	Bass	Nuts
Berries	Bald Eagle	crayfish	Fox	Wolf	Butterfly
Starfish	Perch	Pike	Salmon	Algae	Shark
Otter	Kelp	Maple tree	Flower	Bee	Bear
Deer	Raccoon	Squirrel	Clams	Dolphin	Whale
Zooplankton	Sardine	Grass	Mayfly	Dragonfly	Spider
Snail	Bacteria	Shelf mushroom	Krill	Shrimp	Eel
Mouse	Moth	Bat	Algae	Seal	Owl

Answer the following questions on a separate page

1. Use the list of organisms above to generate the following:
    a. Write 2 terrestrial food chains consisting of 4 trophic levels each
    b. Write a terrestrial food chain consisting of 5 trophic levels
    c. Write a food chain that is partially aquatic and partially terrestrial
    d. Write an aquatic food chain with 6 trophic levels

2. Use the food chain below to answer the following questions

    Grass → Cow → Bot fly → Spider → Bat

    a. What is the secondary consumer? What is the producer?
    b. How many trophic levels are present?
    c. List all of the carnivores present.
    d. What would happen to the spider population if a drought caused a lot of grass to die?

3. What process fixes energy from the sun into chemical energy? Write a chemical formula for this process.

4. "All organisms derive their energy from the sun". Explain this statement in your own words.

5. Distinguish between autotrophs and heterotrophs.

6. What is a decomposer? What important role do they play in an ecosystem?

7. If the butterflies in a habitat consume about 1500J of energy from the nectar they drink, estimate how much of that energy will be available to the blue jays that feed on them (assuming that only blue jays feed on the butterflies)? What happened to the rest of the energy?

8. Why are there fewer lions than there are gazelles in the African Savanah?

9. Using the scientific terms from this lesson explain why It takes between 4 to 5 times more land to produce meat than it does to produce vegetables.

10. It is becoming more and more common to raise fish, including salmon in fish farms (aquaculture). Salmon are carnivorous fish. What is a major problem with trying to farm salmon?

Activity **- Making Food Chains and Food Webs**

Your teacher will give you a set of cards with the names of various creatures on it.

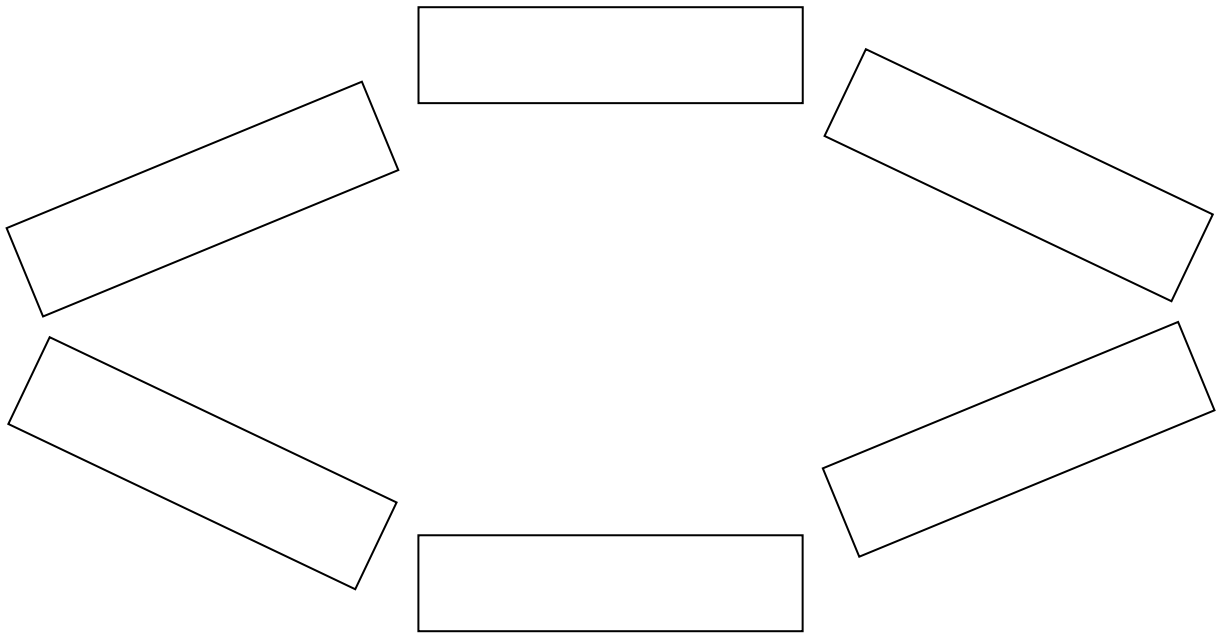
Part A – Food chains

1) Arrange your cards into a food chain (try to include as many creatures as possible)
2) Once you have created a complete food chain write it down in the space provided below
3) Now, using the same cards, find 2 or 3 more food chains. Be sure to write each one down before creating your next food chain

Food Chain #1
Food Chain #2
Food Chain #3
Food Chain #4

Part B – Food Web

1) Place the name of each organism on your cards into the boxes below.
2) Using **Food Chain #1** draw arrows between the organisms in the center of the boxes below.
3) Now, repeat step two for **Food Chain #2, Food Chain #3 and Food Chain #4**. If there is already an arrow between two species, do NOT add a second one



Part C – Food Web (continued)

As you can see from Part B, food webs can be quite complex. There is a better way of organizing them so that relationships between species is more clear.

1) In the space below place the organisms in rows based on where they fit into the food chain. You may not have organisms at all orders listed below.
2) Some organisms fit into more than level depending on which food chain you are using. In this case, place the organism somewhere between the different levels in which it fits
3) Now draw arrows between the species to show which organism eats which.

4th order Consumers

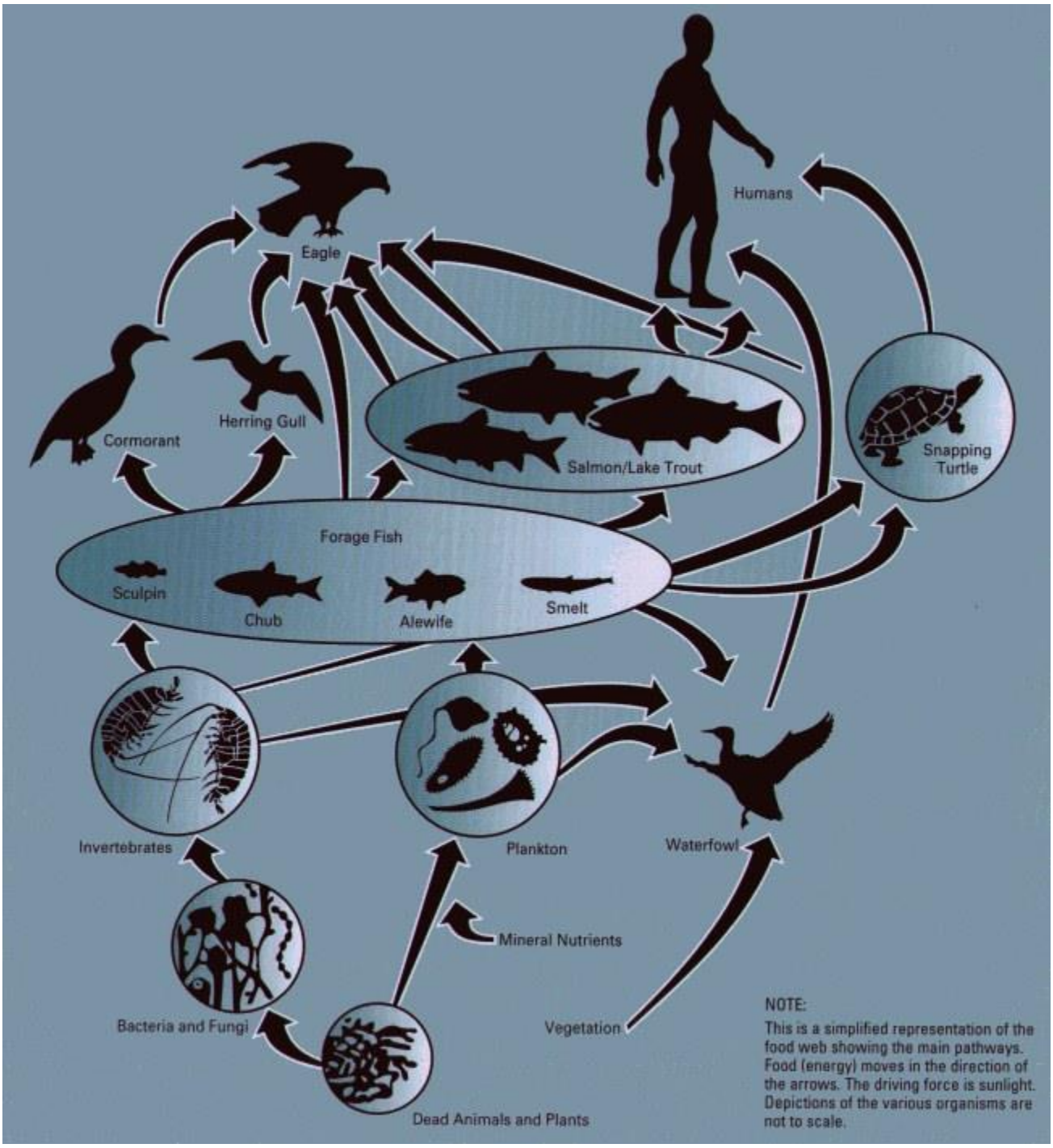
3rd order Consumers

2nd order Consumers

1st order Consumers

Producers

Food Web # 1 – Typical Food Web



Food Web # 2 – Antarctic Food Web

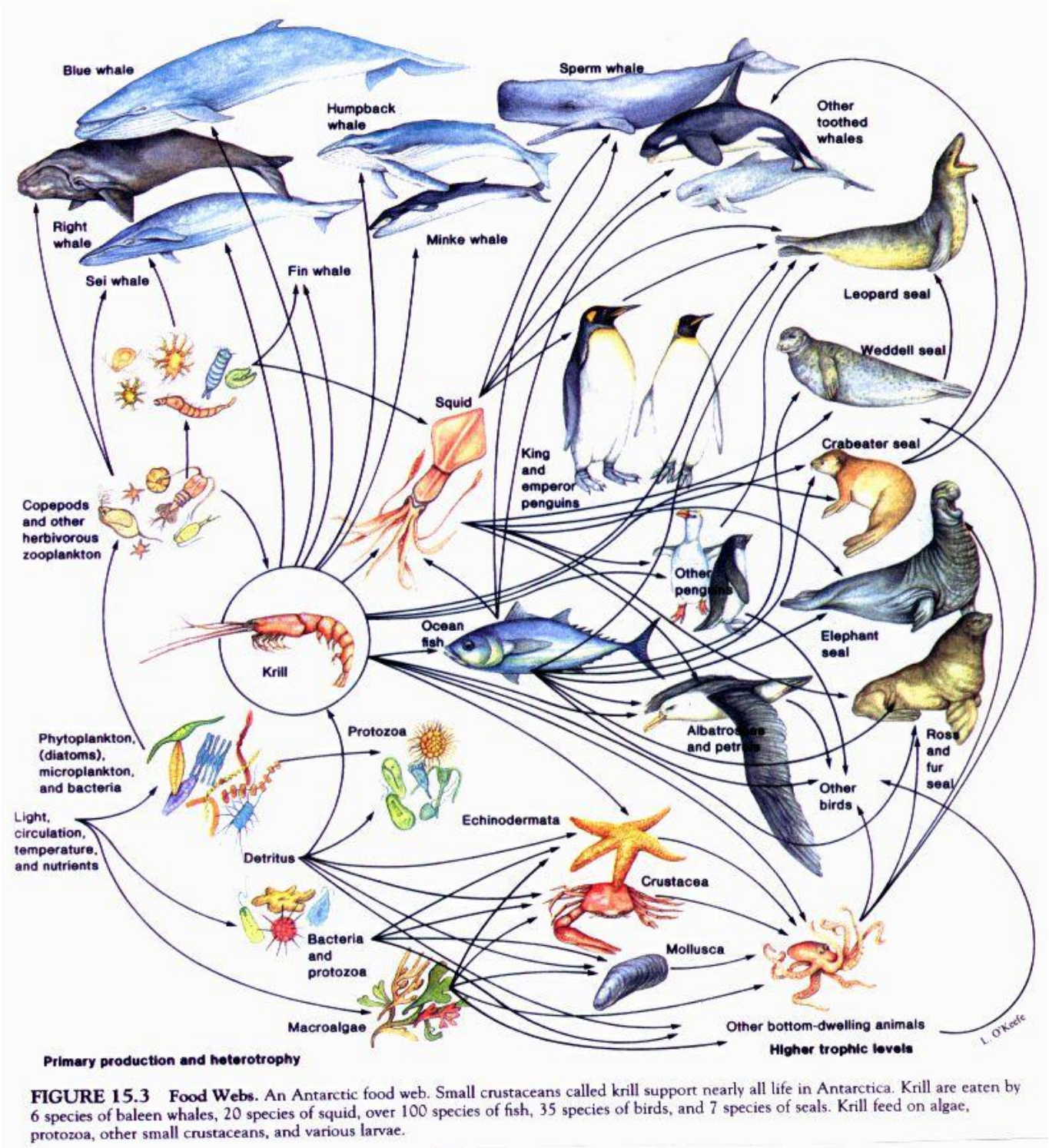
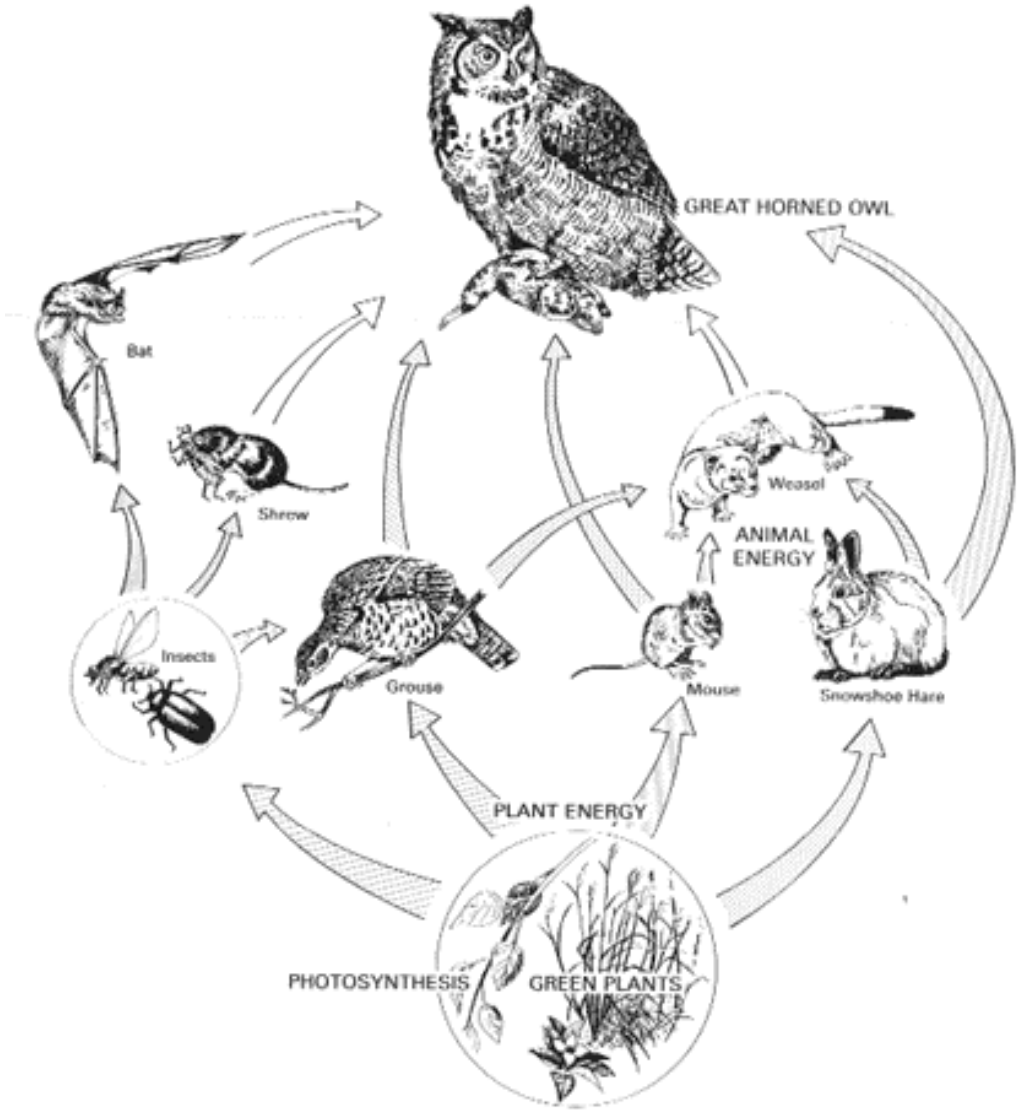


FIGURE 15.3 Food Webs. An Antarctic food web. Small crustaceans called krill support nearly all life in Antarctica. Krill are eaten by 6 species of baleen whales, 20 species of squid, over 100 species of fish, 35 species of birds, and 7 species of seals. Krill feed on algae, protozoa, other small crustaceans, and various larvae.

Food Web # 3 – Terrestrial Ecosystem



Follow up Questions (answer on a separate page)

1) Compare food webs to food chains. Explain 2 advantages and 2 disadvantages for each.

2) In a food web, trophic levels are much harder to define, why?

3) In food web #1, if humans began to fish the forage fish in order to feed livestock, predict what would happen to the populations of the following:
   (a) Salmon (b) Eagles (c) Phytoplankton (d) Waterfowl

4) In food web #3, if humans sprayed insecticide on the plants, predict what would to the populations of the following (briefly explain your answers):
   (a) Insects (b) Bats (c) Owls (d) Snowshoe hares.

5) Do you think the number of different species in an ecosystem affect its resistance to change? Explain your answer.

Finding Food Chains From Food Webs

For each food web provided find 3 food chains of varying length and record them in the table below.

Food Web #1	Trophic Level 1	Trophic Level 2	Trophic Level 3	Trophic Level 4	Trophic Level 5	Trophic Level 6	Trophic Level 7
	Producer	1st order consumer	2nd order consumer	3rd order consumer	4th order consumer	5th order consumer	6th order consumer
Food chain 1							
Food chain 2							
Food chain 3							
Food Web #2	Trophic Level 1	Trophic Level 2	Trophic Level 3	Trophic Level 4	Trophic Level 5	Trophic Level 6	Trophic Level 7
	Producer	1st order consumer	2nd order consumer	3rd order consumer	4th order consumer	5th order consumer	6th order consumer
Food chain 1							
Food chain 2							
Food chain 3							
Food Web #3	Trophic Level 1	Trophic Level 2	Trophic Level 3	Trophic Level 4	Trophic Level 5	Trophic Level 6	Trophic Level 7
	Producer	1st order consumer	2nd order consumer	3rd order consumer	4th order consumer	5th order consumer	6th order consumer
Food chain 1							
Food chain 2							
Food chain 3							