Section 1.2 Review Answers

Student Textbook page 27

1. Producers, specifically photosynthetic species, are the only organisms that can directly capture energy from the Sun. Students may add that chemosynthetic species are the only organisms that can directly capture energy from inorganic molecules. It is the producers that anchor a food web: there cannot be any consumers if there are no producers.
2. Fungi are decomposers. They feed at all trophic levels on waste matter, such as feces, dead bodies, and dead plant matter. In the process, fungi recycle inorganic and organic matter, making it available to all organisms to use for growth, maintenance, and to make energy-rich molecules.
3. The food chain should be linear and should include phytoplankton at the first trophic level (producer), zooplankton at the second trophic level (primary consumer), smaller fish such as sardines at the third trophic level (secondary consumer), and tuna at the fourth trophic level (tertiary consumer). Students may also include humans in the trophic level above tuna. All trophic levels or producer/consumer levels should be labelled.
4. Answers should consist of or a non-linear food web. It should include chemosynthetic bacteria at the first trophic level (producer), tubeworms and mussels at the second trophic level (primary consumer), and crabs and fish at the third trophic level (secondary consumer). All trophic levels or producer/consumer levels should be labelled.
5. Ash in the atmosphere will reflect sunlight, and therefore less radiant energy from the Sun will reach the pond. Since the photosynthetic producers in the pond will receive less energy from the Sun, they will grow less. As a result, less food will be available to the fish that feed on the producers, which may limit the size of the fish population.
6. **(a)** The pyramid of numbers will be upright and each step should be to scale. The bottom step, representing 4×10^9 phytoplankton will be very large compared to the upper levels of 11 herbivorous fish and one carnivorous fish. All population numbers should be labelled on the pyramid.

   (b) The pyramid of biomass will also be upright and each step should be to scale. Students must approximate masses of phytoplankton and fish and should label these approximations on their pyramid of biomass. For example, one phytoplankton may have a mass of 0.01 g while the fish could weigh 10 g. Accept any reasonable approximation. Note that students may be confused to learn that the pyramid of biomass is not inverted, as this is an aquatic ecosystem. Remind them that not all aquatic ecosystems show an inversion. An inversion typically occurs when zooplankton (not present in this hypothetical ecosystem) consume phytoplankton at such a fast rate that their biomass remains low.
7. The unit area in a measure of biomass provides a basis of comparison and could be considered a controlled variable. Without including the unit area, comparisons of dry weight would be meaningless.
8. **(a)** A decrease in the population size of species in a lower trophic level could limit the food supply of species found in higher trophic levels and decrease their population size. This effect will be greater if the species in the higher trophic level consumed the species at the lower trophic level as their main food source. Conversely, an increase in the population size of species found in a lower trophic level could expand the food supply of higher trophic levels, allowing the population size of species to expand at this level. If enough energy is available, the ecosystem may be able to support a larger number of trophic levels.

   (b) As the numbers of organisms in higher trophic levels increase, they will consume more food. The more tertiary consumers there are, for example, the more secondary consumers will be consumed. If the organisms in the higher trophic level consume too many of the organisms in the lower trophic level, the population size of the species in both trophic levels may decline. This could lead to further changes (both increases and decreases) in the number of organisms found in lower trophic levels. For example, if orca (tertiary consumers) eat too many otters (secondary consumers), the number of sea urchins (primary consumers) will increase, and the kelp population (producers) would decrease. Similarly, if the number of organisms in higher tropic levels decreases (i.e., if a decreasing orca population eats fewer otter), species in the lower tropic levels could also be affected.

9. Primary consumers can reduce the amount of photosynthesis in a community when a situation occurs in which they consume a larger than normal amount of photosynthetic producers (i.e. plants or phytoplankton). For example, such a situation could occur if the number of secondary consumers declined, resulting in a subsequent increase in the number of primary consumers. Students should identify a hypothetical example; there are many possibilities.

10. (a) 1 metric tonne (t) = 1000 kg

$$\frac{300\text{ t} \times 1000\text{ kg}}{1\text{ t}} = 3 \times 10^5 \text{ kg per year}$$

As one cow needs 7.7 kg of grain per day, it requires

$$(7.7\ \frac{\text{kg}}{\text{d}})(365\ \frac{\text{d}}{\text{yr}}) = 2810.5\ \frac{\text{kg}}{\text{yr}}$$

$$\frac{3 \times 10^5\ \frac{\text{kg}}{\text{yr}}}{2810.5\ \frac{\text{kg}}{\text{yr}}} = 106.74 \text{ (animals)}$$

Thus the one square kilometre field can support approximately 107 animals per year (100 to correct significant digits).

(b) Correction to first printing of first edition of student text: Grain contains 14 190 $\frac{\text{kJ}}{\text{kg}}$, not 141 900 $\frac{\text{kJ}}{\text{kg}}$. Amount of energy produced by one square kilometre grain field:

$$(3 \times 10^5 \text{ kg})(14\ 190\ \frac{\text{kJ}}{\text{kg}}) = 4.257 \times 10^9 \text{ kJ}$$

As the average person needs a minimum of 2400 $\frac{\text{kJ}}{\text{day}}$, this person requires 876 000 $\frac{\text{kJ}}{\text{year}}$:

$$\left(\frac{2400\text{ kJ}}{\text{d}}\right)\left(\frac{365\text{ d}}{1\text{ yr}}\right) = 876\ 000\ \frac{\text{kJ}}{\text{year}}$$

$$(4.257 \times 10^9 \text{ kJ})\left(\frac{1 \text{ person}}{876\ 000\ \frac{\text{kJ}}{\text{year}}}\right): = 4859.6\ \frac{\text{people}}{\text{yr}}$$

Thus the field can support approximately 4860 people per year if people ate only grain (5×10^3 people per year to correct significant digits.)

(c) From part a, field can support: 106.74 animals $\times$

$$\frac{500\text{ kg}}{1\text{ animal}} = 53\ 370 \text{ kg}$$

Energy in beef: (53 370 kg)(13 900 $\frac{\text{kJ}}{\text{kg}}$) = 7.418×10^8 kJ

$$(7.418 \times 10^8 \text{ kJ})\left(\frac{1\text{ person}}{876\ 000\text{ kJ}}\right) = 846.85 \text{ people}$$

Thus, the field can support about 847 people per year if people ate only beef (8×10^2 people per year to correct significant digits).

(d) Using farmland for growing grain would support more people than using farmland for grazing cattle. One disadvantage to assuming that growing grain is the most efficient use of farmland is that it fails to take into account that some land is more suitable to grazing cattle than growing grain. Further, it fails to take into account whether there are enough water resources to grow the grain or enough people available to harvest it, and other issues such as whether farmers can afford fertilizers for the grain, or whether there is a pest issue that might affect the success of the crop.