# Unit 4 · Ecology

**ANSWER KEY · FOR TEACHERS**

Full marks 48

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

## 1 Key words

K · 4

1. spindle
2. biomass
3. reservoir
4. sedimentary
5. fixation
6. assimilation
7. ammonification
8. denitrification

Each carries 0.5 mark.

## 2 Label the diagram

K · 3

1. fixation
2. ammonium $NH_4^+$
3. ammonification
4. taken up by roots
5. lightning
6. nitrate $NO_3^-$

Each carries 0.5 mark.

## 3 Multiple choice

**i.** **c.** pyramid of energy — K · 1

Every level gets its energy from the level below and loses some as heat, so each bar of a pyramid of energy is narrower than the one under it. Numbers and biomass can be inverted.

**ii.** **c.** inverted — U · 1

Each feeder is more numerous than the one it lives on: one tree, many birds, thousands of lice. The bars get wider upward.

**iii.** **b.** 80 kJ — A · 1

Secondary consumers are at level 3, two steps up: $8{,}000 \times (0.1)^2 = 80$ kJ.

**iv.** **c.** nitrification — K · 1

Nitrification is done by *Nitrosomonas* (ammonium → nitrite) and *Nitrobacter* (nitrite → nitrate).

**v.** **d.** the phosphorus cycle — K · 1

Phosphorus has no common gas; its main reservoir is rocks and soil, so its cycle is sedimentary and slow. The other three have their main reservoir in the air.

## 4 Very short answers

**a.** MARKING SCHEME — K · 1

✓ Charles Elton.

**b.** MARKING SCHEME — K · 1

✓ kJ/m$^2$ per year.

**c.** MARKING SCHEME — K · 1

✓ *Rhizobium*.

**d.** MARKING SCHEME — K · 1

✓ Photosynthesis.



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## 5 Short answers

**a.** MARKING SCHEME U · 2

- ✓ Each level gets all its energy from the level below.
- ✓ Most of it is lost at every step, so each level takes in less than the one below.

**b.** MARKING SCHEME U · 2

- ✓ Only about 10% of the energy passes from each level to the next.
- ✓ At level 5 only about 0.01% of the producers' energy is left, too little for another population.

**c.** MARKING SCHEME U · 2

- ✓ Energy leaves as heat, which no living thing can turn back into food.
- ✓ Decomposers break dead matter into simple substances that plants take up again.

**d.** MARKING SCHEME U · 2

- ✓ The triple bond of $N_2$ is very strong, and plants can't break it.
- ✓ They take up nitrogen only as nitrate or ammonium from the soil, which may be short.

**e.** MARKING SCHEME U · 2

- ✓ Any one difference, e.g. nitrification turns ammonium into nitrate; denitrification turns nitrate into nitrogen gas.
- ✓ Any second difference, e.g. nitrification needs oxygen; denitrification happens in waterlogged soil.

## 6 Long answers

**a.** ANSWER U · 4

**Ten percent law:** at each step of a food chain, only about 10% of the energy of one trophic level is passed on to the next; about 90% is lost, mostly as heat.
Diagram: sunlight → producers (rice, 10,000 kJ) → primary consumers (grasshoppers, 1,000 kJ) → secondary consumers (frogs, 100 kJ) → tertiary consumers (snakes, 10 kJ), with an arrow labeled "heat" leaving each level, and arrows from each level to the decomposers for dead bodies and droppings, which also give off heat.
Producers catch about 1% of the sunlight in photosynthesis. At every level part of the food is not digested (droppings), most is used up in respiration and lost as heat, and only a little becomes new body for the next level to eat. So energy decreases at each level, and flows one way: it is never recycled.

MARKING SCHEME

- ✓ The law: only about 10% of a level's energy passes to the next; about 90% is lost, mostly as heat.
- ✓ A labeled diagram of the levels with their energy (10,000, 1,000, 100, 10 kJ).
- ✓ Arrows for heat lost at each level, and dead bodies and droppings to the decomposers.
- ✓ At each level part is undigested, most is lost in respiration and little becomes body; energy flows one way.


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**b.** ANSWER U · 4

1. **Nitrogen fixation:** nitrogen gas of the air is changed into ammonia or nitrate by *Rhizobium* (in legume root nodules), free-living *Azotobacter* and *Clostridium*, cyanobacteria such as *Nostoc* and *Anabaena*, by lightning (as nitrates in rain) and by factories (Haber process, urea).
2. **Assimilation:** plants take up nitrate and ammonium and make proteins; animals get nitrogen by eating plants.
3. **Ammonification:** decomposers (such as *Bacillus* and fungi) change the proteins and urea of dead matter, urine and dung into ammonia/ammonium.
4. **Nitrification:** *Nitrosomonas* changes ammonium into nitrite, and *Nitrobacter* nitrite into nitrate.
5. **Denitrification:** denitrifying bacteria such as *Pseudomonas*, in waterlogged soil, change nitrate back into nitrogen gas.

Diagram: nitrogen gas in the air at the top; arrows down to "nitrogen-fixing bacteria", "lightning" and "factories"; then ammonium → nitrite → nitrate in the soil; nitrate → plants → animals; plants and animals → dead matter, urine, dung → ammonium; and nitrate → nitrogen gas, labeled "denitrification".

MARKING SCHEME

- ✓ Fixation by *Rhizobium*, *Azotobacter*, cyanobacteria, lightning and factories.
- ✓ Assimilation by plants, and ammonification by decomposers such as *Bacillus*.
- ✓ Nitrification by *Nitrosomonas* (to nitrite) and *Nitrobacter* (to nitrate).
- ✓ Denitrification by *Pseudomonas*, with a labeled diagram of the cycle.

## 7 Numerical problems

**a.** ANSWER A · 2

$$\frac{1{,}800}{15{,}000} \times 100\% = 12\%$$

Energy not passed on: $15{,}000 - 1{,}800 =$ **13,200 kJ/m² per year** (88%), lost mostly as heat or passed to decomposers.
**12% transferred.**

MARKING SCHEME

- ✓ $1{,}800 \div 15{,}000 \times 100\% = 12\%$.
- ✓ $15{,}000 - 1{,}800 = 13{,}200$ kJ/m² per year.

**b.** ANSWER A · 3

By the ten percent law, from level 2 to level 4: $20{,}000 \times (0.1)^2 = 200$ kJ. The snake would get about 200 kJ, not 50 kJ. 50 kJ means an efficiency of $\sqrt{50 \,/\, 20{,}000} = 0.05$, 5% a step: possible in a real ecosystem (efficiencies run from about 5% to 20%), but not by the ten percent law.

MARKING SCHEME

- ✓ From level 2 to level 4 is two steps.
- ✓ $20{,}000 \times (0.1)^2 = 200$ kJ.
- ✓ 50 kJ is not what the law gives (it means about 5% a step).

**c.** ANSWER A · 4

i. Bar lengths: grass $600 \div 50 =$ **12 cm**; grasshoppers $40 \div 50 =$ **0.8 cm**; spiders $6 \div 50 = 0.12$, drawn as **0.5 cm**; lizard **0.5 cm**. The pyramid is upright, with grass at the base.
ii. Grass 9,000 kJ; grasshoppers **900 kJ**; spiders **90 kJ**; lizard **9 kJ**.

MARKING SCHEME

- ✓ Grass 12 cm and grasshoppers 0.8 cm.
- ✓ Spiders and lizard 0.5 cm each.
- ✓ The pyramid drawn upright, with the grass at the base.
- ✓ Grasshoppers 900 kJ, spiders 90 kJ, lizard 9 kJ.


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**d.** ANSWER A · 2

Level 1: 100,000; level 2: 10,000; level 3: 1,000; level 4: 100; level 5: 10; level 6: 1 kJ.
Level 5 has 10 kJ (at least 5); level 6 has only 1 kJ. So the chain can have **five trophic levels**.

MARKING SCHEME

✓ Level 5 has 10 kJ and level 6 has 1 kJ.
✓ Five trophic levels.

## 8 Think

ANSWER HA · 3

A tiger-eater would be one level above the tigers and get only about 10% of their energy. Nepal's 429 tigers together hold far too little energy to feed a population of large hunters, which would have to roam a huge area to find enough of them. There isn't enough energy left at the top of the chain for another level.

MARKING SCHEME

✓ A tiger-eater would get only about 10% of the tigers' energy.
✓ Tigers are few, so together they hold too little energy for a population of hunters.
✓ The hunters would have to roam a huge area; there isn't enough left for another level.

## 9 Activity: Observe an ecosystem and chart its pyramid (Practical 8)

(not marked)

WHAT STUDENTS SHOULD FIND

Almost always many producers, fewer plant-eaters, a few hunters, and perhaps no top consumer inside one square meter. So the pyramid of numbers is usually upright; one big plant carrying many insects may make the base narrower than the next bar. The energy column is 10,000, 1,000, 100, 10 kJ whatever you counted. It is a model from the ten percent law, not a measurement.

## See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **The Ecosystem Pond** (exhibit): Find the producers and a consumer: sunlight's energy, caught by the water plants and algae, passes to the guppies, with much lost on the way.

| Marks by level | Knowledge | Understanding | Application | Higher ability | Total |
|---|---|---|---|---|---|
| **Marks** | 14 | 19 | 12 | 3 | **48** |


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