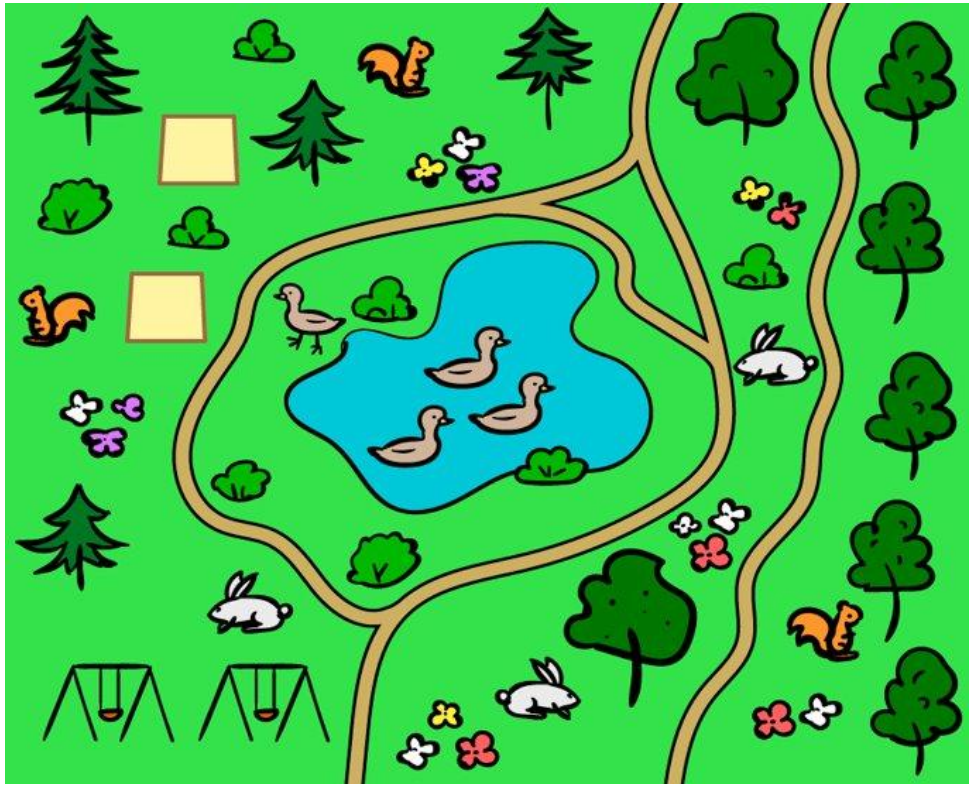
# Ecosystems and Harder Calculations



# Material Covered

## Energy Transfer in Food Chains

1. Biomass
2. Net Productivity
3. Transfer of Biomass

## Population Growth

1. Factors affecting Population Size
2. Interactions between and within Populations

# Material Covered

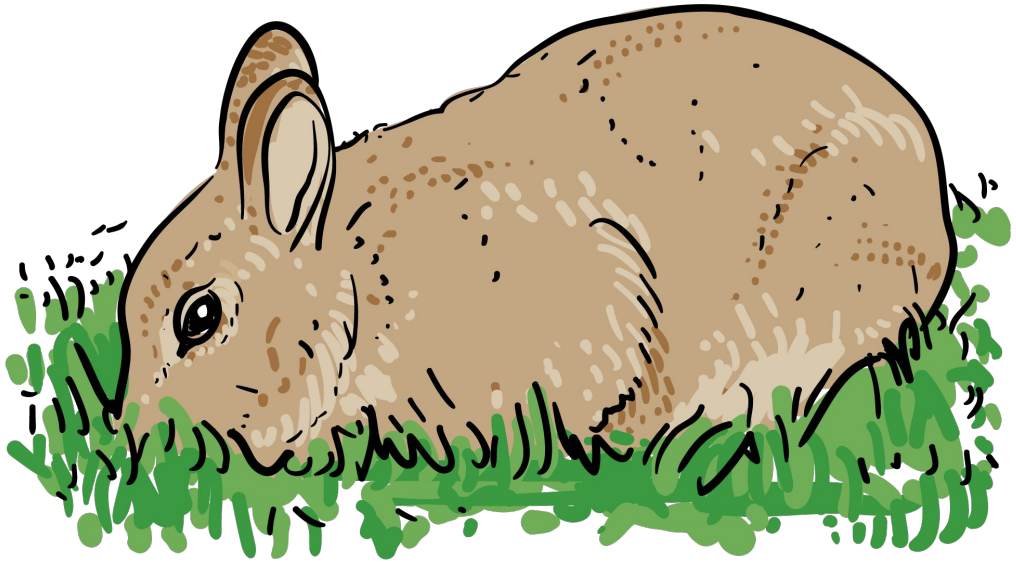
## Succession

1. Primary Succession
2. Features of Succession

## Statistical Tests

1. Students t-test
2. Spearman's Rank Correlation

# Energy Transfer in Food Chains



# Specification Points

## AQA

### 3.5.3 Energy and ecosystems (A-level only)

| Content | Opportunities for skills development |
|---|---|
| In any ecosystem, plants synthesise organic compounds from atmospheric, or aquatic, carbon dioxide.<br><br>Most of the sugars synthesised by plants are used by the plant as respiratory substrates. The rest are used to make other groups of biological molecules. These biological molecules form the biomass of the plants.<br><br>Biomass can be measured in terms of mass of carbon or dry mass of tissue per given area. The chemical energy store in dry biomass can be estimated using calorimetry.<br><br>Gross primary production ($GPP$) is the chemical energy store in plant biomass, in a given area or volume.<br><br>Net primary production ($NPP$) is the chemical energy store in plant biomass after respiratory losses to the environment have been taken into account,<br><br>ie $NPP = GPP - R$<br><br>where $GPP$ represents gross production and $R$ represents respiratory losses to the environment.<br><br>This net primary production is available for plant growth and reproduction. It is also available to other trophic levels in the ecosystem, such as herbivores and decomposers.<br><br>The net production of consumers ($N$), such as animals, can be calculated as:<br><br>$N = I - (F + R)$<br><br>where $I$ represents the chemical energy store in ingested food, $F$ represents the chemical energy lost to the environment in faeces and urine and $R$ represents the respiratory losses to the environment.<br><br>Primary and secondary productivity is the rate of primary or secondary production, respectively. It is measured as biomass in a given area in a given time eg kJ $ha^{-1}$ $year^{-1}$. | **MS 0.1**<br><br>Students could be given data from which to calculate gross primary production and to derive the appropriate units.<br><br>**AT a**<br><br>Students could carry out investigations to find the dry mass of plant samples or the energy released by samples of plant biomass.<br><br>**MS 2.4**<br><br>Students could be given data from which to calculate:<br>• the net productivity of producers or consumers from given data<br>• the efficiency of energy transfers within ecosystems.<br><br>**MS 0.3**<br><br>Students could be given data from which to calculate percentage yields. |

## OCR

### 6.3.1 Ecosystems

| | Learning outcomes | Additional guidance |
|---|---|---|
| **(b)** | biomass transfers through ecosystems | To include how biomass transfers between trophic levels can be measured<br>**AND**<br>the efficiency of biomass transfers between trophic levels<br><br>$efficiency = \frac{biomass\ transferred}{biomass\ intake} \times 100$<br><br>**AND**<br>how human activities can manipulate the transfer of biomass through ecosystems.<br><br>*M0.1, M0.2, M0.3, M0.4, M1.1, M1.3, M1.6*<br>HSW12 |

# Specification Points

## Edexcel A

### Topic 5: On the Wild Side

| Students should: | |
|---|---|
| 5.10 | i) Be able to calculate net primary productivity.<br>ii) Understand the relationship between gross primary productivity, net primary productivity and plant respiration. |

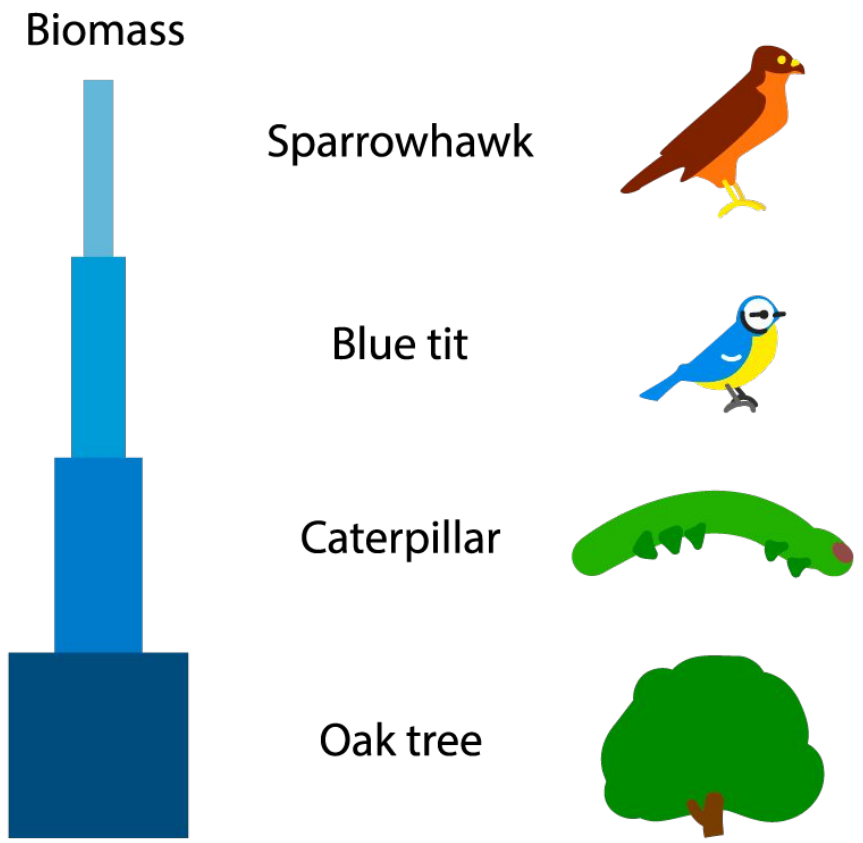
## Edexcel B

### Topic 10: Ecosystems

| Students should: | |
|---|---|
| **10.1** | **The nature of ecosystems** |
| iii | Understand the advantages and disadvantages of pyramids of numbers, biomass (dry) and energy as useful representations of ecosystem structure and how biomass and energy are transferred within them. |

# Biomass

- A **food chain** is the sequence of feeding **interactions** between organisms in a given habitat – they involve **transfer** of **biomass**
- Biomass is the **total mass** of **living material** in a **given area**, measured in **dry mass per given area**, usually given as **grams per square meter ($gm^{-2}$)**
- A **pyramid** of **biomass** shows the amount of **dry biomass** at each **trophic level** in a **food chain**



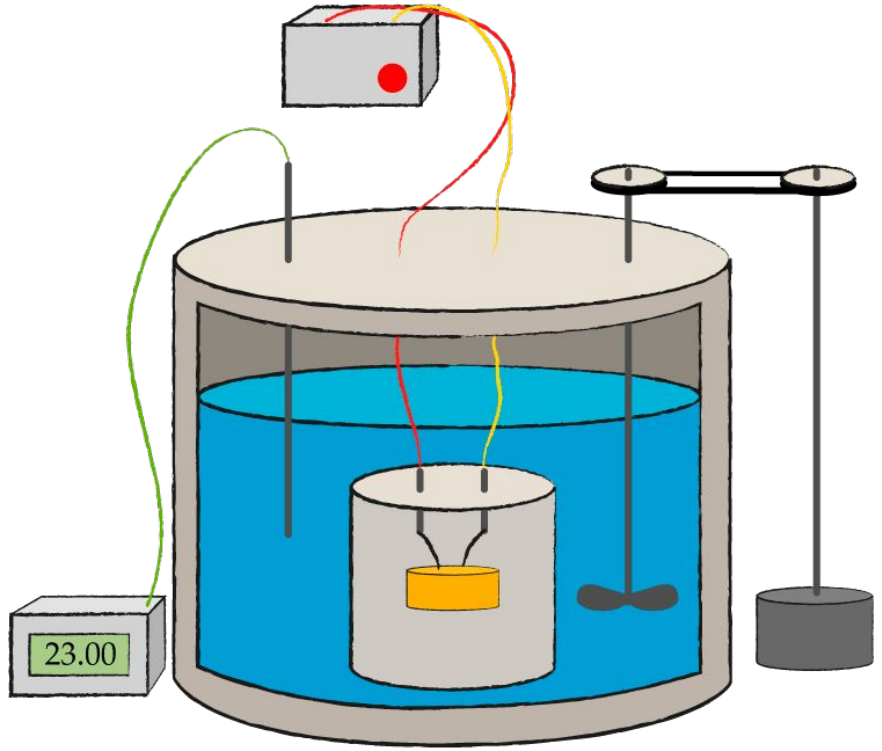
# Measuring Energy Content of Biomass

AQA only

- **Dry biomass** is more **accurate** to use than wet biomass, as **wet biomass** is affected by water uptake and loss whereas dry mass remains **constant**

- **Calorimetry**, using a **bomb calorimeter**, measures the **energy released** by **burning dry biomass** in a **closed environment**

- Dry biomass is **weighed** and burnt in **pure $O_2$**, the **heat** raising the **temperature** of surrounding **water**, and allowing the amount of **energy** released to be calculated



# Exemplar Exam Question - Statement

1) When calculating the biomass at each trophic level, scientists use dry biomass instead of wet biomass.

Give **one** limitation of measuring dry biomass.

**[1 mark]**

**Command**: simple answer

**Direction**: only give one limitation, no mention of wet biomass needed

**Context**: measuring biomass

# Exemplar Exam Question - Statement

1) When calculating the biomass at each trophic level, scientists use dry biomass instead of wet biomass.

Give **one** limitation of using dry biomass.

**[1 mark]**

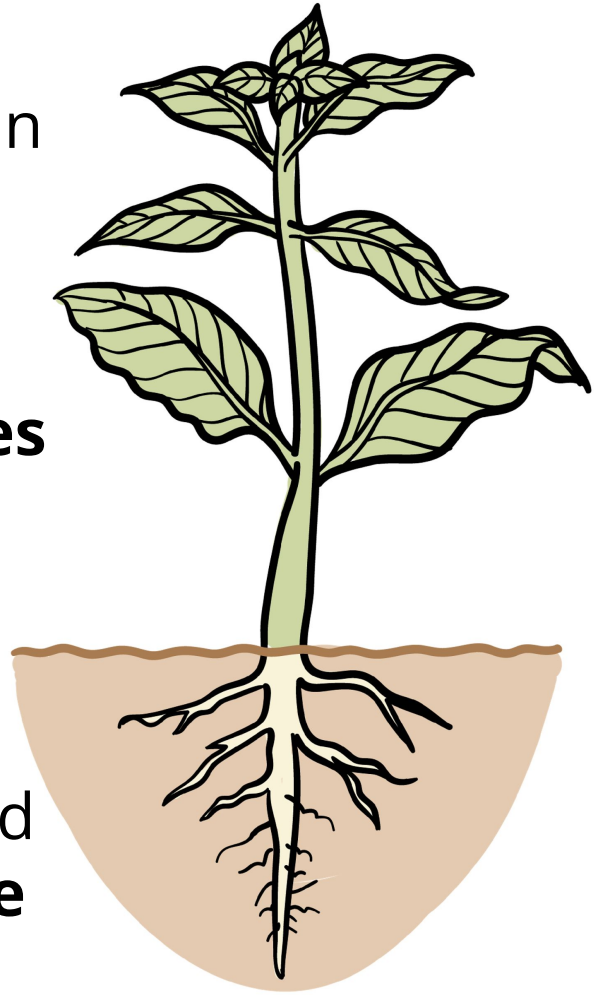
Water content is removed from organisms which means that the organisms need to be killed to measure the dry biomass.

# Gross Primary Production

- Plants use **light energy** and **carbon dioxide** to generate **complex carbon molecules** and **increase** their **biomass** – they are **primary producers**
- **Gross primary production (GPP)** is the **total quantity** of **chemical energy stored** in **biomass produced** by the **plant** by **photosynthesis** in a given **area** or **volume**
- **Gross primary production** can be measured in terms of **biomass** or **energy** in a **given area** or **volume**

# Net Primary Production

- Around **20-50%** of GPP is used by the **plant** in **respiration** and **not stored** as **biomass**
- **Net primary production (NPP)** is the **chemical energy store** in a plant once **losses** due to **respiration** are considered
- **NPP = GPP – R (Respiratory losses)**
- The **rate** of **net primary production** is called **net primary productivity** and includes **time** in the units (g $m^{-2}$ $yr^{-1}$ or kJ $m^{-2}$ $yr^{-1}$)



# Exemplar Exam Question – Calculation

2) Marram grass within an ecosystem has a gross primary productivity of 53200 kJ $m^{-2}$ $yr^{-1}$, but has respiratory losses of 23200 kJ $m^{-2}$ $yr^{-1}$.

Calculate the net primary productivity of the marram grass.

**[2 marks]**

**Command**: numerical figure, include units

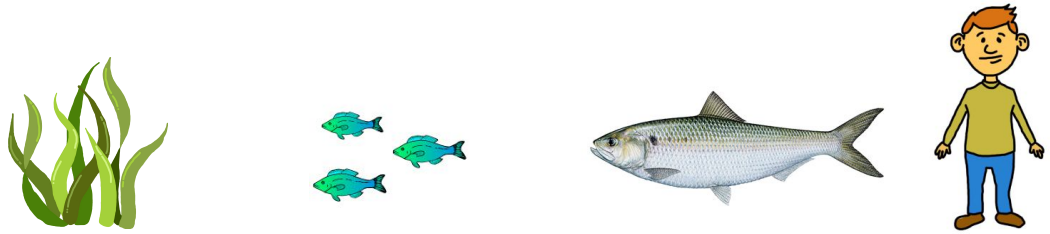
**Direction**: NPP = GPP - R

**Context**: calculating NPP

# Exemplar Exam Question – Calculation

# Net Production of Consumers

**AQA: Net production of consumers**



- All of the **net primary production** is available to consumers but not all of this **energy** is converted to **biomass** in the consumer

- **Net production of consumers** is the **total chemical energy consumers store** after energy losses to **faeces**, **urine** and **respiration** have been taken away

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

- **Transfer** of **biomass** between **trophic levels** is calculated using the following formula for **percentage efficiency**:

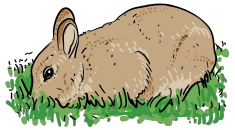
$$= \left( \frac{\text{energy available after transfer}}{\text{energy available before transfer}} \right) \text{x } 100$$

# Sources of Biomass Loss

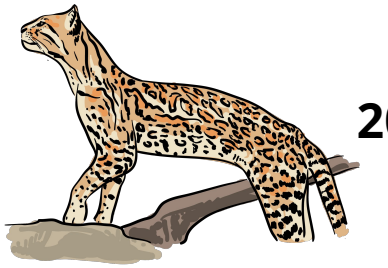
- Only **1-3%** of **light energy** from the sun is converted into **biomass** by **producers**:
    - **Not all wavelengths** of **light absorbed**
    - **Light** may **not hit chlorophyll**
    - **Sun's energy reflected** by **atmosphere**
    - Other **photosynthesis limiting factors**

- **10%** of **producer's energy** is available to **primary consumers**:
    - **Not all** of organism **consumed**/edible
    - **Energy loss** through **excretion/respiration**
    - **Energy loss** through **heat/movement**

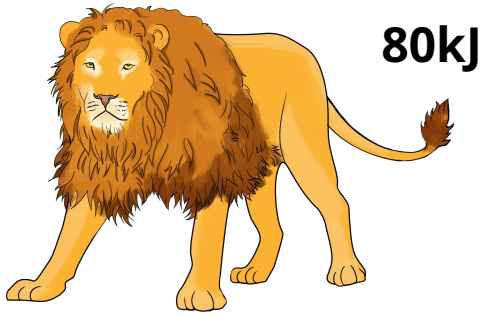
**40,000kJm$^{-2}$yr$^{-1}$**



**6000kJm$^{-2}$yr$^{-1}$**



**2000kJm$^{-2}$yr$^{-1}$**



**80kJm$^{-2}$yr$^{-1}$**

# Exemplar Exam Question – Calculation

3) Calculate the percentage efficiency of energy transfer between an algae plant and a minnow if the net primary productivity of the algae is 54320 $kJm^{-2}yr^{-1}$, and the net productivity of a minnow is 7210 $kJm^{-2}yr^{-1}$.

**[2 marks]**

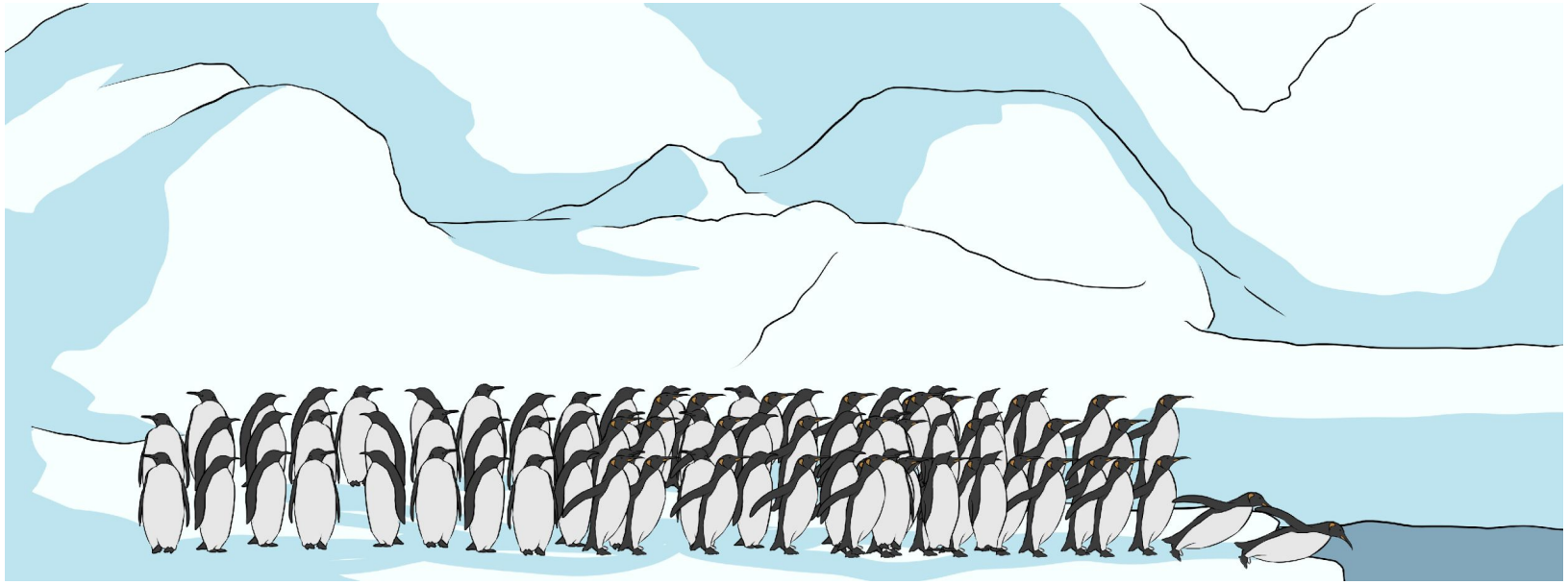
**Command**: numerical answer as a percentage

**Direction**: recall the correct equation

**Context**: ensure to use the correct units

# Exemplar Exam Question – Calculation

# Population Growth



# AQA

## 3.7.4 Populations in ecosystems (A-level only)

| Content | Opportunities for skills development |
|---|---|
| Populations of different species form a community. A community and the non-living components of its environment together form an ecosystem. Ecosystems can range in size from the very small to the very large.<br><br>Within a habitat, a species occupies a niche governed by adaptation to both abiotic and biotic conditions.<br><br>An ecosystem supports a certain size of population of a species, called the carrying capacity. This population size can vary as a result of:<br>• the effect of abiotic factors<br>• interactions between organisms: interspecific and intraspecific competition and predation.<br><br>The size of a population can be estimated using:<br>• randomly placed quadrats, or quadrats along a belt transect, for slow-moving or non-motile organisms<br>• the mark-release-recapture method for motile organisms. The assumptions made when using the mark-release-recapture method.<br><br>Ecosystems are dynamic systems.<br><br>Primary succession, from colonisation by pioneer species to climax community.<br><br>At each stage in succession, certain species may be recognised which change the environment so that it becomes more suitable for other species with different adaptations. The new species may change the environment in such a way that it becomes less suitable for the previous species.<br><br>Changes that organisms produce in their abiotic environment can result in a less hostile environment and change biodiversity.<br><br>Conservation of habitats frequently involves management of succession. | **AT k**<br><br>Students could:<br>• investigate the distribution of organisms in a named habitat using randomly placed frame quadrats, or a belt transect<br>• use both percentage cover and frequency as measures of abundance of a sessile species.<br><br>**AT h**<br><br>Students could use the mark-release-recapture method to investigate the abundance of a motile species.<br><br>**AT i**<br><br>Students could use turbidity measurements to investigate the growth rate of a broth culture of microorganisms.<br><br>**MS 2.5**<br><br>Students could use a logarithmic scale in representing the growth of a population of microorganisms. |

# OCR

## 6.3.2 Populations and sustainability

| | Learning outcomes | Additional guidance |
|---|---|---|
| (a) | the factors that determine size of a population | To include the significance of limiting factors in determining the carrying capacity of a given environment and the impact of these factors on final population size.<br><br>*M0.1, M0.2, M0.3, M0.4, M0.5, M1.3, M2.5, M3.1, M3.2*<br>HSW1, HSW2 |

## Edexcel A

### Topic 10: Ecosystems

| Students should: |
| --- |
| **10.3 Changes in ecosystems** |
| ii Understand the effects of biotic and abiotic factors on population size. |
| CORE PRACTICAL 16: Investigate the effect of one abiotic factor on the distribution or morphology of one species taking into account the safe and ethical use of organisms. |

## Edexcel B

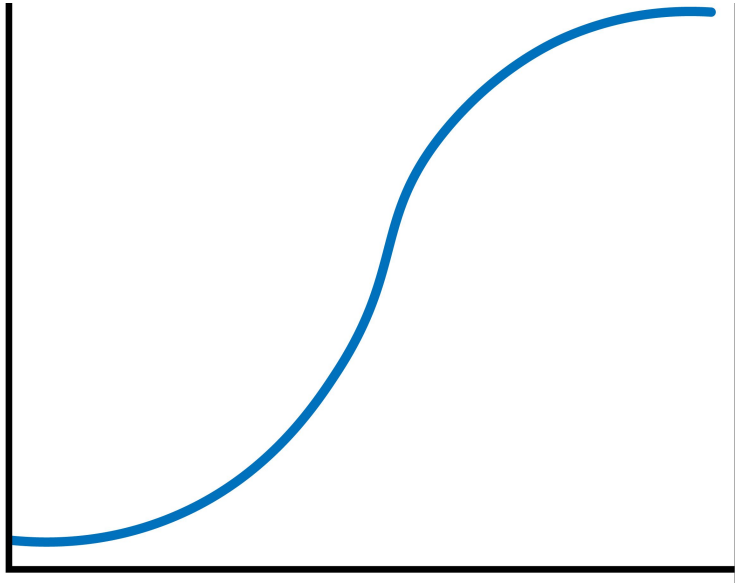
### Topic 10: Ecosystems

| Students should: |
| --- |
| **10.3 Changes in ecosystems** |
| ii Understand the effects of biotic and abiotic factors on population size. |
| CORE PRACTICAL 16: Investigate the effect of one abiotic factor on the distribution or morphology of one species taking into account the safe and ethical use of organisms. |

**AQA & Edexcel A:** Don't need to know the phases

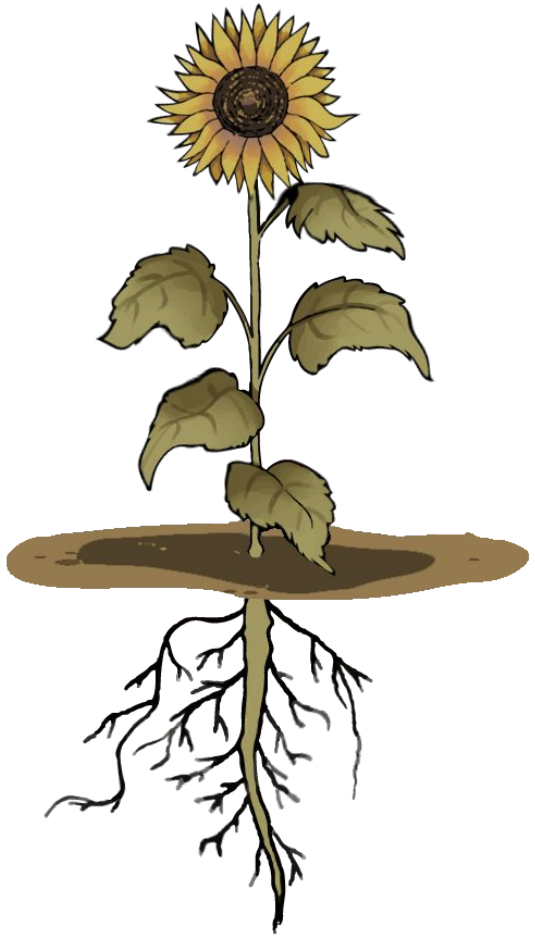
# Population Size

- A population is a **group** of **individuals** of the **same species** that occupy a **particular place** at a **particular time**
- **Carrying capacity** is the **maximum population size** that can be maintained over a period in a **particular habitat**
- There are phases of population growth: **lag**, **log**, **stationary** and **decline**
- **Decline phase** only occurs in **closed environments**



# Limiting Factors

- **Population size** is determined by **birth/death rates** and **emigration/immigration** which are affected by **limiting factors**
- A **limiting factor** is a factor whose **magnitude** slows down the **rate** of a **natural process** – they can be **abiotic** (non-living) or **biotic** (living)
- **Temperature**, **pH** and **light** are examples of **abiotic factors**
- **Disease**, **predation** and **competition** are examples of **biotic factors**



# Exemplar Exam Question – Extended Response

4) Compare and contrast the effects of abiotic and biotic limiting factors on populations, providing examples where possible.

One mark is available for quality of written communication.

**[6 marks]**

**Command**: look for similarities AND differences

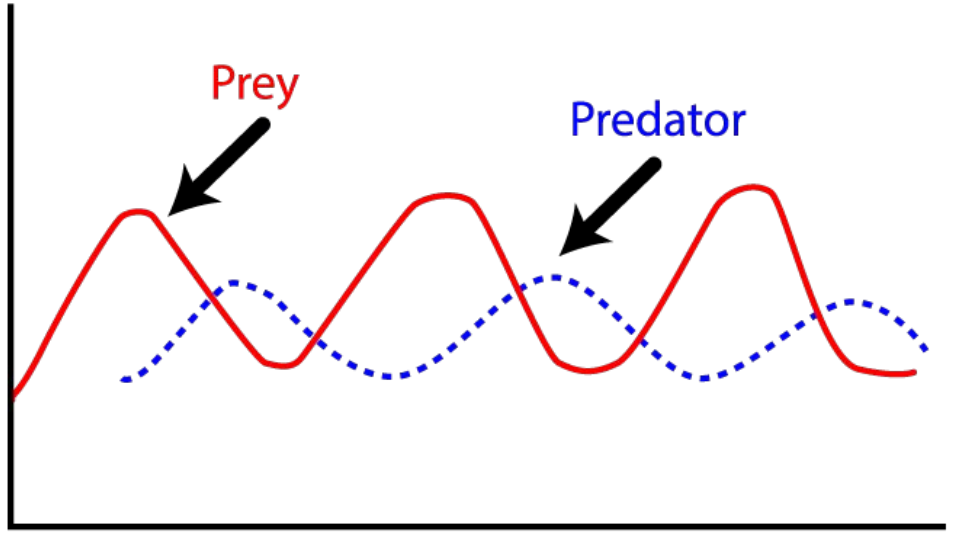
**Direction**: compare abiotic with biotic limiting factors

**Context**: population sizes – impacts on populations

Abiotic and biotic limiting factors both limit population size, therefore determining the carrying capacity. However, biotic limiting factors are living whereas abiotic limiting factors are non-living. Biotic limiting factors are density dependent – their effect is determined by the population size. For example, predation is a density-dependent limiting factor because the larger the population, the greater the number of predators, which then decreases population size. Abiotic factors are usually density-independent, such as temperature, with extreme temperatures reducing population size. However, abiotic factors that organisms compete for, such as light and water, are also density-dependent, as the larger the population, the greater the competition.

# Predator-Prey Relationships

- **Predation** can act as a **limiting factor** to the **prey population size** (biotic factor)
- When the **predator population increases**, more prey are eaten
- This **decreases** the **prey population**, leaving less prey for predators to eat. **Intraspecific competition!**
- Due to fewer prey, **less predators** can survive and their **population decreases.**



**AQA:** Need to know competitive exclusion

# Competition

- **Interspecific** (**between species**) and **intraspecific** (**within same species**) **competition**
- Interspecific competition includes **competition** for **resources** and affects **population sizes** – **decreasing** those that get outcompeted
- **Intraspecific competition** also involves resource competition and helps to keep **population sizes** stable in the **stationary phase**

# Exemplar Exam Question – Explanatory

5) The interaction between predators and prey is able to control the population size of both.

Explain how predator-prey relationships are able to affect population numbers.

**[3 marks]**

**Command**: critical thought required

**Direction**: focus on predator-prey interaction and specific impact on populations

**Context**: population levels, predator-prey relationships

# Exemplar Exam Question – Explanatory

Predator-prey relationships act in a negative feedback loop. An increase in the numbers of predators within an ecosystem result in more prey being eaten, and a subsequent decrease in the numbers of prey. The decrease in numbers of prey means that there are fewer prey to sustain the predator population and increased intraspecific competition, and the predator population subsequently decreases. Ultimately this increases the size of the prey population. This mechanism prevents predator or prey populations from increasing too much, though imbalances can still occur.

# Succession

# AQA

## 3.7.4 Populations in ecosystems (A-level only)

| Content | Opportunities for skills development |
|---|---|
| Populations of different species form a community. A community and the non-living components of its environment together form an ecosystem. Ecosystems can range in size from the very small to the very large.<br><br>Within a habitat, a species occupies a niche governed by adaptation to both abiotic and biotic conditions.<br><br>An ecosystem supports a certain size of population of a species, called the carrying capacity. This population size can vary as a result of:<br>• the effect of abiotic factors<br>• interactions between organisms: interspecific and intraspecific competition and predation.<br><br>The size of a population can be estimated using:<br>• randomly placed quadrats, or quadrats along a belt transect, for slow-moving or non-motile organisms<br>• the mark-release-recapture method for motile organisms. The assumptions made when using the mark-release-recapture method.<br><br>Ecosystems are dynamic systems.<br><br>Primary succession, from colonisation by pioneer species to climax community.<br><br>At each stage in succession, certain species may be recognised which change the environment so that it becomes more suitable for other species with different adaptations. The new species may change the environment in such a way that it becomes less suitable for the previous species.<br><br>Changes that organisms produce in their abiotic environment can result in a less hostile environment and change biodiversity.<br><br>Conservation of habitats frequently involves management of succession. | **AT k**<br><br>Students could:<br>• investigate the distribution of organisms in a named habitat using randomly placed frame quadrats, or a belt transect<br>• use both percentage cover and frequency as measures of abundance of a sessile species.<br><br>**AT h**<br><br>Students could use the mark-release-recapture method to investigate the abundance of a motile species.<br><br>**AT i**<br><br>Students could use turbidity measurements to investigate the growth rate of a broth culture of microorganisms.<br><br>**MS 2.5**<br><br>Students could use a logarithmic scale in representing the growth of a population of microorganisms. |

# OCR

## 6.3.1 Ecosystems

| | Learning outcomes | Additional guidance |
|---|---|---|
| (d) | the process of primary succession in the development of an ecosystem | To include succession from pioneer species to a climax community<br>**AND**<br>deflected succession.<br><br>HSW12 |

## Edexcel A

### Topic 5: On the Wild Side

| Students should: |
| --- |
| 5.4 Understand the stages of succession from colonisation to a climax community. |

## Edexcel B

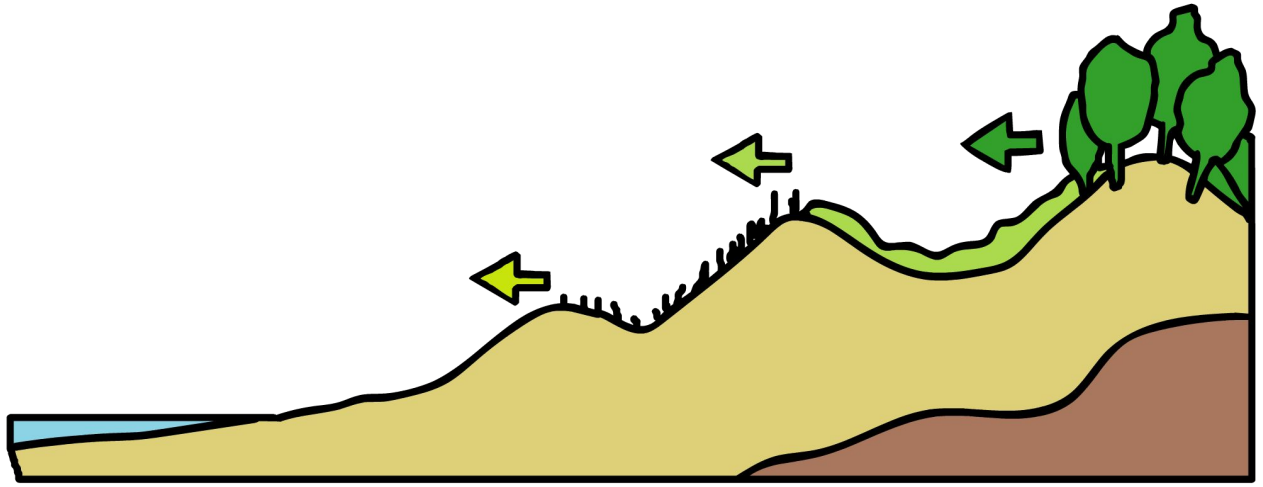
### Topic 10: Ecosystems

| Students should: | |
| --- | --- |
| **10.3** | **Changes in ecosystems** |
| i | Understand how ecosystems can develop over time, including use of the terms colonisation and succession and types of climax communities. |

**OCR:** Don't need to know secondary succession

# Primary Succession

- **Succession** is the term used to describe the **changes** that occur over **time** to a **community**
- **Primary succession** is the **progressive colonisation** of **bare rock** or other **barren terrain** by **living organisms**
- **Secondary succession** begins with **soil**



# Process of Primary Succession

- An **inhospitable environment** is first **colonised** by a **pioneer species** which is adapted to suit the **hostile environment**
- The **pioneer species** changes the **abiotic factors** of the **environment** allowing more species to thrive as the environment becomes less **hostile** – resulting in the **pioneer species** being **outcompeted**
- This process **repeats**, building up **organic matter** from **decaying organisms** until it forms a **stable climax community with an altered biodiversity**

# Exemplar Exam Question – Simple Explanatory

6) Pioneer species are often the first species to colonise an inhospitable environment.

Describe the role of pioneer species in primary succession.

**Command**: what happens and what role this plays

**Direction**: how pioneer species aid the next step of succession

**[2 marks]**

**Context**: succession

# Exemplar Exam Question – Simple Explanatory

6) Pioneer species are often the first species to colonise an inhospitable environment.

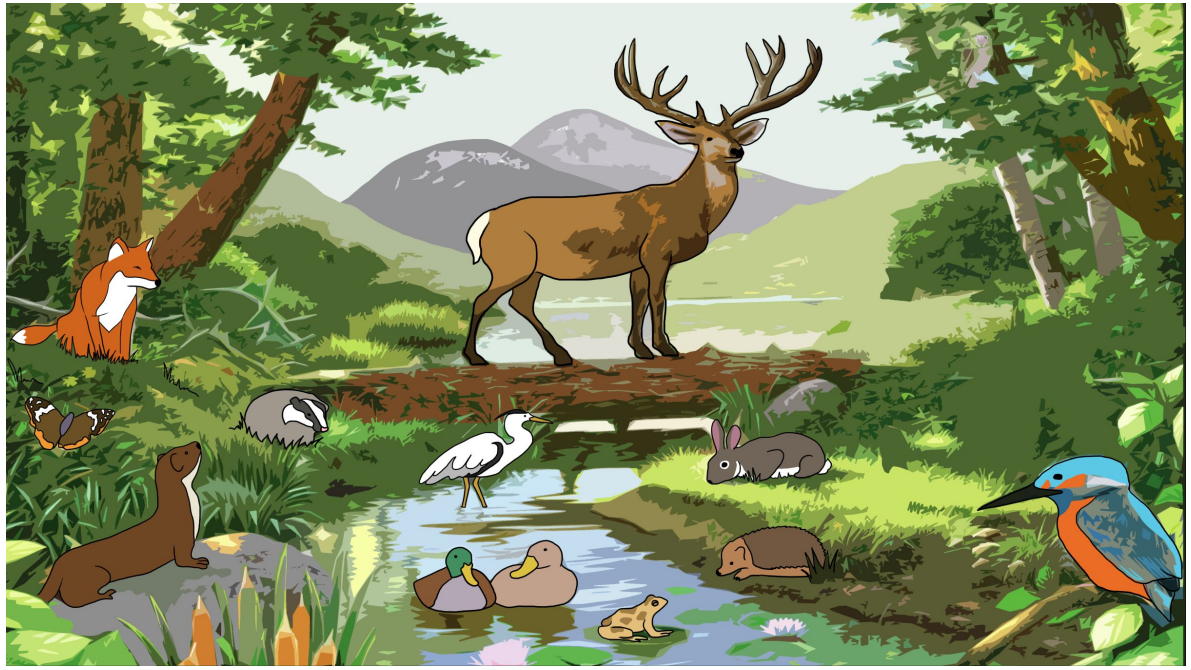
Describe the role of pioneer species in primary succession.

**[2 marks]**

Pioneer species die and decompose, leaving behind organic matter (humus). This makes the abiotic conditions less hostile, permitting new organisms to survive there.

# Common Features of Succession

- **Abiotic factors** in the area become **less hostile**
- **Biodiversity** increases…
- The number and variety of **habitats** and **niches** increases
- **Gross biomass** of the ecosystem increases due to the formation of more complex **food webs**



# Exemplar Exam Question – Explanation/ Qualitative

7) Describe the process of primary succession.

**[4 marks]**

**Command**: Describe what happens

**Direction**: only focus on primary succession. No marks awarded mentioning deflected/secondary succession.

**Context**: primary succession

7) Describe the process of primary succession.

**[4 marks]**

Primary succession is the process in which the structure of an ecological community changes over time in a series of stages/, starting with a bare, hostile environment which is colonised by pioneer species and ending with a stable climax community, with a higher biodiversity. During succession, the species present at each stage change the conditions, such as soil depth and nitrate concentrations, allowing different species to interspecifically compete with them, ultimately removing the previous species.

# Statistical Tests

$$t = \frac{(X_1 - X_2)}{\sqrt{\frac{(S_1)^2}{n_1} + \frac{(S_2)^2}{n_2}}}$$

# AQA: MS 1.9, 1.10

| | Mathematical skills | Exemplification of mathematical skill in the context of Biology |
|---|---|---|
| MS 1.9 | Select and use a statistical test | Students may be tested on their ability to select and use:<br>• the chi-squared test to test the significance of the difference between observed and expected results<br>• the Student's t-test<br>• the correlation coefficient |
| MS 1.10 | Understand measures of dispersion, including standard deviation and range | Students may be tested on their ability to:<br>• calculate the standard deviation<br>• understand why standard deviation might be a more useful measure of dispersion for a given set of data, eg where there is an outlying result |

# OCR A: MS 1.9, 1.10

| | Mathematical skill to be assessed | Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below) | Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below) |
|---|---|---|---|
| M1.9 | Select and use a statistical test | Learners may be tested on their ability to select and use:<br>• the chi squared test ($\chi^2$) to test the significance of the difference between observed and expected results<br>• the Student's *t*-test<br>• the Spearman's rank correlation coefficient. | 4.2.1(b), 5.1.5(e), 6.1.2(c), 6.3.1(e) |
| M1.10 | Understand measures of dispersion, including standard deviation and range | Learners may be tested on their ability to:<br>• calculate the standard deviation<br>• understand why standard deviation might be a more useful measure of dispersion for a given set of data e.g. where there is an outlying result. | 2.1.5(e), 4.2.1(b), 4.2.2(f), 5.1.5(e), 5.1.5(k), 5.2.2(l), 6.2.1(i), 6.3.1(e) |

# Edexcel A: A 1.9, 1.10

| | Mathematical skills | Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below) |
|---|---|---|
| A.1.9 | Select and use a statistical test | Candidates may be tested on their ability to select and use:<br>• the Chi squared test to test the significance of the difference between observed and expected results<br>• the Student's t-test<br>• the correlation coefficient |
| A.1.10 | Understand measures of dispersion, including standard deviation and range | Candidates may be tested on their ability to:<br>• calculate the standard deviation<br>• understand why standard deviation might be a more useful measure of dispersion for a given set of data, e.g. where there is an outlying result |

# Edexcel B: A 1.9, 1.10

| | Mathematical skills | Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below) |
|---|---|---|
| A.1.9 | Select and use a statistical test | Candidates may be tested on their ability to select and use:<br>• the Chi squared test to test the significance of the difference between observed and expected results<br>• the Student's t-test<br>• the correlation coefficient |
| A.1.10 | Understand measures of dispersion, including standard deviation and range | Candidates may be tested on their ability to:<br>• calculate the standard deviation<br>• understand why standard deviation might be a more useful measure of dispersion for a given set of data, e.g. where there is an outlying result |

# Student's *t*-test

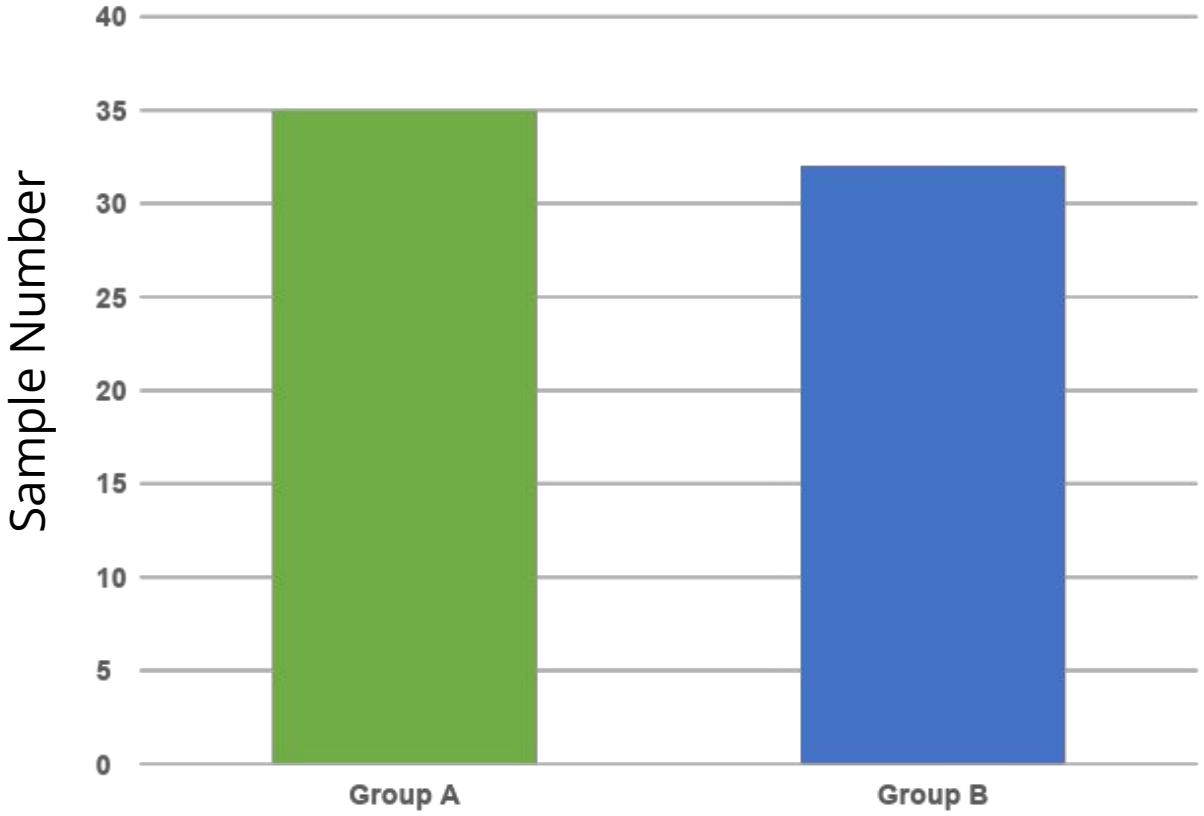
- The **students t-test** is used to **determine** if there is a significant **difference** between the **means** of **two groups** of **data** or if the difference is **due** to **chance**

- If comparing the **average heights** of **two** different populations, this test determines whether the **difference** in the **mean heights** of the groups is due to **chance** (**null hypothesis**) or due to an alternative reason (alternative hypothesis)

$$t = \frac{(X_1 - X_2)}{\sqrt{\frac{(S_1)^2}{n_1} + \frac{(S_2)^2}{n_2}}}$$

# Null Hypothesis

- The **null hypothesis** states that there is **no significant difference** between the means of **two groups** of data
- A **large sample size** and **normally distributed data** is necessary for the **Student's *t*-test** to be **reliable**
- The **size** of the **groups** determines the **degrees** of **freedom**



# Exemplar Exam Question – Data Analysis

8) A new weight loss treatment for humans is being tested. The test group receives the treatment with every meal whilst the control group receives a sugar placebo. Using the data below, determine if there is a significant difference between the control group and the test group.

The formula for the Student's *t*-test is shown below:

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{S_1^{\,2}}{N_1} + \frac{S_2^{\,2}}{N_2}}}$$

| | Test Group | Control Group |
|---|---|---|
| **Sample Size** | 29 | 33 |
| **Mean (mass lost after 3 months (kg))** | 8.7 | 7.9 |
| **Standard deviation** | 5.3 | 6.5 |

**[6 marks]**

**Command**: determine by comparing *t*-value to critical value

**Direction**: use t-test

**Context**: data provided

# Exemplar Exam Question – Data Analysis

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{S_1^{\,2}}{N_1} + \frac{S_2^{\,2}}{N_2}}}$$

| | Test Group | Control Group |
|---|---|---|
| **Sample Size** | 29 | 33 |
| **Mean (mass lost after 3 months (kg))** | 8.7 | 7.9 |
| **Standard deviation** | 5.3 | 6.5 |

***t* value = 0.533**

**Degrees of freedom (df) = $N_1 + N_2 - 2 = 60$**

**For df = 60, critical value = 2.000**

**Our value of 0.533 is less than the critical value of 2.000**

**We do not reject the null hypothesis so the groups are not significantly different. Probability of getting results by change is greater than 5%**

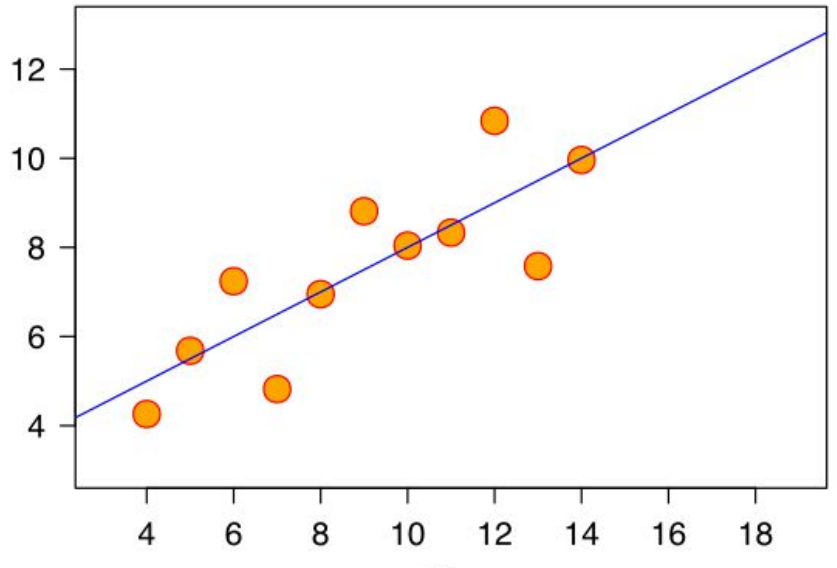
| Degrees of freedom | Significance level | | | | | |
|---|---|---|---|---|---|---|
| | 20% (0.20) | 10% (0.10) | 5% (0.05) | 2% (0.02) | 1% (0.01) | 0.1% (0.001) |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.819 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.792 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.767 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.745 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.725 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.707 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.690 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.674 |
| 29 | 1.311 | 1.699 | 2.043 | 2.462 | 2.756 | 3.659 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.646 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.551 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.460 |
| 120 | 1.289 | 1.658 | 1.980 | 2.158 | 2.617 | 3.373 |
| ∝ | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.291 |

# Spearman's Rank

- **Spearman's rank correlation coefficient** is **used** to **determine** if there is a **significant correlation between two variables**

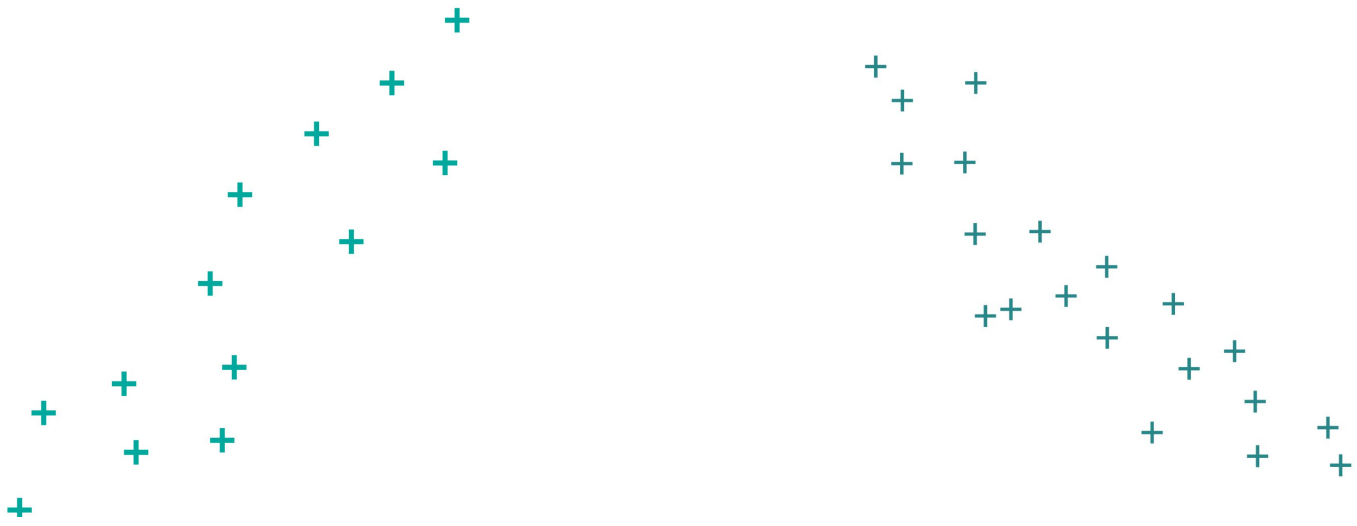
- **For example**: **seeing** if there is a **correlation between temperature** and the **number** of **ice creams sold** by an **ice cream van**

- If the **coefficient** is **greater** than the **critical value**, then there is a **significant correlation between** the **two variables**



# Null Hypothesis

- The **null hypothesis** for **Spearman's rank** is that there is **no significant correlation** between the **two variables** being **tested**
- **Spearman's rank** does not **require** the **data** to have a **normal distribution**
- Correlations are **linear** and are either **positive** or **negative**



# Exemplar Exam Question – Data Analysis

9) A teacher is investigating if there is a correlation between students' test results in Biology and Geography. The teacher compares the test scores of 10 students and performs a Spearman's rank correlation test. The results are shown in the table.

| Biology | Geography |
|---|---|
| 94 | 39 |
| 48 | 64 |
| 29 | 64 |
| 79 | 49 |
| 52 | 86 |
| 29 | 28 |
| 21 | 81 |
| 65 | 45 |
| 54 | 38 |
| 82 | 62 |

Complete the test and state your findings.

**Command**: State findings by comparing calculated coefficient to critical value

**Direction**: use spearman's rank

**Context**: data provided

**[6 marks]**

# Exemplar Exam Question – Data Analysis

| Biology | Geography | Biology Rank | Geography Rank | Rank Difference | $D^2$ |
|---|---|---|---|---|---|
| 94 | 39 | | | | |
| 48 | 64 | | | | |
| 29 | 64 | | | | |
| 79 | 49 | | | | |
| 52 | 86 | | | | |
| 29 | 28 | | | | |
| 21 | 81 | | | | |
| 65 | 64 | | | | |
| 54 | 38 | | | | |
| 82 | 62 | | | | |

$$r_s = 1 - \frac{6\sum D^2}{n\left(n^2 - 1\right)}$$

# Exemplar Exam Question – Data Analysis

| Biology | Geography | Biology Rank | Geography Rank | Rank Difference | $D^2$ |
|---|---|---|---|---|---|
| 94 | 39 | 1 | 8 | -7 | 49 |
| 48 | 64 | 7 | 4 | 3 | 9 |
| 29 | 64 | 8.5 | 4 | 4.5 | 20.25 |
| 79 | 49 | 3 | 7 | -4 | 16 |
| 52 | 86 | 6 | 1 | 5 | 25 |
| 29 | 28 | 8.5 | 10 | -1.5 | 2.25 |
| 21 | 81 | 10 | 2 | 8 | 64 |
| 65 | 64 | 4 | 4 | 0 | 0 |
| 54 | 38 | 5 | 9 | -4 | 16 |
| 82 | 62 | 2 | 6 | -4 | 16 |

$$r_s = 1 - \frac{6\sum D^2}{n\left(n^2 - 1\right)}$$

# Exemplar Exam Question – Data Analysis

| Rank Difference | $D^2$ |
|---|---|
| -7 | 49 |
| 3 | 9 |
| 4.5 | 20.25 |
| 4 | 16 |
| 5 | 25 |
| -1.5 | 2.25 |
| 8 | 64 |
| 0 | 0 |
| -4 | 16 |
| -4 | 16 |

$$r_s = 1 - \frac{6\sum D^2}{n\left(n^2 - 1\right)}$$

| | |
|---|---|
| $\Sigma D^2$ | |
| $6 \Sigma D^2$ | |
| $n(n^2-1)$ | |
| $r_s$ | |

| Number of pairs of measurements (n) | Significance level p = 0.05 (95%) (+ or -) | Significance level p = 0.01 (99%) (+ or -) |
|---|---|---|
| 5 | 1.000 | |
| 6 | 0.886 | 1.000 |
| 7 | 0.786 | 0.929 |
| 8 | 0.738 | 0.881 |
| 9 | 0.683 | 0.833 |
| 10 | 0.648 | 0.818 |
| 11 | 0.623 | 0.794 |
| 12 | 0.591 | 0.780 |
| 13 | 0.566 | 0.745 |
| 14 | 0.545 | 0.716 |
| 15 | 0.525 | 0.689 |
| 16 | 0.507 | 0.666 |
| 17 | 0.490 | 0.645 |
| 18 | 0.476 | 0.625 |
| 19 | 0.462 | 0.608 |
| 20 | 0.450 | 0.591 |
| 25 | 0.400 | 0.526 |
| 30 | 0.364 | 0.478 |
| 35 | 0.336 | 0.442 |
| 40 | 0.314 | 0.413 |

# Exemplar Exam Question – Data Analysis

| Rank Difference | $D^2$ |
|---|---|
| 7 | 49 |
| 4 | 16 |
| 7 | 49 |
| 3 | 9 |
| 6 | 36 |
| 6 | 36 |
| 7 | 49 |
| 2 | 4 |
| 3 | 9 |
| 3 | 9 |

$$r_s = 1 - \frac{6\sum D^2}{n\left(n^2 - 1\right)}$$

| | |
|---|---|
| $\Sigma D^2$ | **217.5** |
| $6 \Sigma D^2$ | **1305** |
| $n(n^2-1)$ | **990** |
| $r_s$ | **-0.32** |

| Number of pairs of measurements (n) | Significance level p = 0.05 (95%) (+ or -) | Significance level p = 0.01 (99%) (+ or -) |
|---|---|---|
| 5 | 1.000 | |
| 6 | 0.886 | 1.000 |
| 7 | 0.786 | 0.929 |
| 8 | 0.738 | 0.881 |
| 9 | 0.683 | 0.833 |
| 10 | 0.648 | 0.818 |
| 11 | 0.623 | 0.794 |
| 12 | 0.591 | 0.780 |
| 13 | 0.566 | 0.745 |
| 14 | 0.545 | 0.716 |
| 15 | 0.525 | 0.689 |
| 16 | 0.507 | 0.666 |
| 17 | 0.490 | 0.645 |
| 18 | 0.476 | 0.625 |
| 19 | 0.462 | 0.608 |
| 20 | 0.450 | 0.591 |
| 25 | 0.400 | 0.526 |
| 30 | 0.364 | 0.478 |
| 35 | 0.336 | 0.442 |
| 40 | 0.314 | 0.413 |

**Spearman's rank correlation coefficients fall between ±1 (-1, strong –ve correlation)**

**We received an $r_s$ value of -0.32**

**Number of pairs (n) = 10**

**Critical value for p=0.05 is +/-0.648**

**-0.32 is less than the critical value**

**Can't reject the null hypothesis – no significant correlation. Over 5% probability that the difference is due to chance**

| | Significance level | |
|---|---|---|
| Number of pairs of measurements (n) | p = 0.05 (95%) (+ or -) | p = 0.01 (99%) (+ or -) |
| 5 | 1.000 | |
| 6 | 0.886 | 1.000 |
| 7 | 0.786 | 0.929 |
| 8 | 0.738 | 0.881 |
| 9 | 0.683 | 0.833 |
| 10 | 0.648 | 0.818 |
| 11 | 0.623 | 0.794 |
| 12 | 0.591 | 0.780 |
| 13 | 0.566 | 0.745 |
| 14 | 0.545 | 0.716 |
| 15 | 0.525 | 0.689 |
| 16 | 0.507 | 0.666 |
| 17 | 0.490 | 0.645 |
| 18 | 0.476 | 0.625 |
| 19 | 0.462 | 0.608 |
| 20 | 0.450 | 0.591 |

SNAPREVISE

# Mini Mock Paper

# Mini Mock Paper

a) Figure 1 gives an example of the organisms present at each stage of succession of a sand dune.

Suggest which species in Figure 1 is a pioneer species.

**[1 mark]**

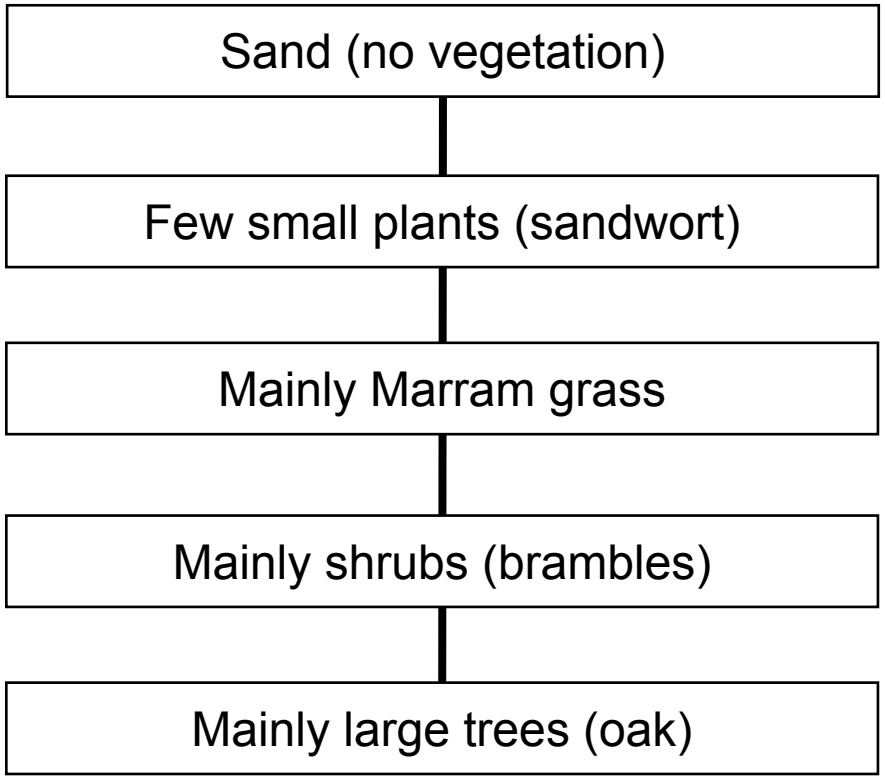



Figure 1

# Mini Mock Paper

b) Using figure 1 suggest why marram grass was only dominant in the third stage of succession.

**[3 marks]**

# Mini Mock Paper

c) The treatment of sewage produces sludge as a product, which can be applied to grassland. This sludge contains high concentrations of nitrogen compounds such as nitrates and ammonia. After rainfall, these nitrogen compounds can drain out of soil and enter water in the soil, in a process known as leaching.

Experiments have been carried out into the leaching of nitrate from grassland to which sludge has been applied. The sludge was applied to two areas of grassland. On one area it was spread onto the surface whilst in the other it was injected into the soil at various points across the area.

The rate of leaching was measured by taking samples from the water flowing through the soil and measuring the concentration of nitrate in them after different volumes of rainfall had fallen.

Figure 2 shows the results obtained in the experiment.

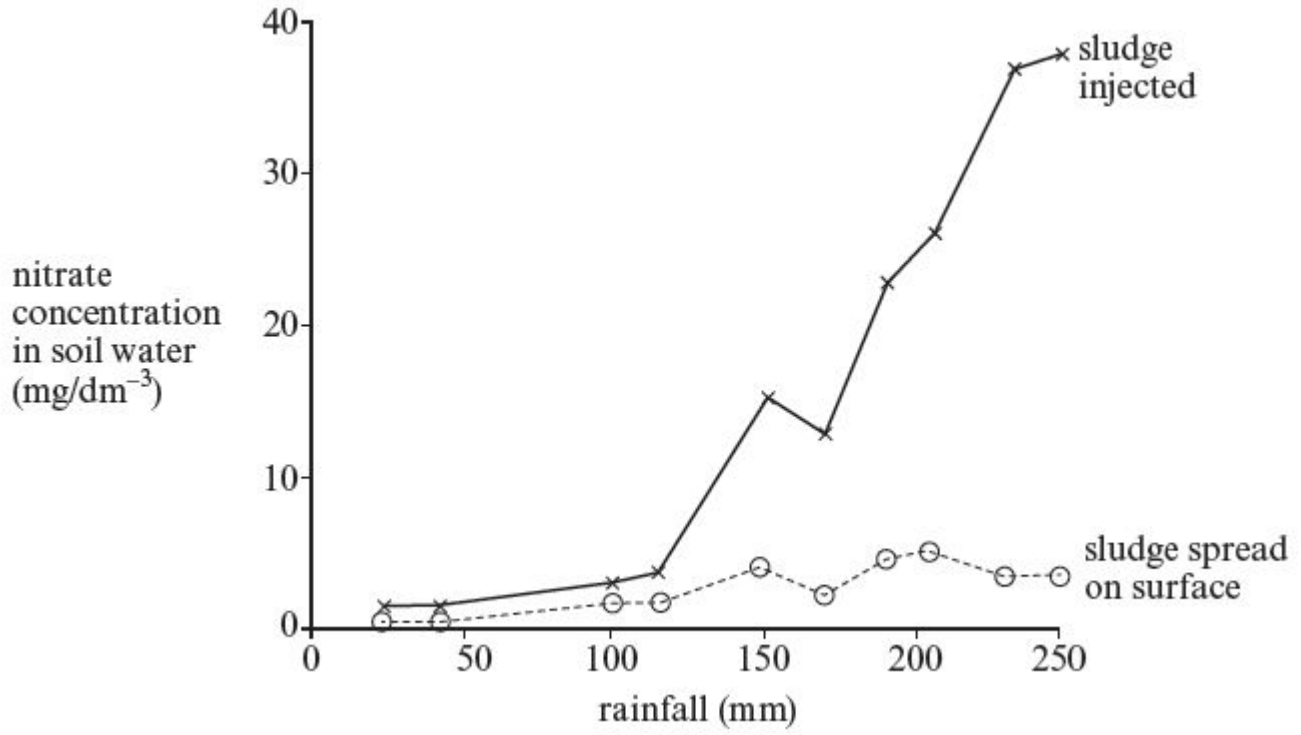



Figure 2

i) State two variables that needed to be controlled during this experiment.

**[2 marks]**

i) State two variables that needed to be controlled during this experiment.

**[2 marks]**

_____

_____

_____

Figure 2 shows the results obtained in the experiment.

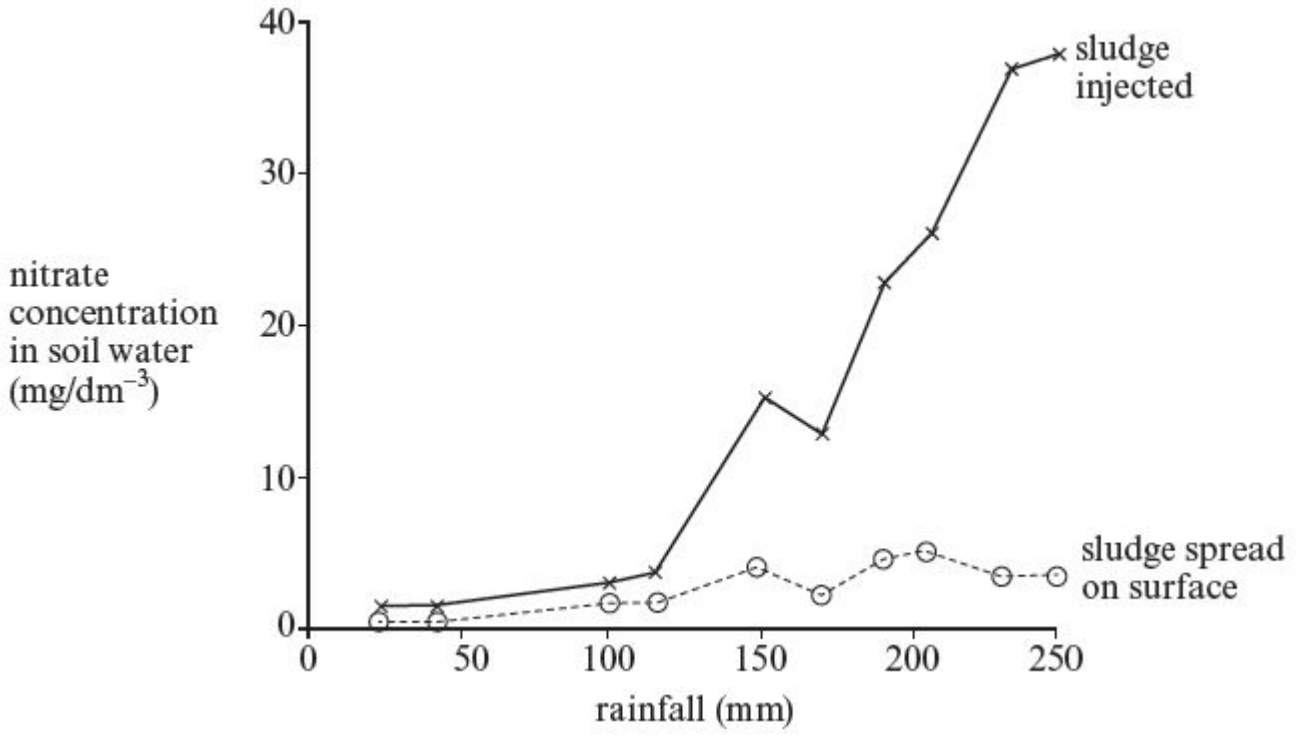



Figure 2

ii) Describe the results shown in Figure 2.

**[3 marks]**

ii) Summarise the results shown in Figure 2.

**[3 marks]**

SNAPREVISE

# Mini Mock Paper Answers

# Mini Mock Paper

a) Figure 1 gives an example of the organisms present at each stage of succession of a sand dune.

Suggest which species in Figure 1 is a pioneer species.

**[1 mark]**

Sandwort

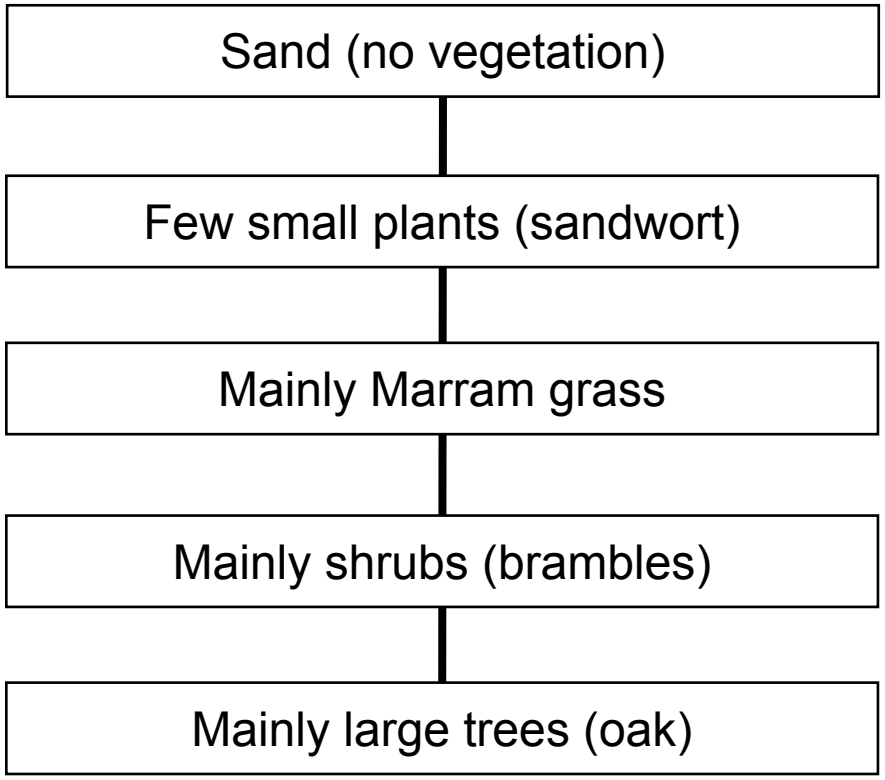



Figure 1

# Mini Mock Paper

b) Using figure 1 suggest why marram grass was only dominant in the third stage of succession.

**[3 marks]**

Marram grass would only be able to survive after a thin layer of soil was formed by rock erosion and decomposing sandwort. It may also be that marram grass is well adapted to the third stage of succession – for example they do not require much shelter to develop. As the abiotic/biotic conditions changed the marram grass may not be the best adapted to the environment and becomes outcompeted by the brambles.

# Mini Mock Paper

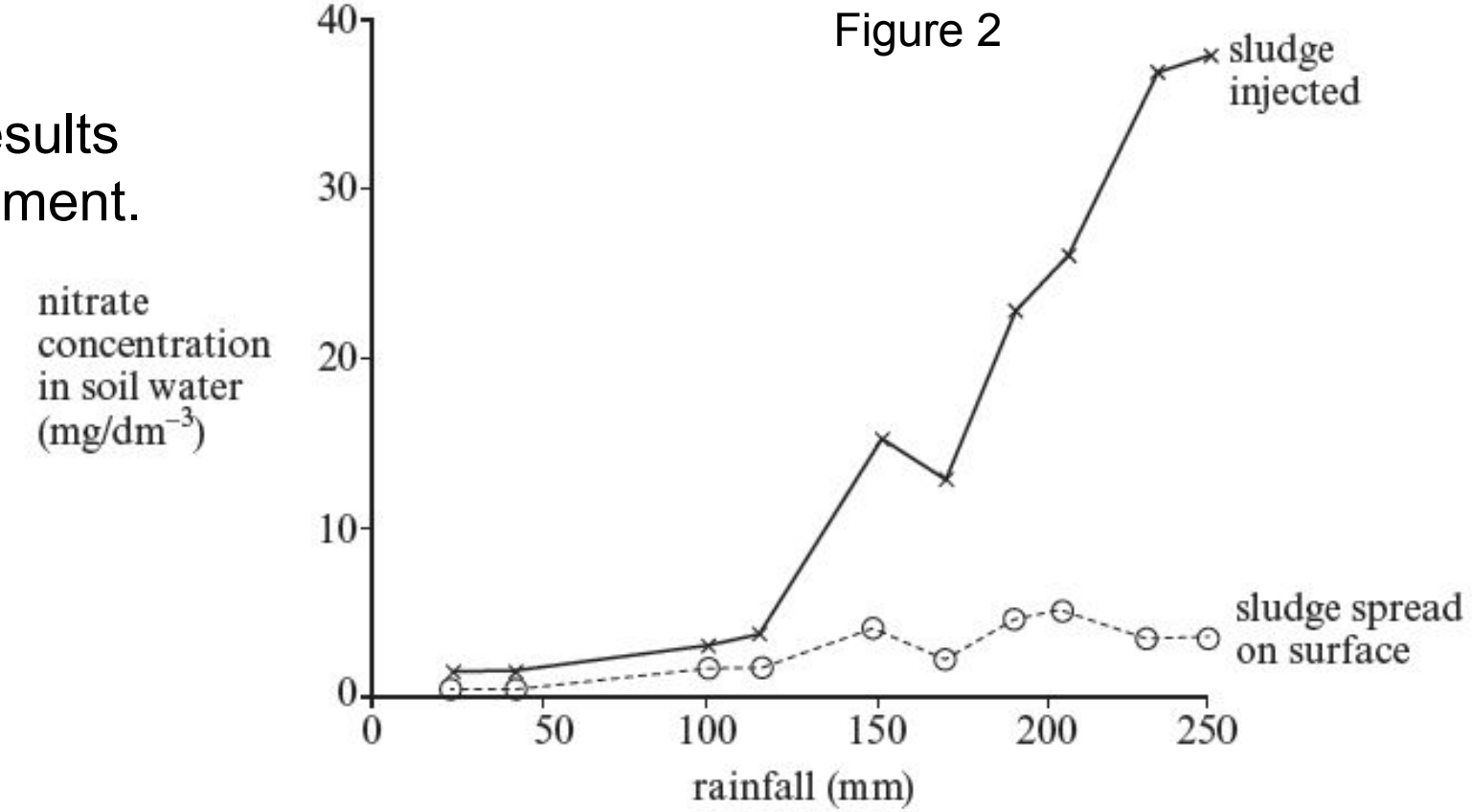
c) The treatment of sewage produces sludge as a product, which can be applied to grassland. This sludge contains high concentrations of nitrogen compounds such as nitrates and ammonia. After rainfall, these nitrogen compounds can drain out of soil and enter water in the soil, in a process known as leaching.

Experiments have been carried out into the leaching of nitrate from grassland to which sludge has been applied. The sludge was applied to two areas of grassland. On one area it was spread onto the surface whilst in the other it was injected into the soil at various points across the area.

The rate of leaching was measured by taking samples from the water flowing through the soil and measuring the concentration of nitrate in them after different volumes of rainfall had fallen.

Figure 2 shows the results obtained in the experiment.

Figure 2




i) State two variables that needed to be controlled during this experiment.

**[2 marks]**

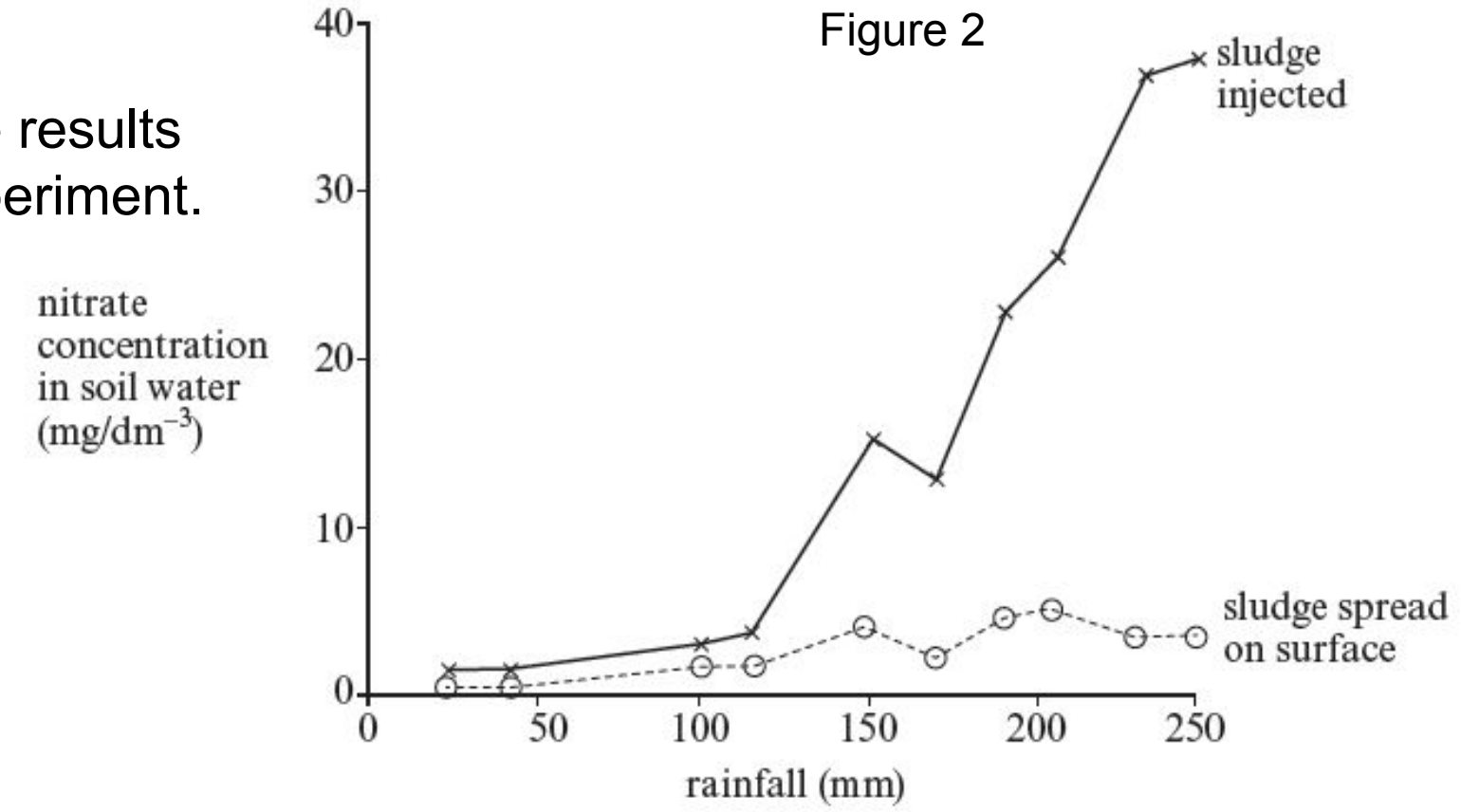
i) State two variables that needed to be controlled during this experiment.

**[2 marks]**

The sludge applied should be injected to the same depth every time. The same volume of sludge should also be applied to each area of grassland.

Figure 2 shows the results obtained in the experiment.

Figure 2




ii) Describe the results shown in Figure 2.

**[3 marks]**

ii) Summarise the results shown in Figure 2.

**[3 marks]**

An increase in rainfall increases the concentration of nitrates in soil water, when sludge is applied on the surface and when it in injected. However, high levels of rainfall had a much greater effect on the concentration of nitrates in the soil water for sludge injected (at 200mm of rainfall.l around 40 $mg/dm^3$ is seen in injected sludge compared to 4$mg/dm^3$ when applied on the surface)