2.2 Energy and biomass in ecosystems

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS trophic level • producer • gross primary productivity • net primary productivity • ecological pyramid • bioaccumulation • biomagnification

Objective

Build the skills to answer exam questions on **energy** and **biomass** in ecosystems: trophic levels, ecological pyramids, **productivity** and **biomagnification**.

You must be able to:

- construct food chains and webs, and assign trophic levels
- explain energy loss between trophic levels and the shapes of ecological pyramids
- calculate gross and net productivity and transfer efficiency
- explain bioaccumulation and biomagnification of pollutants

1 Key knowledge and worked examples

Energy flow

Energy enters most ecosystems as sunlight, which **producers** turn into chemical energy by photosynthesis. It passes along food chains: producer → primary consumer → secondary consumer → tertiary consumer. At each step most energy is lost as **heat** from respiration, and in parts not eaten or not digested (the second law of thermodynamics: no energy change is 100% efficient). Only about 10% passes on, so food chains rarely have more than 4–5 trophic levels.

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productivity	meaning
gross primary productivity (GPP)	energy fixed by producers per area per time
net primary productivity (NPP)	GPP minus producers' respiration: NPP = GPP − R; available to consumers
gross secondary productivity (GSP)	food eaten minus faeces: energy **assimilated** by consumers
net secondary productivity (NSP)	NSP = GSP − R

$$\text{transfer efficiency} = \frac{\text{energy at the higher level}}{\text{energy at the lower level}} \times 100\%$$

pyramid	can it be inverted?
numbers	yes, e.g. one oak tree feeds thousands of insects
biomass	sometimes, e.g. phytoplankton in the sea at one moment
productivity (energy)	**never**: energy is lost at every level

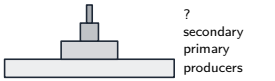
Biomagnification: a persistent pollutant that is not broken down or excreted (DDT, mercury) builds up in each organism (**bioaccumulation**) and becomes more concentrated at each higher trophic level, so top predators receive the highest doses.

Worked example. GPP = 20 000 and R = 12 000 kJ m^{-2} yr^{-1}: NPP = **8000** kJ m^{-2} yr^{-1}.

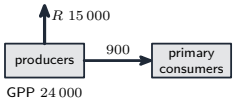
Answer shapes: show the subtraction or division with units; for pyramids, say what is measured.

2 Practice

2.1 Explain why food chains rarely have more than five trophic levels. [2]



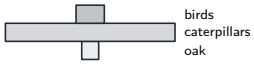
2.2 Grassland producers have a GPP of 24 000 kJ m^{-2} yr^{-1} and lose 15 000 kJ m^{-2} yr^{-1} in respiration. Primary consumers gain 900 kJ m^{-2} yr^{-1}. (i) Calculate the NPP. (ii) Calculate the transfer efficiency from NPP to primary consumers. [3]



3 Exam-style questions

3.1 An oak tree supports 2000 caterpillars, which are eaten by 20 birds.

(a) Sketch the pyramid of numbers and the pyramid of biomass for this food chain. [2]



(b) Explain why the two pyramids have different shapes. [2]

3.2 The table shows the concentration of the pesticide DDT in a lake food chain.

organism	DDT (ppm)
water	0.00005
plankton	0.04
small fish	0.5
large fish	2.0
fish-eating bird	25

(a) Calculate how many times more concentrated the DDT is in the bird than in the plankton. [1]

(b) Explain how the DDT becomes so concentrated in the bird. [3]



(c) Suggest **one** effect on the bird population. [1]

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