

4.2 Productivity and energy transfer

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS gross primary productivity • net primary productivity
• trophic level • transfer efficiency

Objective

Practise statements 5.9-5.10: gross and net primary productivity, the units of productivity, and the efficiency of energy and biomass transfers between trophic levels.

1 Key knowledge and worked examples

■ The productivity equation

$$NPP = GPP - R$$

Gross primary productivity : energy fixed by photosynthesis, per unit area per time ($\text{kJ m}^{-2} \text{yr}^{-1}$). **Net primary productivity** : what remains after the producers' own respiration – the energy actually available to herbivores.

■ Ten per cent, four losses

Each transfer upward keeps about 10 %: losses to respiration (heat), egestion (faeces), excretion and uneaten parts. Biomass transfer efficiency:

$$\text{efficiency} = \frac{\text{energy or biomass at next level}}{\text{energy or biomass at this level}} \times 100\%$$

■ Worked example: the arithmetic of eating lower

Plankton fix $12\,000 \text{ kJ m}^{-2} \text{yr}^{-1}$, respiring 7 200. $NPP = 4\,800$. Fish eating plankton keep 10 % = 480; humans eating the fish keep 48. Humans eating the plankton directly (seaweed farm) would access 480 – ten times more energy per unit area.

2 Practice

2.1 Define net primary productivity and give its units. [2]

2.2 State two reasons energy is lost between a rabbit and the fox that eats it. [2]

2.3 Producers fix $80\,000 \text{ kJ m}^{-2} \text{yr}^{-1}$ and respire 30 000. Calculate the energy reaching second-order consumers if each transfer is 10 % efficient. [2]

3 Exam-style questions

3.1 The table shows the energy entering and leaving each trophic level of a lake ($\text{kJ m}^{-2} \text{yr}^{-1}$).

Level	Energy in	Respiration	Egestion + excretion	Eaten by next level
Algae	55 000 (fixed)	22 000	3 000	?
Zooplankton	?	2 400	900	470
Fish	470	210	60	44

Calculate the algae’s NPP, the transfer efficiency from algae to zooplankton, and the efficiency from zooplankton to fish.

[5]

3.2 Explain why a vegetarian human population can be larger than a meat-eating one on the same land, referring to the energy losses at each transfer.

[4]

3.3 A farmer measures biomass transfer from grass to cattle at 8 % in a cold winter and 15 % in summer. Suggest why the winter percentage falls, referring to respiration, and state one management change that would raise it.

[4]