Exercise walk-through

2.2
Energy and biomass in ecosystems

International Baccalaureate · IB Diploma · Environmental Systems and Societies · HL

Simpson's reciprocal index

- Site A has 10, 6 and 4 individuals; site B has 18, 1 and 1.
- Same richness, but A is shared more evenly.

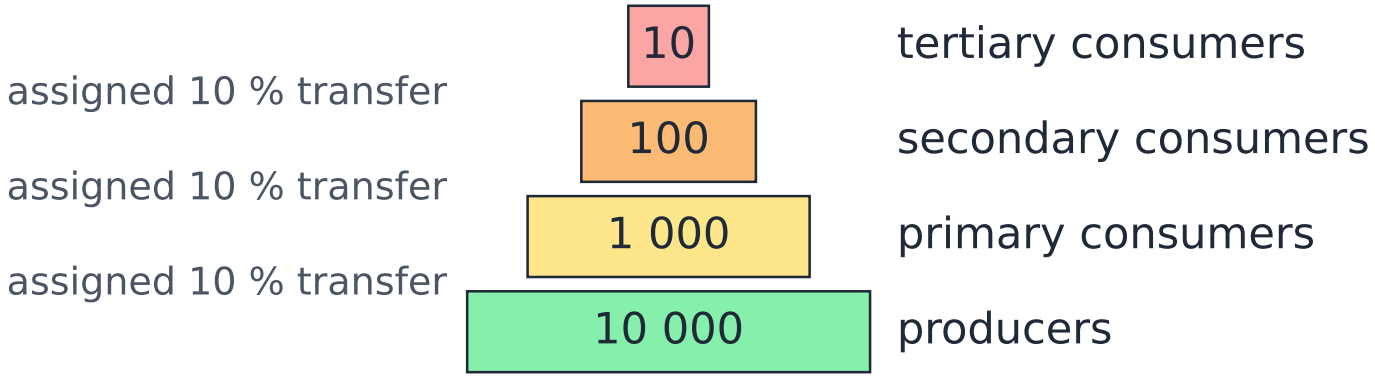
$$D = \frac{N(N-1)}{\sum n(n-1)}$$

$$D_A = \frac{380}{132} = 2.88$$

$$D_B = \frac{380}{306} = 1.24$$

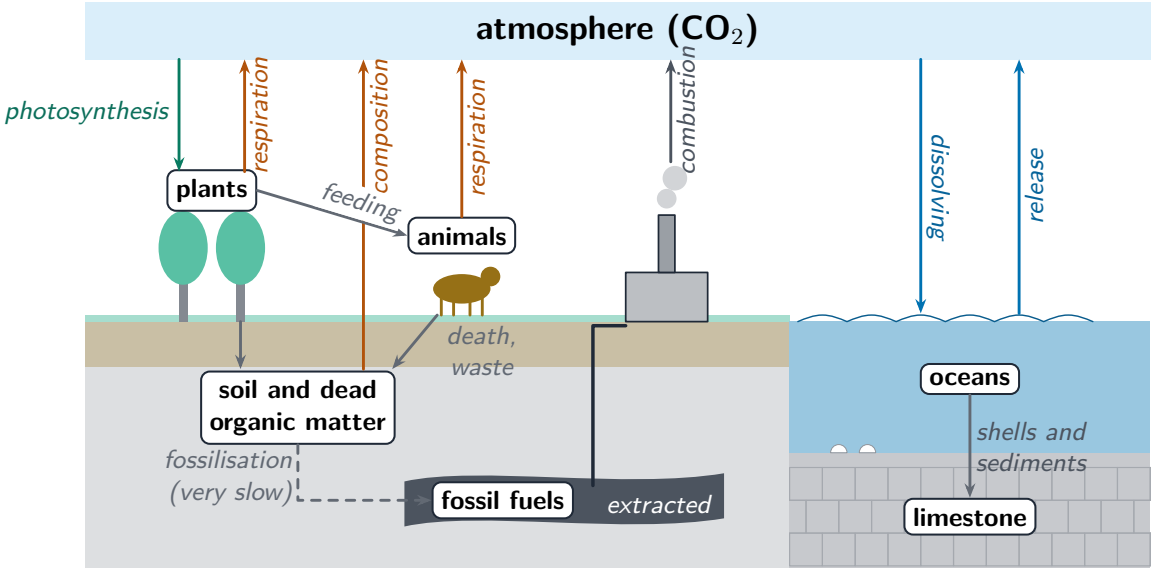
These invented samples have equal richness and different evenness; compare like sampling.

Why food chains are short



- **Respiration** disperses energy; uneaten matter and wastes also enter detrital pathways.
- The displayed 10% transfers are assigned examples, not a fixed universal rule.

The carbon cycle

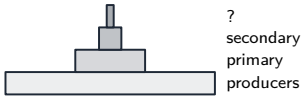


storages in boxes, flows on arrows; not to scale

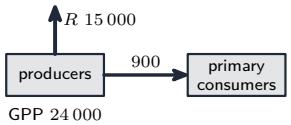
A store is an amount; a net **sink** is defined by the balance of flows over time.

Exercises 2.1·2.2

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

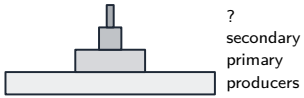


2.2 Grassland producers have a GPP of 24 000 kJ m^{-2} yr^{-1} and lose 15 000 kJ m^{-2} yr^{-1} in respiration. Primary consumers gain 900 kJ m^{-2} yr^{-1}. (i) Calculate the NPP. (ii) Calculate the transfer efficiency from NPP to primary consumers. [3]



Exercises 2.1·2.2

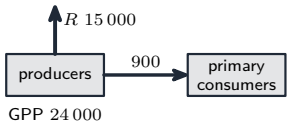
2.1 Explain why food chains rarely have more than five trophic levels. [2]



2.1

only about 10% of energy passes to the next level; most is lost as heat in respiration, or in waste and parts not eaten; after a few levels too little energy is left to support another population

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]



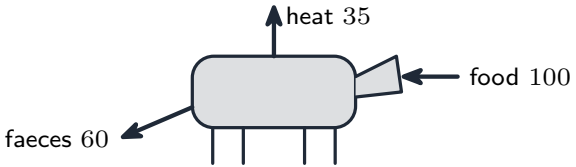
2.2

(i) $24\,000 - 15\,000 = \mathbf{9000}$ kJ m^{-2} yr^{-1}; (ii) $\frac{900}{9000} \times 100 = \mathbf{10}\%$

exercises.lol exercises.com.cn

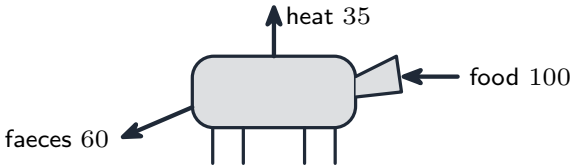
Exercise 2.3

2.3 A cow eats food containing 100 MJ. It loses 60 MJ in faeces and 35 MJ in respiration. Calculate its gross and net secondary productivity, and suggest why the NSP is so low. [3]



Exercise 2.3

2.3 A cow eats food containing 100 MJ. It loses 60 MJ in faeces and 35 MJ in respiration. Calculate its gross and net secondary productivity, and suggest why the NSP is so low. [3]



2.3

GSP $= 100 - 60 =$ **40** MJ; NSP $= 40 - 35 =$ **5** MJ; grass is hard to digest, and keeping a large warm body moving uses much energy in respiration

Exercise 3.1 (a)

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]



Exercise 3.1 (a)

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]



(a) numbers: a narrow bar for the one tree, a wide bar for the caterpillars, a narrow bar for the birds; biomass: widest at the base, getting narrower at each level

Exercise 3.1 (b)

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

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

Exercise 3.1 (b)

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

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

(b) a pyramid of numbers ignores size: one tree is very large; biomass takes mass into account, and biomass falls at each level because energy is lost

Exercise 3.2 (a)

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]

Exercise 3.2 (a)

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]

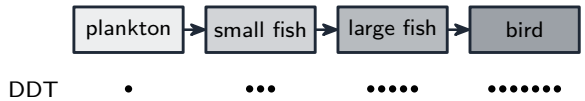
(a) $25 \div 0.04 = \mathbf{625}$ times

Exercise 3.2 (b)

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

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

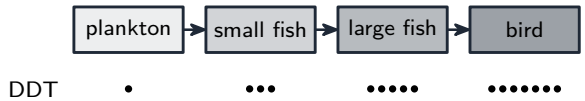


Exercise 3.2 (b)

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

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



(b) DDT is persistent and fat-soluble, so it is stored in body fat and not excreted (bioaccumulation); each organism eats many from the level below; so the DDT is passed on and concentrated at each level (biomagnification)

Exercise 3.2 (c)

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

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

Exercise 3.2 (c)

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

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

(c) eggshells become thin and break, so fewer chicks hatch and the population falls

Exercise 3.3 (a)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

(a) Calculate the efficiency of transfer from primary to secondary consumers. [1]

Exercise 3.3 (a)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

(a) Calculate the efficiency of transfer from primary to secondary consumers. [1]

(a) $64 \div 800 \times 100 = \mathbf{8}\%$

Exercise 3.3 (b)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

(b) Explain why a pyramid of productivity can never be inverted. [2]

Exercise 3.3 (b)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

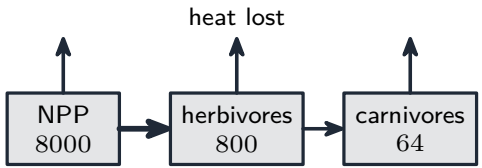
(b) Explain why a pyramid of productivity can never be inverted. [2]

(b) it shows energy flow over time; energy is lost at every transfer, so each level must be smaller than the one below

Exercise 3.3 (c)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

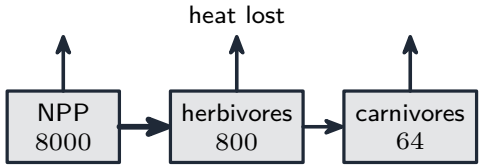
(c) Using the data, discuss whether people should eat less meat to feed a growing population. [3]



Exercise 3.3 (c)

3.3 The diagram shows energy flow in a temperate grassland, in kJ m^{-2} yr^{-1}: NPP 8000; primary consumers 800; secondary consumers 64.

(c) Using the data, discuss whether people should eat less meat to feed a growing population. [3]



(c) eating plants uses NPP directly: about ten times more energy per area than eating herbivores; so less land is needed per person; but some land (dry grassland, hills) cannot grow crops, and meat provides protein and incomes, so a reduction rather than an end may be best