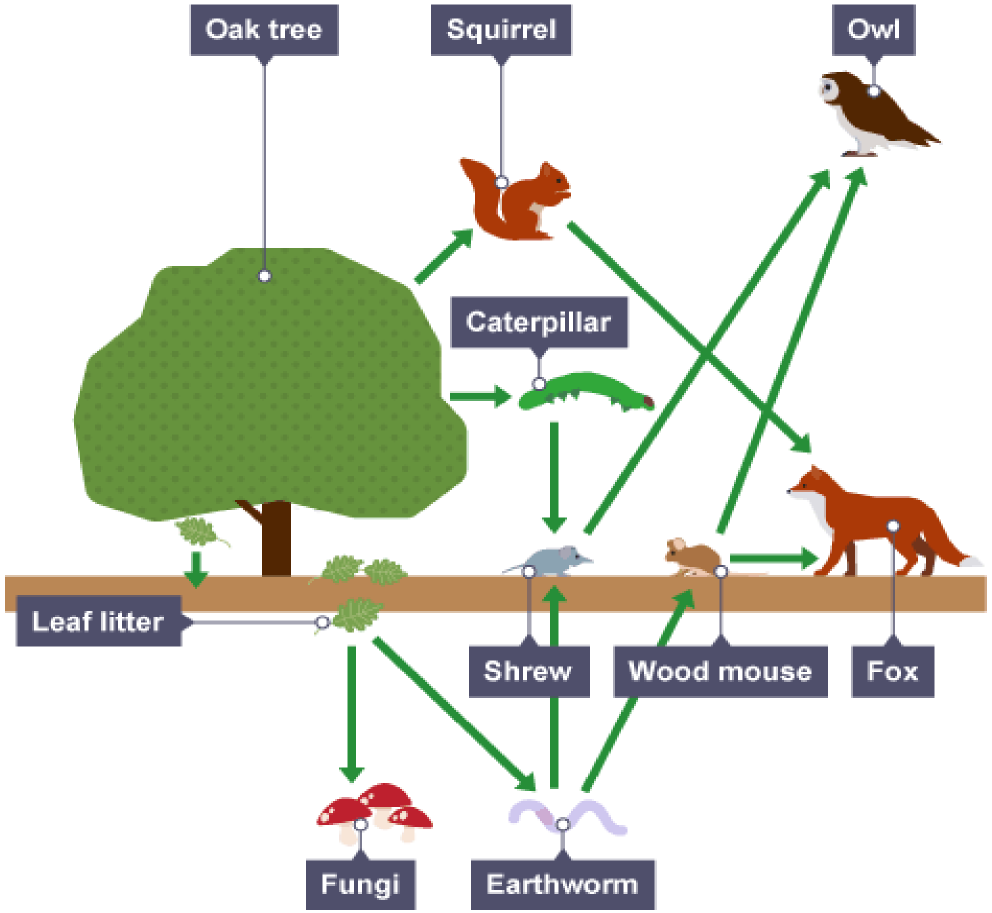
Energy and Ecosystems



Lesson 1: Learning Outcome

- **Explain how plants utilise the sugars from photosynthesis**
- **Explain what is meant by biomass and how it can be measured**
- **Suggest units for biomass**
- **Explain the process of calorimetry**
- **Evaluate the accuracy of results from simple calorimetry**

Task:

Write a sentence which links the following terms together.

DO NOT just give a definition, these are **EXPLAIN** questions.

Terms :6,7,8

Terms: 1,9,6

Terms: 6,9,10

1. Producers	Photosynthetic organisms; manufacture organic substances using light energy, water, carbon dioxide and mineral ions. Usually plants and algae
2. Consumers	Obtain energy by feeding on other organisms- the organic nutrients they consume
3. Primary Consumer	Eat producers; usually herbivores
4. Secondary consumer	Eat the primary consumers
5. Tertiary consumer	Eat the secondary consumers
6. Saprobionts/ decomposers	All fungi and most bacteria; break down complex molecules in dead organisms into simple ones, releasing minerals and elements which can then be recycled
7. Food chain	The feeding relationship, and the related energy transfer – 1^o consumers eat producers, 2^o consumers eat 1^o consumers etc.; arrows show the direction that the energy flows
8. Trophic level	The name for each stage in the food chain
9. Food web	Formed by many food chains linking together in an ecosystem
10.Biomass	Total mass of living material in a specific area at a given time. Measured in dry mass per unit area – g m^{-2}
11. Calorimetery	Used to estimate the chemical energy stored in dry mass

How Energy Enters an Ecosystem

Photosynthesis is the main route by which **energy** enters an **ecosystem.**

Definition: An ecosystem is formed from a community and the non-living (abiotic) components of its environment.

- In any ecosystem plants synthesise organic compounds from either **atmospheric CO_2** (for land-based plants) or **aquatic CO_2** (for aquatic plants and algae).
- The **light energy** is transferred to **chemical energy** in the **organic compounds** made in photosynthesis. Most of the sugars made in photosynthesis, such as **glucose**, are immediately used as respiratory substrates.
- The rest are used to make other carbohydrates such as **starch** and **cellulose** or other biological molecules such as **lipids** and **amino acids.**
- These biological molecules form the **biomass** (mass of living material in the plant) of the plants.

Q: Explain the relationship between photosynthesis, respiration and biomass by answering the question "Where does an oak tree get the materials it needs to grow from?"

- Complete the sentences using the words provided.

1. **Photosynthesis** produces sugars, proteins, fats
2. Sugars are **hydrolysed** into glucose
3. Glucose is **respired** to produce ATP
4. **Energy**/ATP used for growth/mitosis.
5. Energy is stored in biomass

Measurement of biomass

a) A measurement of the mass of carbon **per unit area**

OR

b) the **dry mass** of tissue produced **per unit area** (more commonly used)

- **Dry mass gives you a measure of the *productivity* of an ecosystem.**
- Productivity is a **RATE** so the biomass per unit area, **per unit time**.
- The **higher** the productivity the **higher** the biomass.

Why do you think we compare dry mass not wet mass?

Learn this….

Measuring Dry mass

1. The sample of organism is dried in an oven (normally below 100^{o}C).
2. The sample is weighed after a certain amount of time e.g. 24 hours
3. The sample is **dried again** in the oven **and re-weighed** over and over until the **mass remains constant**, which means all the water has been removed.

<u>Q: Suggest units for dry mass.</u>

kg m^{-2} yr^{-1} (kilograms per metre squared per year)

Or

kg ha^{-1} yr^{-1} (kilograms per hectare per year)

Q: What is the advantage of using these units?

- Allows a comparison of different situations

Estimation the dry mass of wheat in a field

- Collect all wheat in **1 square metre**, **dry them 80^{o}c**, **weigh** them, and **repeat** process until **no further change** in weight, showing that all the water has been removed.
- Then **multiply** answer by number of **square metres** in the field.

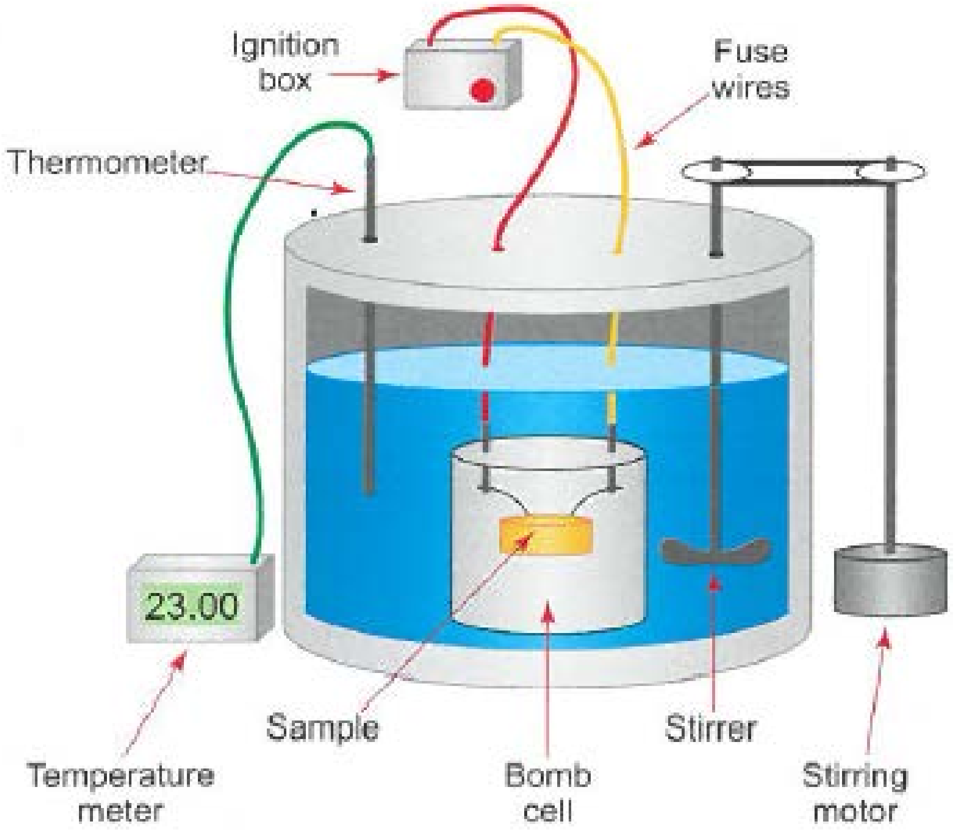
Why does this method help to provide a reliable measurement of the biomass? [2]

- ✓ **Removes water**
- ✓ **Water content may vary in a plant**

Why is this method not usually used in practice? [1]

- ✓ **Destroys the sample**

The Bomb calorimeter



[video](https://www.youtube.com/watch?v=YXo9B2AbH0s)

https://www.youtube.com/watch?v=YXo9B2AbH0s;
https://www.youtube.com/watch?v=EAgbknIDKNo

Calorimetry – Learn this….

Method for calorimetry- Mark scheme answer

1. This is used to measure the chemical energy stored in organic material (biomass)
2. Organic material dried out
3. **Burnt in oxygen** in a combustion chamber.
4. The energy given off is used to heat **a known volume** of water.
5. Increase in temperature of water indicated energy contained in material.
6. The **units are joules / kilojoules (J/kJ)**

Exam question

Q1: ***Explain how you would obtain accurate results from simple calorimetry [2]***

- Check the accuracy of the calorimeter by using KNOWN standards

- Burn pure foods with a KNOWN energy content

Working out energy transfer

In biology we burn materials to work out the chemical energy trapped in their biomass. We **always use water** in a bomb calorimeter so the specific heat is always 4.18 $Jg^{-1}\,^{o}C^{-1}$.

You don't need to learn this equation but its worth having a go! Could come up as application question.

Energy (heat) transfer (J) =

mass of water(g)

x

specific heat capacity($Jg^{-1}\,^{o}C^{-1}$)

x

temperature change(^{o}C)

NOT IN BOOKLET – Use lined paper

Q: In biology we burn materials to work out the chemical energy trapped in their biomass. We always use water in a bomb calorimeter so the specific heat is always 4.18 $Jg^{-1}\,^{o}C^{-1}$. Complete the questions below

a) We use 250g of water and the temperature changes by 30°C. What was the quantity of heat transferred?

- 250 x 4.18 x 30 = 31,350J

b) An oak tree was dehydrated to its biomass. We used 250g of water with an initial temperature of 12°C, once all the biomass was burned the final temperature was 62°C. What was the quantity of heat transferred in the oak tree?

- 250 x 4.18 x 50 = 52,250J

c) From the same food chain a squirrel was dehydrated to its biomass. We used 250g of water with an initial temperature of 18°C, once the biomass was burned the final temperature was 30°C. Compare the energy content of the squirrel biomass to the energy content of the oak tree, can you explain your answer?

- 250 x 4.18 x 12 = 12,540J
- Squirrel is smaller organisms so less biomass (39,710J less energy)

Q2:

Yield can be determined by measuring the dry mass of plants.

(a) Suggest how you could determine the dry mass of a sample of plant material.

....

....

....

....

(2)

(b) What is the advantage of using dry mass and not fresh mass to compare the yield of plants?

....

....

....

....

(2)

(Total 4 marks)

(a) Heat at 100°C / heat to temp to evaporate water;

Value which would not burn material

Weigh and heat until no further change in mass;

(b) Amount of water present will vary;

This will affect fresh mass / will not affect dry mass;

Question 3

(a) 1. 35.22 or 35.23% = 2 marks;

Award 1 mark if only fresh and dry masses correct, 1335.59 and 865.13 g;

2

(b) (After 24 hours)

1. Record mass and reheat;

   Accept return to oven = reheat

2. Until constant mass recorded;

2

(c) 1. Positive correlation (between diameter and biomass);

2. Not linear / geometric / exponential / gradient gets steeper;

2

(d) 1. Calculate a mean diameter;

2. (Use this to) estimate / determine the mean fresh biomass of trees;

3. Use the percentage water content to find the dried biomass;

4. Use the dried density to calculate the mass of tree;

5. Count / estimate the number of trees in plantation and multiply by (mean) carbon content (to find total carbon);

4 max

[10]

Energy Flow through ecosystems

Lesson 2: Learning Outcomes

- ***Explain the concepts of Gross Primary Production and Net Primary Production***
- ***Understand the mathematical relationship between the two, and use it to calculate values when supplied with data***

Definition:

- **Gross Primary Production (GPP) is** the chemical energy store in plant biomass, in a given area.

- GPP represents the total amount of **light energy** which is converted into **stored biomass** during photosynthesis.
- Units are the **energy stored as biomass**, **per area** or **volume**.

$kJ\ m^{-2}$

energy

area

Note: Primary **productivity** is the **RATE** of chemical energy store in a plant biomass in a given area**, in a given time**

kJ m^{-2} $year^{-1}$

energy area time

Net Primary Production (NPP)

Definition:

Net Primary Production (NPP) is the chemical energy store in plant biomass after respiratory losses (**R**) have been subtracted.

Net Primary Production (NPP)

- Plants **respire** to release energy from the biological molecules which make up the **biomass** made in **photosynthesis**, such as glucose.
- We therefore have to **minus** these **respiratory losses** of energy from the GPP.
- This is the **net primary production (NPP).**
- NPP is what is left after the plant has taken what it requires**.**
- NPP represents the potential food available to consumers.

Exam tip: **If an exam questions asks you about NPP or GPP, always write out the equation. It is likely to get you one mark!**

NPP can be calculated using the formula:

$$NPP = GPP - R$$

Net primary production

Gross primary production

Respiratory losses to the environment

- Net primary production is available for plant growth and reproduction.
- It is also available for other trophic levels in the ecosystem such as herbivores and decomposers.

Questions not in booklet - complete on file paper

3 Table 12.1 shows some information about energy transfers in three ecosystems.

	Mature rain forest in Puerto Rico	Alfalfa field in the USA	Young pine forest in England
GPP/ $kJ\,m^{-2}\,year^{-1}$	188 000	102 000	51 000
Respiration by plants/ $kJ\,m^{-2}\,year^{-1}$	134 000		20 000
NPP/ $kJ\,m^{-2}\,year^{-1}$	54 000	64 000	

Table 12.1

a Calculate the figures for respiration by plants in the alfalfa field, and the NPP of the young pine forest.

b How much energy is available to be passed on to the primary consumers in the rain forest?

c Suggest why the GPP of the rain forest is so much greater than that of the pine forest. (You should be able to think of several possible reasons.)

d Suggest why the NPP of the alfalfa field is greater than that of the rain forest. (Again, you may be able to think of several reasons.)

Answer

4 Table 12.2 shows some typical values for NPP in a range of different ecosystems.

Type of ecosystem	NPP/ $kJ\,m^{-2}\,year^{-1}$
desert	280
subsistence farming	3 000
temperate grassland	15 000
temperate forest	26 000
intensive agriculture	30 000
tropical rainforest	40 000

Table 12.2

a Explain why the NPP in desert is so low.

b Suggest why the NPP of temperate forest is greater than that of temperate grassland.

Answer

3 **a** $38\,000\,kJ\,m^{-2}\,year^{-1}$ and $31\,000\,kJ\,m^{-2}\,year^{-1}$

b $54\,000\,kJ\,m^{-2}\,year^{-1}$

c For example, higher light intensity, higher temperatures and higher rainfall allow photosynthesis to take place at a greater rate; there are few seasonal variations in these factors, so photosynthesis can continue all the year round. Coniferous trees in the pine forest must be adapted to withstand cold and water shortage in winter, so they have narrow needles, limiting maximum rates of light absorption even when environmental conditions are ideal for photosynthesis. Tropical rain forest has a greater density of plants.

d Alfalfa plants are young and growing, so much of the carbon they fix in photosynthesis is incorporated into new cells rather than being respired. In the rain forest, the trees are mostly mature and amounts of growth will be small. Alfalfa is a nitrogen-fixer and this, together with the probable application of fertiliser to the crop, could allow greater rates of growth than in the rain forest.

4 **a** The lack of water in a desert limits the density of plants that can grow there, and also their rate of photosynthesis.

b There is a much greater total leaf surface area in a forest than in grassland, so more light is intercepted and more of it is transferred to chemical potential energy during photosynthesis.

Lesson 2 continued….

Learning outcomes:

- Explain the reduction in energy/biomass along a food chain

Factors affecting primary (plant) production

- Production is related directly to the **rate of photosynthesis,** and so is affected by a wide range of biotic and abiotic factors.

Task: For the following examples state if they are biotic or abiotic…..

Factor	
1. The intrinsic ability of the particular species and variety of plant	
2. The intensity of light that falls on them	
3. The duration of light each day	
4. The amount of water that is available	
5. The temperature	
6. The concentration of CO_2 in the atmosphere	
7. The availability of inorganic ions in the soil E.g. nitrates	
8. Competition for light and other resources	
9. Damage to the plants by fungi, insects and other pests	

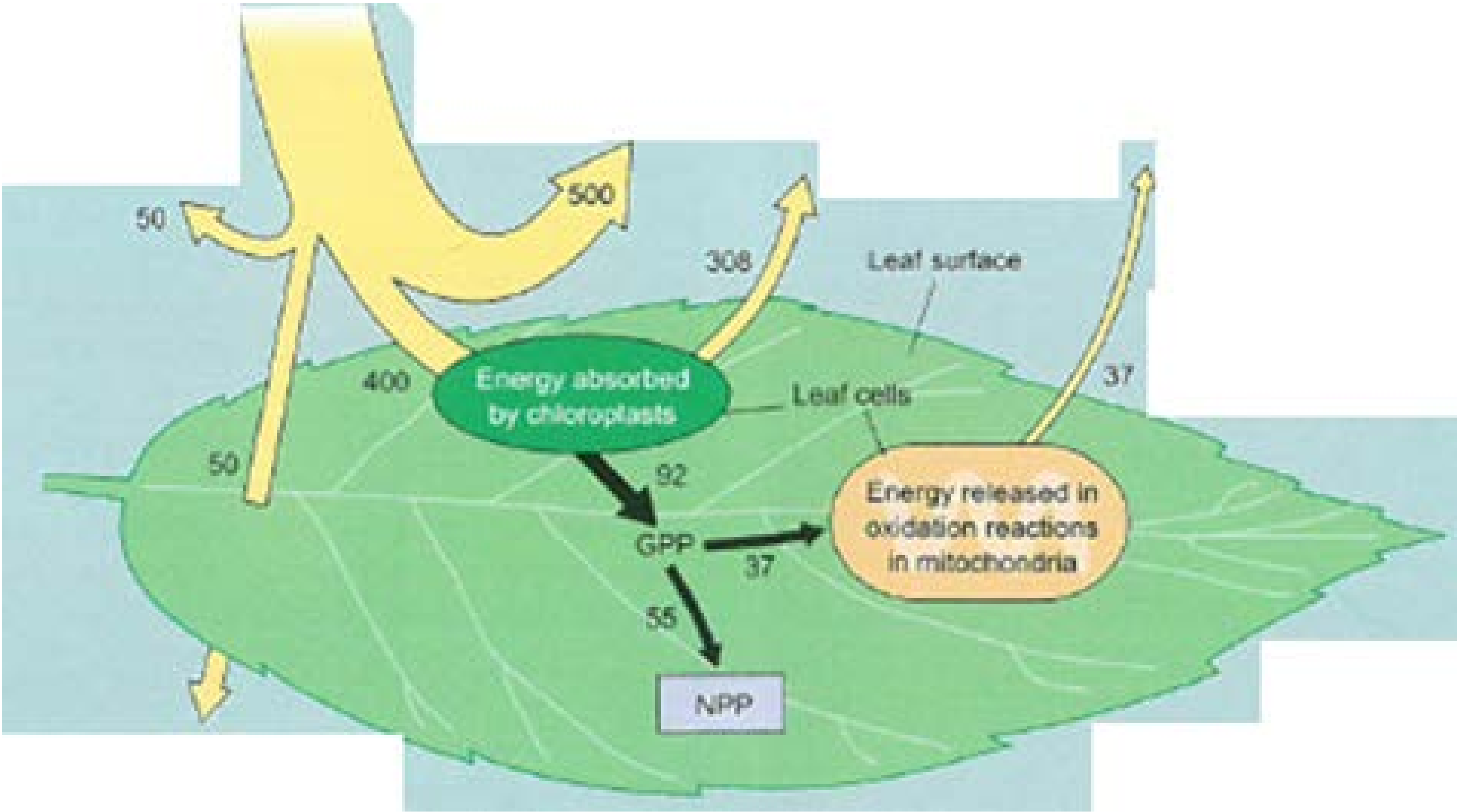
Factor	Type
1. The intrinsic ability of the particular species and variety of plant	Biotic
2. The intensity of light that falls on them	Abiotic
3. The duration of light each day	Abiotic
4. The amount of water that is available	Abiotic
5. The temperature	Abiotic
6. The concentration of CO2 in the atmosphere	Abiotic
7. The availability of inorganic ions in the soil E.g. nitrates	Abiotic
8. Competition for light and other resources	Biotic
9. Damage to the plants by fungi, insects and other pests	Biotic

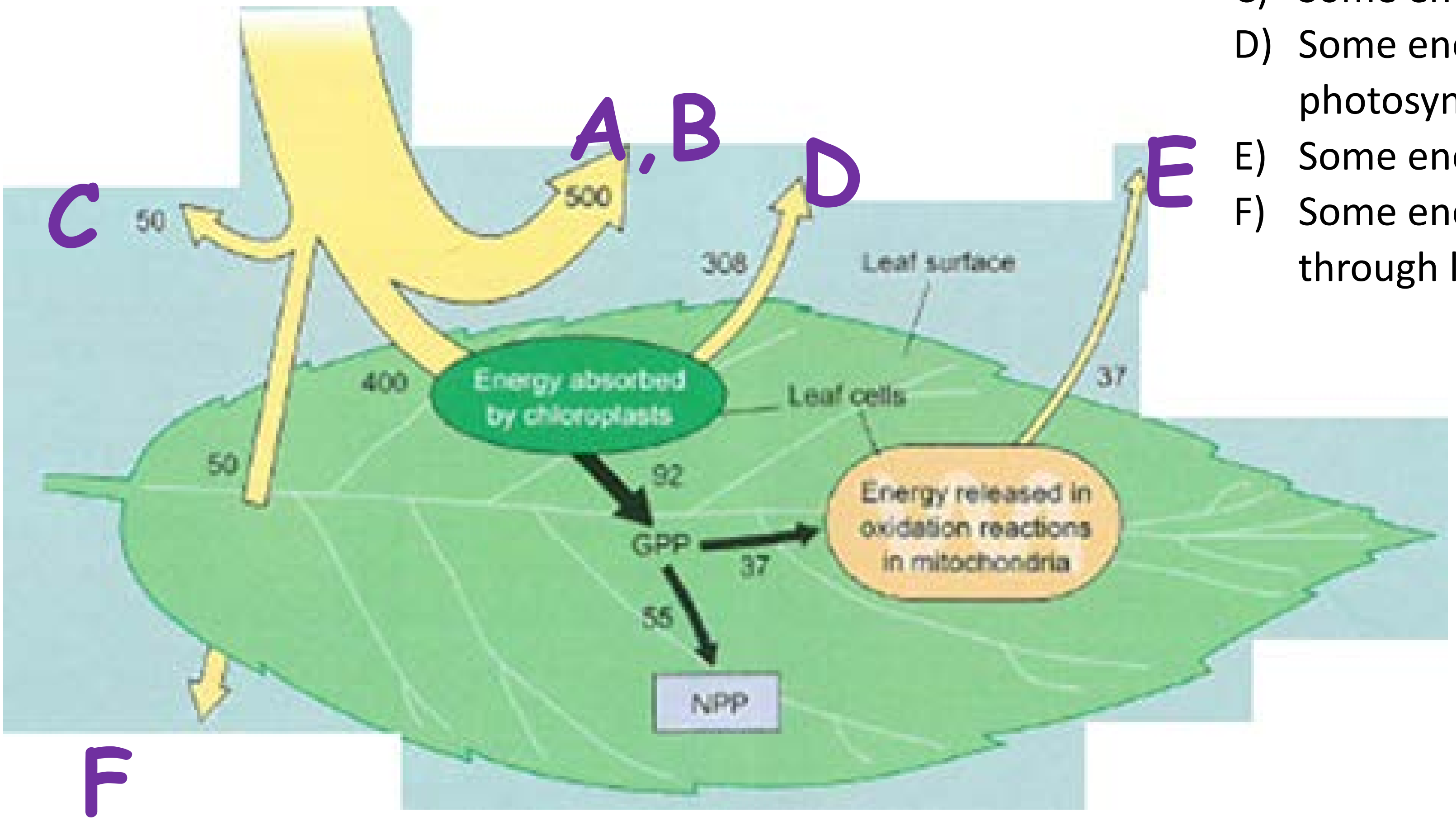
Energy Flow

What are the energy losses?

- The sun is the source of energy for ecosystems.
- However, only 1 % of this light energy is captured by green plants and converted to organic compounds, and so is available to organisms in the food chain.

<u>Task</u>: Add labels A-F onto the diagram on page 7 in your booklet





A) Some is the wrong wavelength to be absorbed by chlorophyll.
B) Some energy is used in evaporating water from leaves
C) Some energy is reflected
D) Some energy is lost during photosynthetic reactions
E) Some energy is lost in respiration
F) Some energy is transmitted straight through leaf, missing the chloroplasts.

Food Chains

- A food chain shows the flow of energy between organisms. Each organism represents a trophic level.
- Decomposers are often not represented on a food chain.
- Producers start the food chain.
- They are photosynthetic organisms such as plants and form their own organic molecules (autotrophic).
- Consumers rely on an external source of organic compounds (heterotrophic) that they have **feed** on. Animals are consumers.

- Primary consumers eat producers
- Secondary consumers eat primary consumers
- Tertiary consumers eat secondary consumers

- Example of food chain with three trophic levels

Water lily (producer)

↓

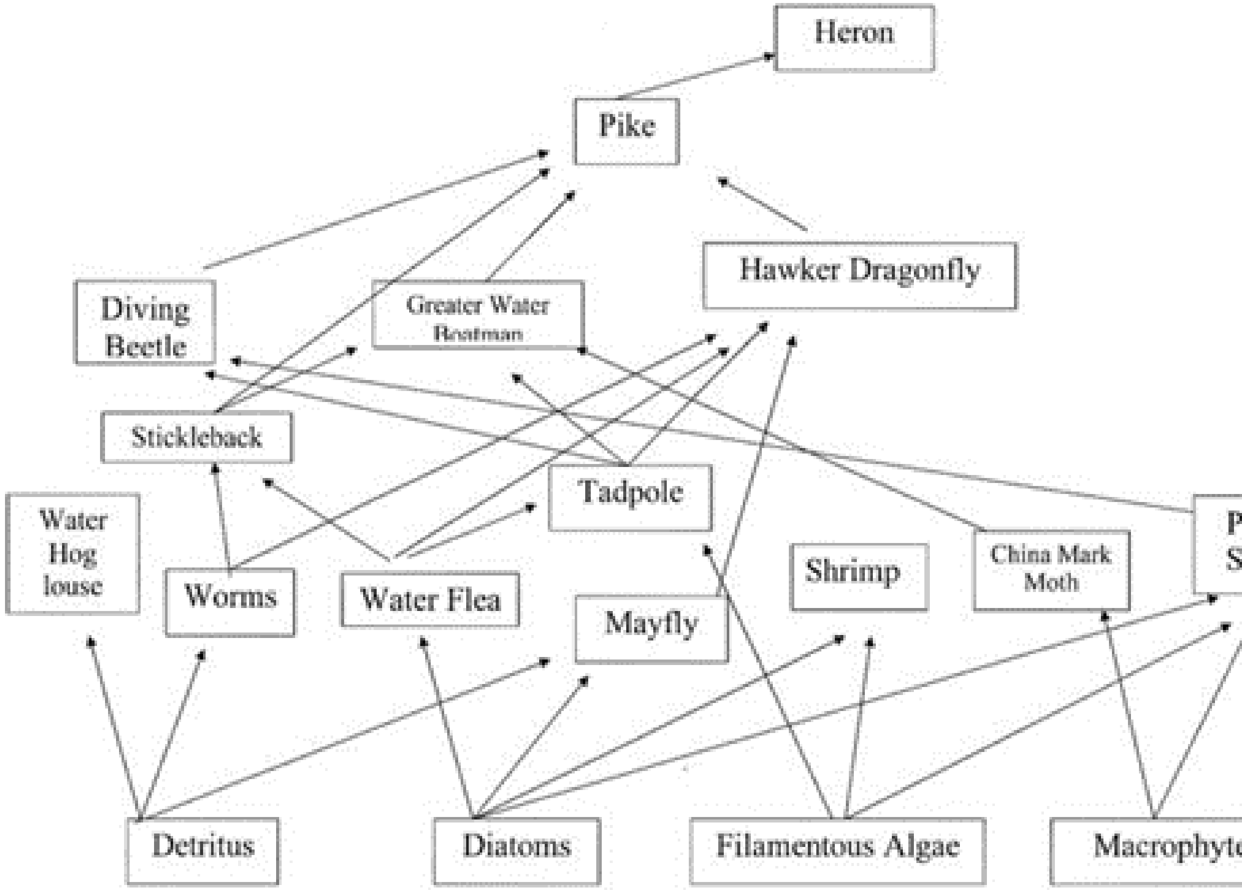
Water boatmen (Primary consumer)

↓

Roach (fish) (Secondary consumer)

Food webs

- In a particular habitat many food chains can be linked together to form a food web.
- The more complex the food web means that any one change in a population will have less of an effect on the other populations, making it more stable.



NPP in Food Chains

NPP is the energy available to:

- **producers** for growth and reproduction.
- **primary consumers** when they eat the producers.
- **decomposers** when they feed on the dead producers/consumers.

Only about 10% of the NPP is transferred to the consumer.

90% is lost.

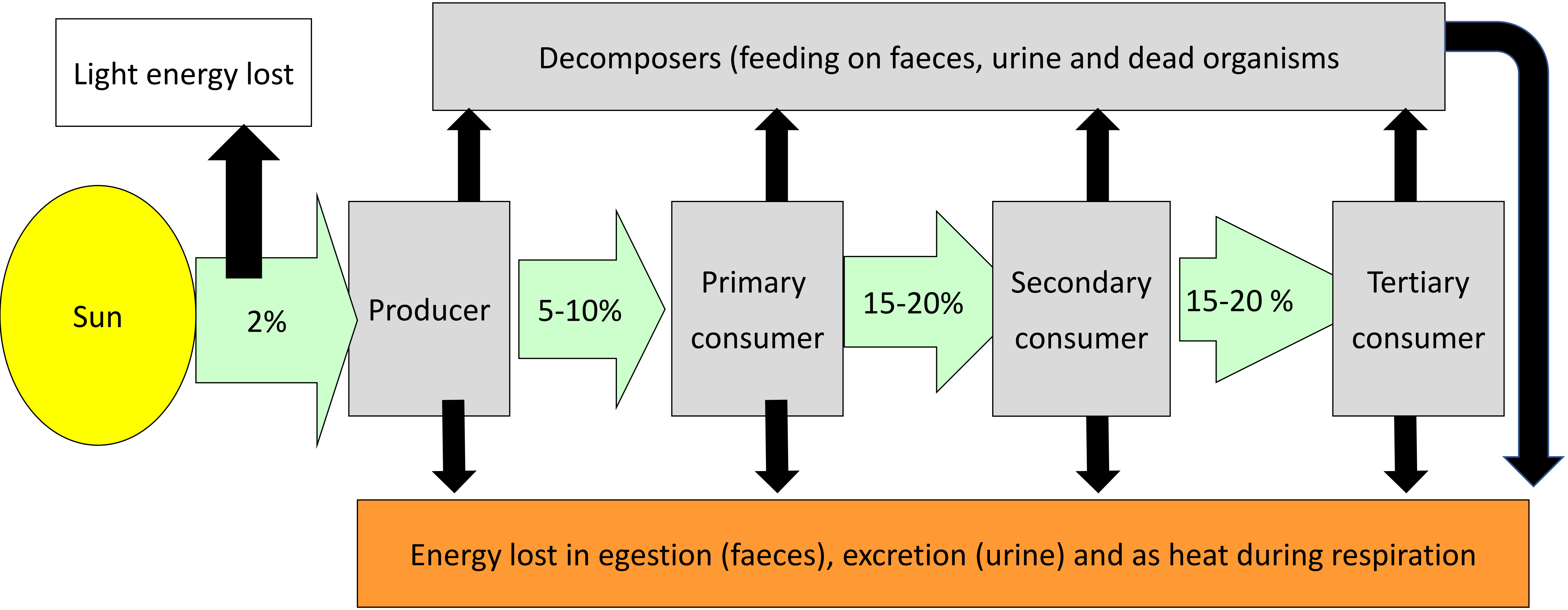
- Some of the organism is indigestible and the energy is egested as faeces.
- Some of the energy is excreted in urine.
- Some of the biological molecules taken in are respired and not incorporated into consumer biomass, this respired energy is lost as heat.

Exam tip:

If an exam question mentions net primary production then you must write

NPP = GGP – R

- This may get you a mark!


Light energy lost
Decomposers (feeding on faeces, urine and dead organisms
Sun
2%
Producer
5-10%
Primary consumer
15-20%
Secondary consumer
15-20 %
Tertiary consumer
Energy lost in egestion (faeces), excretion (urine) and as heat during respiration

Energy transfer

- The % of energy transferred between the producer and primary consumer is less (5-10% compared to 15-20% between consumers)

- due to more indigestible matter in producers, such as cellulose, lost in faeces.

Exam question 4

(a) Used to produce <u>named</u> phosphate compound in cells;
e.g. ATP / ADP / phospholipids / DNA / RNA / RuBP / TP /GP etc.

1

(b) Example of a carbon-containing biological compound e.g. carbohydrate / amino acid / vitamin;

Accept: sugars / organic (compounds).

Ignore: products of photosynthesis.

Ignore: starch.

1

(c) 1. Represents dry <u>mass</u> / <u>mass</u> of carbon;
2. Represents gross production minus respiratory losses;

2. Accept: NPP = GPP −R.

2. Accept: Chemical energy minus respiratory losses.

1 and 2. Chemical energy <u>store</u> minus respiratory losses = 2 marks.

2

(d) 1. For the control an increase in phosphate increases (plant) growth;
2. For *Entrophospora* an increase in phosphate reduces (plant) growth;
3. *Scutellospora* reduces (plant) growth (compared to control);
4. *Entrophospora* and *Glomus* increases (plant) growth (compared to control);
5. No SD / statistical test to determine significance;
6. Only 20 weeks of growth;
7. Underground / root growth not known;

5. *Accept: no error bars.*

7. *Accept: only shows shoot growth.*

4 max

(e) 1. Answer in range 0.07 to 0.09 = **2 marks**;
2. Answer in range 9.97 to 12.2
OR
Shows division by 140 or 20 × 7 = 1 mark;

Lesson 3

Learning outcomes:

- Explain the concept of net production in consumers, linked to energy losses along food chains

Net production

Net production (N) in a <u>consumer</u> is the energy available to the next trophic level. The N reduces as you go from one trophic level to the next due to the energy loss at each level. N can be measured in a consumer as:

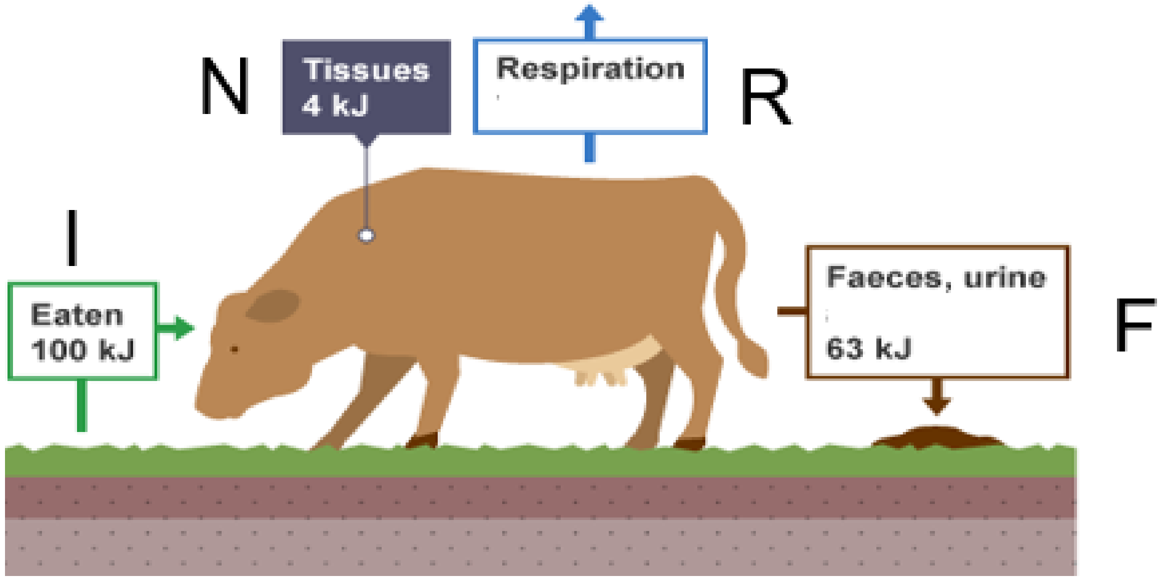
$$N = I - (F + R)$$

Net production

Chemical energy in ingested food

Chemical energy lost in faeces and urine

Energy lost through respiration



Reminder:
NPP refers to the net **<u>primary</u>** production in a **<u>producer</u>**,
N refers to the net production in a **consumers** (higher trophic level)

Secondary production refers to the net quantity of energy transferred and stored in the tissues of consumers (heterotrophs) (i.e. it is net production)

Definitions:

Primary productivity: The **rate** of primary production. It is measured as biomass in a given area in a given time e.g. in kJ m-2 year -1 or kJ ha^{-1} $year^{-1}$

Secondary productivity: The **rate** of secondary production. It is measured as biomass in a given area in given time e.g. kJ m^{-2} $year^{-1}$ or kJ ha^{-1} $year^{-1}$

Exam Tip:

- **ha^{-1} $year^{-1}$ means per hectare per year**
- **1 hectare is equivalent to 10,000m^2**

Example of calculation

- *Note: When net production is expressed as a* ***RATE*** *it is net* ***productivity.***

- The rabbits in a ecosystem ingest 20,000 kJ m^{-2} yr^{-1} of energy.
- They lose 12,000 kJ m^{-2} yr^{-1} of energy in their faeces and urine, and use 6,000 kJ m^{-2} yr^{-1} for respiration.

- **What is the net productivity of the rabbits?**

$$N = I - (F + R)$$

$$N = 20{,}000 - (12{,}000 + 6{,}000)$$

$$= 20{,}000 - 18{,}000$$

$$= 2{,}000 \text{ kJ m}^{-2} \text{ yr}^{-1}$$

Efficiency of Energy Transfer

To calculate the efficiency of energy transfer between trophic levels:

$$\% \text{ efficiency of energy transfer} = \frac{\text{net production of trophic level}}{\text{net production of previous tropic level}} \times 100$$

e.g. The available energy, N, in a trout is 250 kJ m^{-2} $year^{-1}$ and the energy available to a human after eating it is 50 kJ m^{-2} $year^{-1}$. What is the efficiency of the energy transfer?

$$\% \text{ efficiency of energy transfer} = \frac{50}{250} = 0.2 \times 100 = 20\%$$

Learning outcomes:

- Explain the ways in which productivity is affected by simplifying food webs

Increasing Efficiency in Food Chains

- Productivity is affected by farming practices designed to increase the efficiency of energy transfer to humans by:
- Simplifying food webs to reduce energy losses to non-human food chains
- Reducing respiratory losses within a human food chain
- Simplifying food webs involves getting rid of food chains which do not include humans. This can increase the proportion of energy transferred to humans as less is eaten by other organisms.

- e.g. Weed → aphid → ladybird
- Wheat → human

- In this example by removing the aphids, there is less competition between the aphids and the humans for the wheat as the aphids reduce the biomass of the wheat by eating it. The aphids can be removed in 3 ways:

- By using **chemical control**
  - Using an **insecticide** to kill the aphids directly.
  - Using an **herbicide** to kill the weeds which in turn removes interspecific competition for the crop for abiotic factors such as light and also removes a food source for the aphids reducing their numbers.

- By using **biological control**, such as adding ladybirds to the ecosystem which in turn eat the aphids.

Reducing Respiratory Losses

- By **reducing rate of respiration** in livestock this will reduce R in the equation, increasing N. Less energy is lost through respiration and more is used for growth and biomass.

- **Movement can be restricted** by keeping animals in pens so less respiration occurs to release energy for muscle contraction.
- **Animals can be kept indoors or heated rooms** so less respiration occurs to generate heat to maintain body temperature.

Task: Use the words below to fill in the blanks on the mark scheme perfect answers on page 12 of your booklet

- higher; respiration ; eat; consume; moving around; excretory; roots; herbivores; faeces; faeces; digest; digest; warm; hooves, horns, hair; respiration; energy; reflected; body temperature; chloroplast; respiration; wavelength; excretion; misses; faeces; eaten; heat; food;

Learn

xam question: ***Describe reasons for the low efficiency of energy transfer from producer to primary cons.***

1. The primary consumers **herbivores** / cattle, do not eat all the grass (e.g. **roots**).
2. They do not **digest** all the grass consumed (produce lots of **faeces**.
3. Most of the energy they DO absorb is used in **respiration**.
4. A lot of the energy is used to keep themselves **warm** by **moving around.**

Exam question: ***Describe reasons for the low efficiency of energy transfer <u>between consumers</u>.***

1. Secondary consumers (us) don’t **eat** all the cow (e.g. **hooves, horns, hair**).
2. We can’t **digest** everything we **consume** (produce **faeces**)
3. There are losses in **excretory** materials – urine
4. Some is lost as heat from **respiration** to the environment – the higher the body temp., the **higher** the **energy** needed to maintain it

Exam question: ***Describe reasons for the low efficiency of energy transfer through ecosystems-***

- Some light is **reflected** / not of the appropriate **wavelength**
- Some light **misses** leaves / does not strike **chloroplasts**
- There is **heat** loss / energy is used to maintain **body temperature**
- There is energy loss via **respiration**
- There is energy loss via **faeces** / undigested **food** / some parts of organism are not **eaten**
- There is loss via **excretion** / urine

Lesson 4

Learning outcomes:

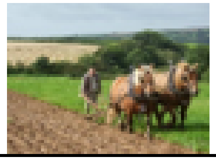
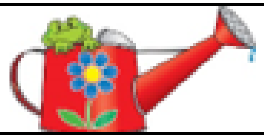
- Explain the ways in which farmers are reducing respiratory losses within a human food chain
- Interpret and calculate data on efficiency when provided with appropriate information
- Evaluate the ethics of some of these farming practices

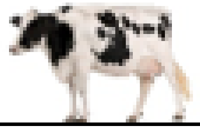
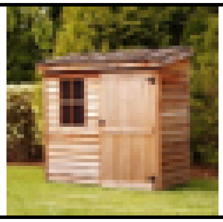
Tasks:

1. Complete farming practices table.

- Read Toole and Toole, p.303-304. **This is available on connect in the online learning tab.**
- Match up the action with reason in the table

2. Complete the efficiency of grazing animals questions on page 14 – 15.

Action to improve productivity	Reason
Add fertilisers to soil 	e.g. nitrates for protein synthesis; phosphate for ATP & DNA synthesis
pesticides are added	to prevent damage or consumption of crop
weed killers/herbicides, are added	to remove competition
Crops are selectively bred or genetically modified	For high productivity
Use of greenhouses increase temperature, CO_2 conc and light intensity 	To increase rate of photosynthesis / remove limiting factors
Ploughing	aerates soil so improves drainage
Ploughing/ aeration 	allows nitrification (decreases denitrification)
Crops are protected by birds / pests / frost, by use of netting, covers	To prevent loss of crop / increase yield
Watering 	So it is not a limiting factor
Crop rotation	to improve soil nutrients

Livestock is slaughtered when still growing 	more energy is transferred into biomass
Livestock is fed on concentrate / a controlled diet 	a higher proportion of food is digested, absorbed and used for biomass / less is lost in faeces
Their movement is restricted	less heat / energy, is lost - there is less respiratory loss
They are kept warm 	less energy is used to maintain body temperature
There is selective breeding	for high productivity

Limiting factor	Management in glasshouse/polytunnel
CO_2 concentration	Increased by burning propane in generator
Light	Light through glass Lights in the dark
Temp	Glass traps lights' heat Heating and cooling systems incl circulating systems.

The efficiency of a grazing animal

- Scientists investigated the efficiency of an individual herbivore. They chose a bullock, because its energy transfer is not complicated by the milk producing process.

- Firstly, they needed to estimate the energy contained in the food eaten by the animal, which they did by taking samples of grass from a field. The plot selected was one hectare.

- One hectare measures 100m by 100m. It’s about the size of a football or rugby pitch.

THE EFFICIENCY OF A GRAZING ANIMAL – ANSWERS

1. 10 000
2.
a. 0.2%
b. It mimics grazing. It just removes the upper parts/leaves, leaving the roots.

3. To avoid bias / the conscious choice of the scientist.

4. Give each square metre a number. Select 20 using a random number generator.

5. To make sure all the water was removed.

6. 63.2% (1.25 – 0.46 = 0.79, 0.79/1.25 x100)

7. **Burnt in oxygen** in a combustion chamber. The energy given off is used to heat **a known volume** of water. Increase in temperature of water indicated energy contained in material (**units: J/kJ)**

8. N = 160 kJ

9. 160 as a % of 5000 is 3.2%.

10. Meat is much more digestible than plant material. Less is wasted in faeces (indigestible cellulose, etc.)

Task:

- Complete the additional questions on the following two slides on file paper.

Practice Questions — Application

Q1 A scientist wanted to measure the biomass of a crop of wheat. To do so, he took a sample of the wheat and measured its dry mass.

a) Describe how the scientist could have measured the dry mass of the wheat.

b) At what point in the year might it be most appropriate for the scientist to take his sample? Give a reason for your answer.

c) Once the scientist has a sample of dry mass, he decides to burn it in a calorimeter. What will the results from this procedure tell him about the wheat?

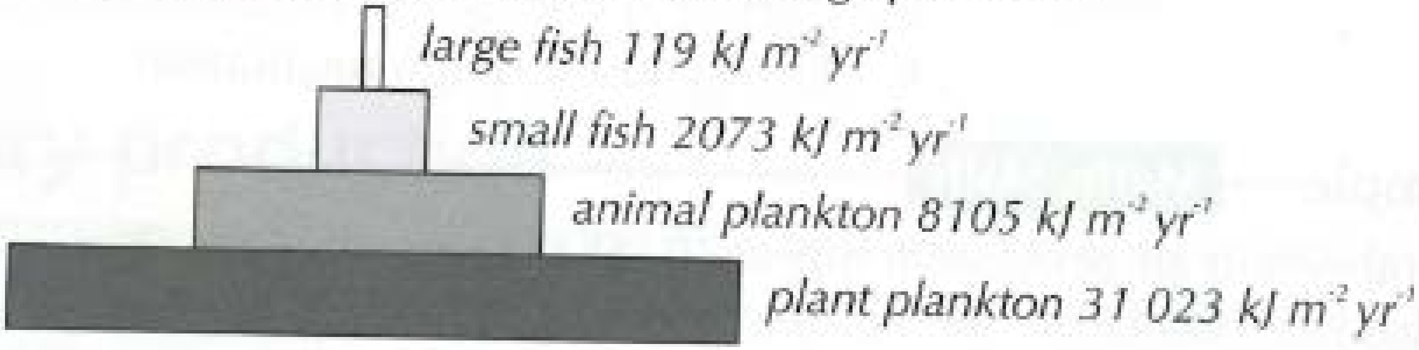
Q2 The mussels in an ecosystem ingest 57 153 kJ m^{-2} yr^{-1}. 34 292 kJ m^{-2} yr^{-1} is indigestible or lost through urine and 17 000 kJ m^{-2} yr^{-1} is lost through respiration.

a) Calculate the net production of the mussels.

The mussels provide food for crayfish which have a net production of 627 kJ m^{-2} yr^{-1}.

b) Calculate the efficiency of energy transfer between the mussels and the crayfish.

Q3 The diagram below shows the net primary production of plant plankton in a food chain, as well as the net production at different trophic levels in the same food chain.
Use the diagram to answer the following questions.



a) The respiratory loss of the plant plankton is 15 604 kJ $m^{-2}yr^{-1}$ Calculate their gross primary production.

b) The small fish ingest 8105 kJ $m^{-2}yr^{-1}$ and lose 3988 kJ $m^{-2}yr^{-1}$ in faeces and urine. Calculate the respiratory loss of the small fish.

c) The respiratory loss of the large fish is 879 kJ $m^{-2}yr^{-1}$. Calculate the amount of energy lost in faeces and urine by the large fish.

d) Give two reasons why the net production of the large fish is less than the net production of the small fish.

e) Calculate the percentage efficiency of energy transfer between each stage of the food chain.

1. Energy Transfer in Ecosystems

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Q1 a) He could have dried out the sample he took in an oven set at a low temperature, checking the weight every day until it became constant. At this point, all the water would have been removed and this would be the dry mass of the sample.

b) It will give him an estimate of the chemical energy stored in the wheat.

Q2 a) $N = I - (F + R)$

$N = 57\ 153 - (34\ 292 + 17\ 000)$

$N =$ **5861 kJ m^{-2} yr^{-1}**

b) % efficiency of energy transfer = (net productivity of trophic level ÷ net productivity of previous trophic level) × 100

$(627 \div 5861) \times 100 =$ **10.7%**

Q3 a) $NPP = GPP - R$. This can be rearranged to give:
$GPP = NPP + R$, so
$GPP = 31\ 023 + 15\ 604$
$= \mathbf{46\ 627\ kJ\ m^{-2}\ yr^{-1}}$

b) $N = I - (F + R)$. This can be rearranged to give:
$R = I - F - N$, so
$R = 8105 - 3988 - 2073$
$= \mathbf{2044\ kJ\ m^{-2}\ yr^{-1}}$

Remember, N is the net productivity of the small fish, I is the amount of energy the small fish ingest from food, F is the amount of energy lost in faeces and urine, and R is the respiratory loss of the fish. You're given the numbers you need for I and F in the question — you just have to find N from the diagram, and rearrange the formula to find R. Double check your answer by plugging the values for I, F, and R back into the equation for N. If you've calculated R correctly, you should come up with
$N = 2073$ KJ $m^{-2}\ yr^{-1}$.

c) $N = I - (F + R)$. This can be rearranged to give:
$F = I - R - N$, so
$F = 2073 - 879 - 119$
$= \mathbf{1075\ kJ\ m^{-2}\ yr^{-1}}$

Again, rearrange the formula and put in the values you know. R is given in the question, N is shown on the diagram and I is also on the diagram — it's the net productivity of the small fish.

d) Any two from: e.g. because some parts of the small fish aren't eaten so the energy isn't taken in. / Because some parts of the small fish are indigestible and so are egested as faeces. / Because some of the energy is lost to the environment through respiration or excretion of urine.

e) % efficiency of energy transfer =
(net productivity of trophic level ÷ net productivity of previous trophic level) × 100
Between plant plankton and animal plankton =
(8105 ÷ 31 023) × 100 = **26.1%**
Between animal plankton and small fish =
(2073 ÷ 8105) × 100 = **25.6%**
Between small fish and large fish =
(119 ÷ 2073) × 100 = **5.7%**

Complete exam question 5

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Exam Q 5

1. Two marks for correct answer in range 16.8 to 18.9;; 2. One mark for incorrect answer in which candidate divides 19 to 21 by 111 to 113;	2	Ignore additional decimal places. Working shown in mm. Accept working in cm/2mm squares (10/56) for 1 mark.
1. Single-celled producers are more digestible / contain less cellulose (than plants) / less energy lost in faeces; 2. All of producer eaten/parts of plant not eaten; 3. Less heat/energy lost / less respiration;	2 max	3. May refer to either trophic level
1. Photosynthesis/light dependent reaction/light independent reaction; 2. Carbon-containing substances;	2	Allow organic substance or named organic substance

Thank you!