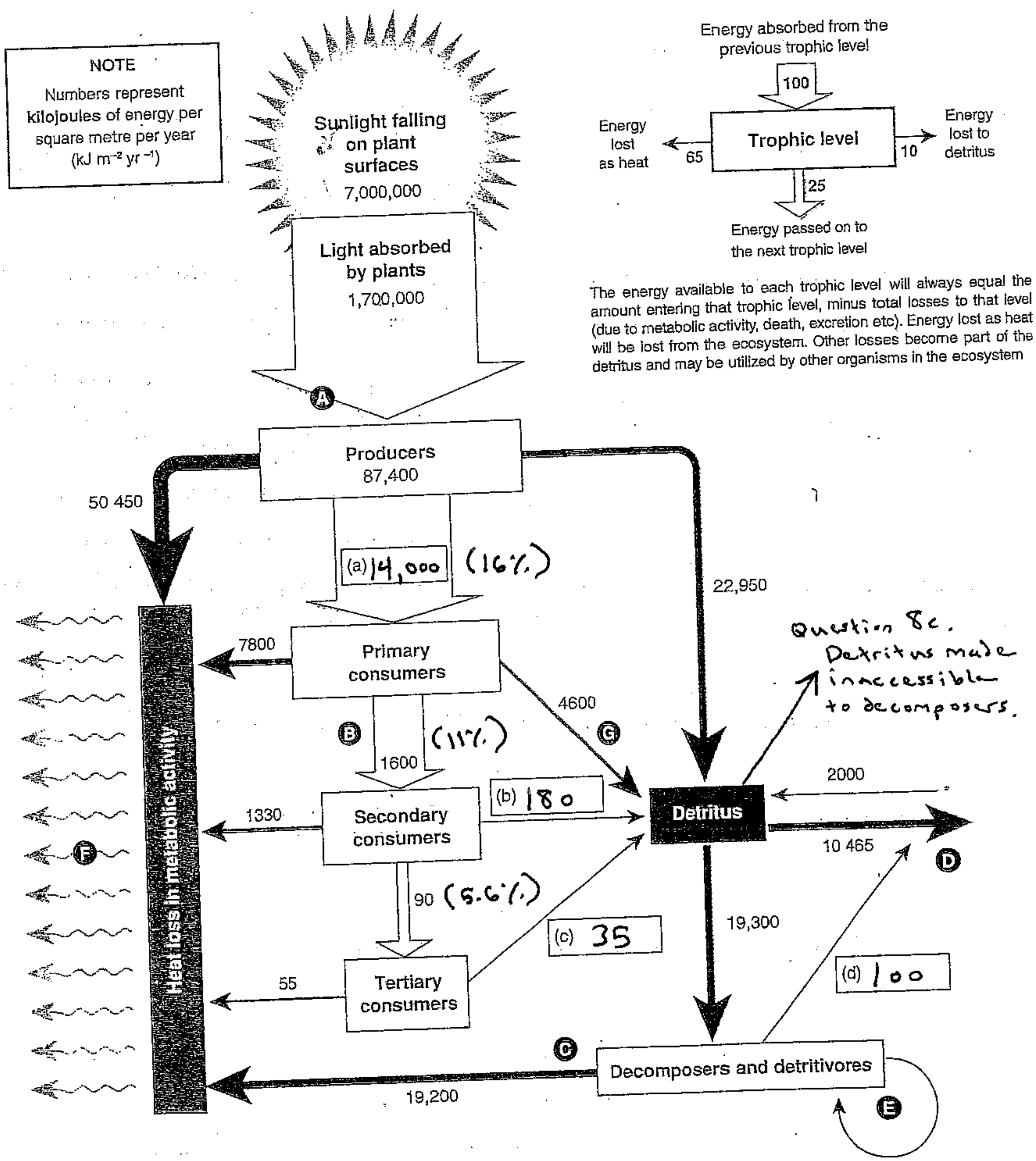
Quantifying Energy Flow in an Ecosystem Answer Key 3

The flow of energy through an ecosystem can be measured and analyzed. It provides some idea as to the energy trapped and passed on at each trophic level. Each trophic level in a food chain or web contains a certain amount of biomass: the dry weight of all organic matter contained in its organisms. Energy stored in biomass is transferred from one trophic level to another (by eating, defecation etc.), with some being lost as low-grade heat energy to the environment in each transfer. Three definitions are useful:

- **Gross primary production:** The total of organic material produced by plants (including that lost to respiration).
- **Net primary production:** The amount of biomass that is available to consumers at subsequent trophic levels.
- **Secondary production:** The amount of biomass at higher trophic levels (consumer production). Production figures are sometimes expressed as rates (productivity).

The percentage of energy transferred from one trophic level to the next is called the **trophic efficiency** or ecological efficiency. It varies between 5% and 20% and is a measure of the efficiency of energy transfer. An average figure of 10% is often used (called the **ten percent rule**). The path of energy flow in an ecosystem depends on its characteristics. In a tropical forest, most of the primary production enters the detrital and decomposer food chains. However, in an intensively grazed pasture more than half the primary production may enter the grazing food chain.

Energy Flow Through an Ecosystem



The energy available to each trophic level will always equal the amount entering that trophic level, minus total losses to that level (due to metabolic activity, death, excretion etc). Energy lost as heat will be lost from the ecosystem. Other losses become part of the detritus and may be utilized by other organisms in the ecosystem

1. Study the diagram on the previous page illustrating energy flow through a hypothetical ecosystem. Use the example at the top of the page as a guide to calculate the missing values (a)–(d) in the diagram. Note that the sum of the energy inputs always equals the sum of the energy outputs. Place your answers in the spaces provided on the diagram.

2. What is the original source of energy for this ecosystem? Sunlight

3. Identify the processes occurring at the points labelled A – G on the diagram:

A. Photosynthesis

B. Predation

C. Metabolism of decomposers + detritivores

D. Detritus lost from the ecosystem

E. Decomposers and detritivores feeding on dead decomposers + detritivores

F. Metabolic + heat losses

G. Detritus from primary consumers

4. (a) Calculate the percentage of light energy falling on the plants that is absorbed at point A:

Light absorbed by plants ÷ sunlight falling on plant surfaces x 100 = $\frac{1,700,000}{7,000,000}$ x 100 = 24%.

(b) What happens to the light energy that is not absorbed?

It is reflected.

5. (a) Calculate the percentage of light energy absorbed that is actually converted (fixed) into producer energy:

Producers ÷ light absorbed by plants x 100 = $\frac{87,400}{1,700,000}$ x 100 = 5.1%.

(b) How much light energy is absorbed but not fixed: 1,700,000 − 87,400 = 1,612,600 KJ

(c) Account for the difference between the amount of energy absorbed and the amount actually fixed by producers:

Photosynthesis is a multi-step process with inefficiencies and energy losses at each step. (2nd Law of Thermodynamics.)

6. Of the total amount of energy **fixed** by producers in this ecosystem (at point A) calculate:

(a) The total amount that ended up as metabolic waste heat (in kJ): 50450 + 7800 + 1330 + 55 + 19,200 = 78,835 KJ

(b) The percentage of the energy fixed that ended up as waste heat: 78,835/87,400 = 90%.

7. (a) State the groups for which detritus is an energy source: Decomposers + Detritivores

(b) How could detritus be removed or added to an ecosystem? Added: death and waste, washed in, blown in, etc. Removed: Consumed by decomposers + detritivores, washed away, blown away, buried, etc.

8. Under certain conditions, decomposition rates can be very low or even zero, allowing detritus to accumulate:

(a) From your knowledge of biological processes, what conditions might slow decomposition rates?

Low temperatures and/or low oxygen availability.

(b) What are the consequences of this lack of decomposer activity to the energy flow?

Energy is trapped in that non-decomposed material.

(c) Add an additional arrow to the diagram on the previous page to illustrate your answer. See diagram.

(d) Describe three examples of materials that have resulted from a lack of decomposer activity on detrital material:

Oil, coal, natural gas, fossils.

9. The **ten percent rule** states that the total energy content of a trophic level in an ecosystem is only about one-tenth (10%) that of the preceding level. For each of the trophic levels in the diagram on the preceding page, determine the amount of energy passed on to the next trophic level as a percentage:

(a) Producer to primary consumer: 16%.

(b) Primary consumer to secondary consumer: 11%.