nelson net.

Chapter 4 Energy and matter in ecosystems

Question set 4.1

Remembering

1 The Sun

2 **a** Matter consists of atoms and is anything that takes up space and has mass. It is required to build and maintain complex structures throughout the universe.

b Biogeochemical cycling is the cycling of matter through the living components (organisms) and non-living components (such as soils, rocks, water and the atmosphere) of an ecosystem.

Understanding

3 Energy that is transformed is energy that changes from one form to another, such as light energy to heat energy or light energy to chemical energy. In contrast, energy that is transferred remains in the same form but moves from one reservoir to another.

4 There are examples of ecosystems that survive on geothermal energy rather than energy from the Sun. These include Archaea found in the Wai-O-Tapu geothermal reserves in New Zealand and tube worms found in deep sea trenches in the Pacific Ocean. In both instances these organisms live in high temperatures devoid of sunlight and use inorganic chemical compounds such as those containing sulfur as their energy source.

Question set 4.2

Remembering

1 Autotrophs such as plants and algae are able to photosynthesise. Chloroplasts are specialised organelles in the cells of autotrophs. They contain the pigment chlorophyll. This pigment is able to absorb most of the wavelengths in sunlight.

2

	Performs photosynthesis	Performs respiration	Autotropic or heterotrophic
Producer	Yes	Yes	Autotrophic
Consumer	No	Yes	Heterotrophic

Understanding

3 **a** Plants are 'energy converters' because they convert light energy into chemical energy.

b Producers are the autotrophs, and they provide the chemicals that other organisms in an ecosystem depend on to produce energy.

4 GPP refers to gross primary productivity and is the total amount of organic matter made in an ecosystem by producers. NPP refers to net primary productivity and is the total amount of energy available to organisms that depend on producers. NPP is less than GPP.

nelson net.

Question set 4.3

Remembering

1 Producers are vital to a community because they are the only organisms which convert the energy of sunlight into the chemical energy that maintains the ecosystem. Consumers depend on producers for energy.

2 Food chains and food webs are examples of qualitative and predictive models that allow ecologists to monitor the sustainability of an ecosystem by investigating feeding relationships.

3 **a** Producers: **iii** photosynthetic autotrophs

b Consumers: **i** herbivores, carnivores, omnivores

c Decomposers: **ii** break down organic remains and products

4 **a** Scavengers feed on the dead remains of other organisms.

b Detritivores feed on dead or decaying organic remains and wastes. They are relatively large organisms that help speed up decay by breaking down large pieces of detritus into smaller pieces, increasing the surface area for decomposers to continue their work more efficiently.

c Decomposers decompose (break down) complex organic molecules into simpler inorganic forms and returns nutrients to the soil or water.

5 Turtle

6 Detritus means pieces of dead organic matter.

7 **a** A food web consists of several food chains interlinked.

b A herbivore eats plants; a carnivore eats animals.

c A second-order consumer eats herbivores (first-order consumers) and a third-order consumer eats second-order consumers. A second-order consumer is one trophic level lower in a food chain than a third-order consumer.

8 If a member at one trophic level is eliminated it is likely that the members of a lower trophic level will increase in number and that members of a higher trophic level will decrease in number. What may also happen is that members of the higher trophic level will consume other members of the eliminated organism's trophic level.

Question set 4.4

Remembering

1 An ecological pyramid, such as a pyramid of numbers, is used to quantify species within a food chain.

2 An inverted pyramid can occur when a single very large producer supports a large number of primary consumers. It can also result when communities contain parasites.

Understanding

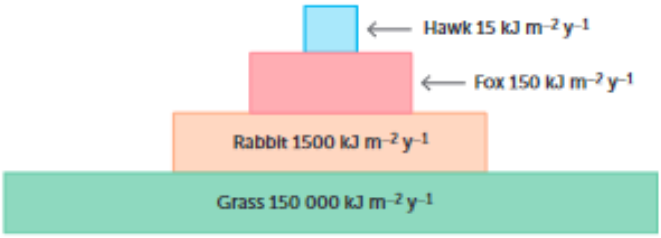
3 Data needs to be gathered over a year in a certain area. The amount of energy in each trophic level needs to be recorded.

4 Pyramids of numbers are not always pyramidal in shape; for example, one large tree can support many herbivores.

5 Pyramids of energy can never be inverted as the total amount of energy decreases with every trophic level. Only some of the energy stored in a trophic level goes to the next trophic level, giving the pyramidal shape.

Applying

6 Usually only 10% of energy is transferred between trophic levels. The following figure is not to scale.



7 The pyramid of biomass will get narrower as the food chain progresses. The grass will be on the lowest level with the greatest amount of biomass and the eagle will be at the top with the least amount of biomass.

Question set 4.5a

Remembering

1 Biogeochemical cycling is a model used to describe how chemical compounds are transformed and stored in Earth's biosphere. Total matter is a fixed resource and is cycled between biotic (biological) and abiotic (geological) processes.

2 Animals and plants are two examples of living reservoirs where matter cycles through, whereas oceans and sedimentary rock are two examples of non-living reservoirs.

3

Main Forms	Reservoirs
Carbon dioxide gas	Atmosphere
Glucose in producers	Plants
Glucose, proteins, fats in consumers	Animals
Methane	Ruminants, such as cattle, and seafloor sediment
Fossil fuels	Earth's crust – sediment, rock
Carbonic acid	Oceans

4

Process	Associated Biotic or Abiotic Component
a Photosynthesis	**iv** Producer
b Consumption	**vii** Consumer
c Cellular respiration	**i** Any living organism
d Combustion/fire	**iii** Fossil fuels, wood
e Geological activity, e.g. volcanic eruption	**ii** Volcano
f Dissolving	**v** Oceans, other water bodies
g Decomposition	**vi** Decaying organisms

Understanding

5 Photosynthesis is a process that coverts solar energy into potential chemical energy that is stored in chemical bonds. Cellular respiration is a process that breaks down organic compounds into simpler compounds, to release energy. In photosynthesis atmospheric carbon, carbon dioxide, is fixed into organic compounds such as glucose, which is used for energy by plants. In the breakdown of these organic compounds, carbon is released back into the atmosphere as carbon dioxide through the process of cellular respiration.

Applying

6 Following a bushfire a significant amount of carbon is trapped in the burnt remains, charcoal, of the forest which would become part of the soil. If the fire is large and intense, the output of carbon dioxide may be much greater. As vegetation regrows it consumes carbon through photosynthesis, taking in atmospheric carbon dioxide and storing it. These factors create a carbon sink in the area of forests that were burnt.

7 Nitrogen gas is much more abundant than carbon dioxide in the atmosphere, but needs to be fixed into a form that is usable by organisms. Nitrogen gas is fixed by prokaryotes in the soil. This usable form of nitrogen is taken up by plants. Plants are then eaten by animals and when an animal dies and decomposes, both carbon and nitrogen are released into the soil.

8 **a** If large quantities of fossil fuels continue to be consumed an imbalance in the carbon cycle would occur. Fossil fuels are a finite resource and the rate of carbon dioxide released into the atmosphere would be greater than the rate of formation of fossil fuels. Temperatures would increase and the oceans would absorb more of the atmospheric carbon, leading to the acidification (lowering of pH) of waters.

b If major deforestation occurred, an imbalance in the carbon cycle would occur. The levels of atmospheric carbon dioxide would increase as the rate of carbon dioxide that is fixed and stored is dramatically decreased, because there wouldn't be enough vegetation to remove the carbon dioxide through photosynthesis. Temperatures would increase and the oceans would absorb more of the atmospheric carbon, leading to their acidification.

Question set 4.5b

Remembering

1 Given the interdependence of biotic and abiotic components, scientists describe the cycling of matter as biogeochemical cycling. A biogeochemical cycle is a model describing how chemical elements (e.g., nitrogen, carbon) or molecules (e.g. water) are transformed and stored by both biological and geological components in Earth's biosphere. These chemicals are recycled through biological food webs and through geological processes, such as weathering, erosion and volcanic activity.

2

Form	Reservoirs
Nitrogen gas, N_2	Atmosphere
NO_2, NO_3, NH_3	Soil
Protein	Organisms, e.g. plants and animals

3

Process	Biotic or Abiotic Component Involved
a Nitrogen fixation	**iii** Microorganisms/bacteria/prokaryotes found in root nodules of legumes or lightning/volcanoes fix nitrogen
b Ammonification	**i** Bacteria and fungi convert nitrogenous substances in dead and decaying matter into ammonia in the soil
c Assimilation/ absorption	**v** Plants absorb/assimilate nitrates through their roots
d Consumption	**ii** Consumers pass nitrogen through food chains
e Denitrification	**iv** Soil bacteria convert soil nitrate into nitrogen gas

Understanding

4 **a** Volcanic emissions and the denitrification of certain bacteria both contribute to the level of nitrogen in the atmosphere.

b Nitrogen can be removed from the atmosphere by lightning and by nitrogen fixation.

Applying

5 The cycling of carbon, nitrogen and water are interconnected. For example, the movement of water is critical for the leaching of nitrogen and phosphate into rivers, lakes and oceans. The ocean is a reservoir for carbon. Mineral nutrients are cycled through the entire biosphere from one living organism to another.

6 **a** The diagram will depend on students' responses.

b Minimal or no cycling of matter would be particularly detrimental to the nitrogen cycle.

c This will depend on students' responses.

Question set 4.6

Remembering

1 The way a species functions within its environment is known as its ecological niche. The example will depend on the students' responses.

2 For example, the emperor penguin.

Feeding: They feed mainly on fish, crustaceans and squid, so are predators.

Relationships: In addition to being predators, they are prey to larger animals, such as killer whales.

Abiotic factors: They have bodies adapted to hunting in water at very low temperatures.

Habitat: open ice in Antarctica

Reproductive behaviours: Male emperor penguins keep the newly laid eggs warm by balancing them on their feet and covering them with feathered skin known as a brood pouch.

Understanding

3 Fundamental niche: the 'ideal' niche a species would occupy if there were no competitors, predators or parasites.

Realised niche: the actual niche it occupies due to its ability to exploit the resources available and cope with restrictions.

4 Gause found that when he grew each species as two separate cultures, with a constant source of food, the population numbers increased exponentially until they reached the carrying capacity of the culture. However, he found that when the two species were grown in the same culture, one had a competitive advantage and was able to obtain the food more effectively than the other, driving the less competitive species to extinction.

Applying

5 The species live at different heights and inhabit different niches within the tree. They are not competing for the same food or space. In other words, the warblers are not competing for the same resources so they are able to co-exist.

Question set 4.7

Remembering

1 A keystone species is a species of relatively low abundance that has a disproportionately large influence over lower trophic levels, determining the coexistence of these species in an area.

Understanding

2 A keystone species increases an ecosystem's biodiversity by controlling populations of other species that would otherwise dominate the community or by providing critical resources for a wide range of species.

3 A keystone species is often a species of relatively low abundance, whereas a dominant species is one that is more numerous than other species in the ecosystem.

Chapter review questions

Remembering

1 A food chain follows only one path through the food web. A food web shows all of the food chains present in an ecosystem.

2 Zooplankton

Understanding

3 At particular times of the year, the biomass of the tiny herbivorous organisms that float in lakes and oceans (zooplankton) may exceed the biomass of the tiny photosynthetic organisms (phytoplankton) on which they feed. This would result in an inverted pyramid. Another example is when a single very large producer such as the eucalypt tree supports a large number of primary consumers.

4 A mushroom (a fungi) is a saprophyte, which is the same as a detritivore, but they secrete enzymes into the decaying matter and then absorb the nutrients, whereas detritivores feed and then digest plant and animal matter.

Bacteria are decomposers, and they decompose (break down) complex organic molecules into simpler inorganic forms and returns nutrients to the soil or water.

Worms are detritivores, which feed on dead or decaying organic remains and wastes. They are

relatively large organisms that help speed up decay by breaking down large pieces of detritus into smaller pieces, increasing the surface area for decomposers to continue their work more efficiently.

Applying

5 10% of 800 kJ = 80 kJ

6 Omnivores eat both plants and animals. If there is a shortage in one type of food, an omnivore has alternatives.

7 The migration of organisms transfers energy and matter along different pathways out of the ecosystem. Organisms that depend on them will be affected and may move too.

Analysing

8 Energy is 'lost' from food chains at every link in the form of heat energy (due to cellular respiration in the tissues of organisms), detritus, organic waste, and dead plant and animal tissues.

9 A change in population of one species affects the populations of species that depend on or are affected by that species. The effect is felt along the food chains of the oceans. Monitoring is important for this reason.

10 B

11 It is most likely that the photosynthetic rate would be higher at 25°C.

Evaluating

12

Type of ecosystem	Primary productivity (kJ m^{-2} $year^{-1}$)	Energy available to primary consumers (kJ m^{-2} $year^{-1}$)	Energy available to secondary consumers (kJ m^{-2} $year^{-1}$)
Grassland	8400	840	84
Ocean	3350	335	33.5
Tropical rainforest	3800	380	38
Desert	<840	<8.4	<0.84

a GPP: total amount of biomass produced in the ecosystem. NPP: total amount of biomass available to organisms in the next link in the food chain.

b From the data in the table, the desert is the least productive ecosystem due to the low rate of productivity.

13 The weather conditions in colder climates and deserts do not favour efficient photosynthesis. In deserts, this is because of the lack of available water. In cold climates, low temperatures and less light energy reduce the rate of photosynthesis. Tropical forests and grasslands receive higher levels of sunlight and water, hence the higher production of organic matter.

14 Students' own responses. For an example, see Figure 4.22 on page 120 of the student book.

15 Food webs are interactions between species and show their particular roles in the web. Usually a population of large size will have the most impact on the dynamics of the ecosystem.

However, keystone species have a much larger effect on other species of an ecosystem even though their abundance is relatively low. This may be due to the keystone species' ability to do something critical, such as recycle nutrients. For an ecosystem to remain stable, nutrients must be recycled by specific organisms. If the keystone species disappears, this could put the survival of all of the other species in the community at great risk.

Practice exam questions

1 C

2 D

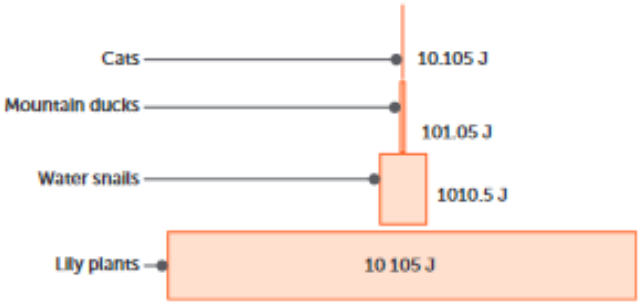
3 A

4 **a** Lily plant → water snails → mountain ducks → cats

b Correct labels (1 mark)

Approximately 90% decrease/trophic level labels close to scale in diagram (1 mark)

10 105 J (lily), 1010.5 J (water snails), 101.05 J (mountain ducks), 10.105 J (cats) (1 mark)



5 5 marks for five forms found in their correct reservoir, all labelled.

Main forms	Reservoirs
Carbon dioxide gas	Atmosphere, ocean
Glucose in producers	Plant and animal tissue
Glucose, proteins, fats in consumers	
Methane	Farm animals and atmosphere
Fossil fuels	Rocks
Carbonic acid	Ocean

5 marks for five processes mentioned in cycle and inserted correctly between reservoirs

Process	Biotic or abiotic component associated with process
Photosynthesis	Producer
Consumption (along a food chain)	Consumer
Cellular respiration	Any living organism
Combustion	Fossil fuels
Geological activity e.g. volcanic eruption	Volcano
Dissolving (in oceans)	Carbon dioxide in to oceans
Decomposition	Dead and decaying organisms