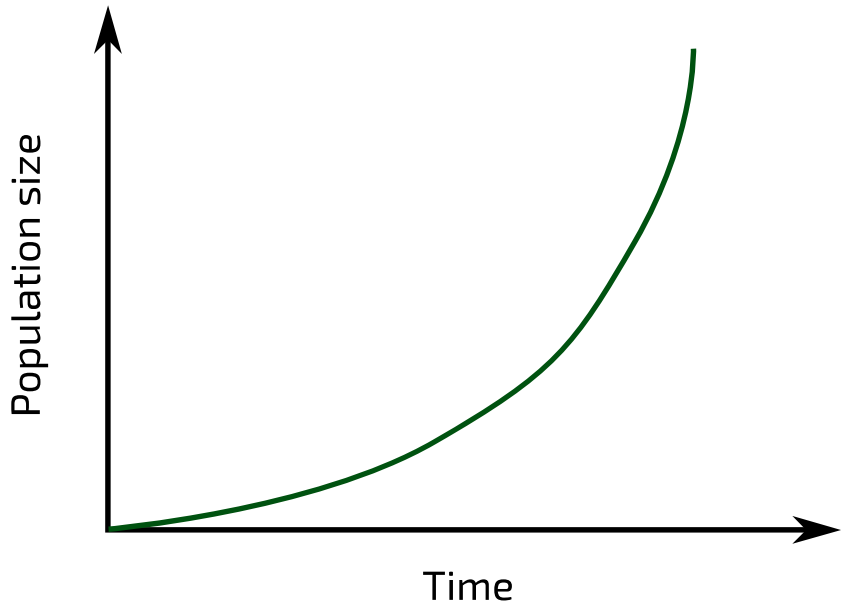
Patterns of Population Change

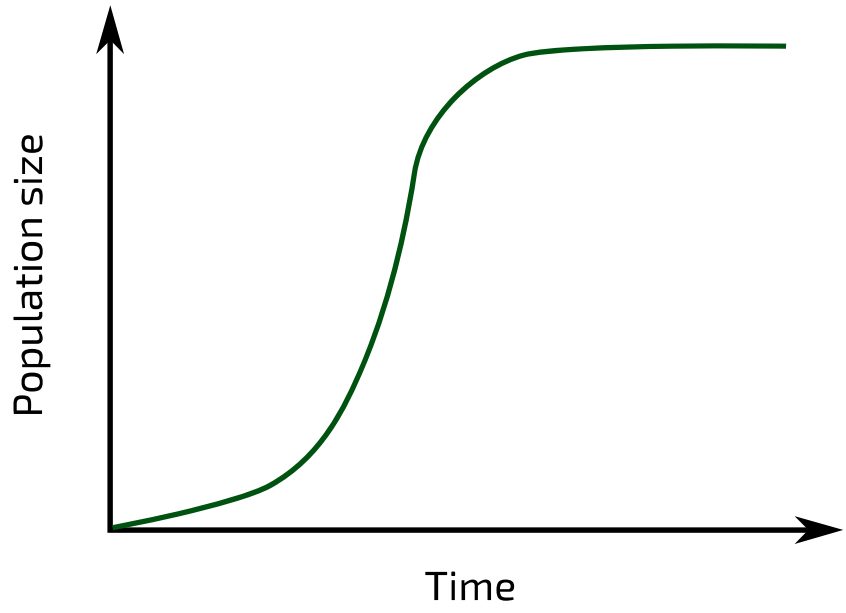
A Level

A population's size can change over time. The way in which it changes depends on various environmental factors.

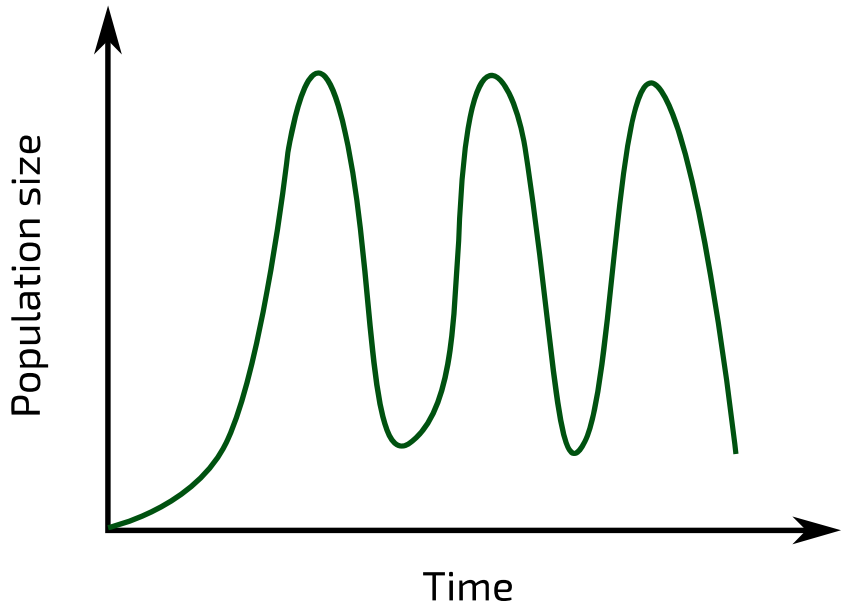
The three graphs below (A, B, C) each show a different way in which a population may change over time.



A



B



C

Part A Types of change

Match the graph to the scenario.

[ ]: A population in a highly stable environment with limiting factors.

[ ]: A population in a highly seasonal environment. Food availability varies greatly between seasons.

[ ]: A population in an environment with no limiting factors. There is unlimited availability of food and no predation on the population.

Items:

A **B** **C**

Part B Common feature

Which of the following features are common to all three graphs?

- the carrying capacity is different at different points in time
- the population reaches carrying capacity
- exponential growth
- logistic growth

Part C Unrealistic growth

Graph A shows a population undergoing exponential growth. Which of the following factors prevent this from happening indefinitely (forever) in real populations? Select all that apply.

- [ ] resources (e.g. food, space, etc.) are not unlimited, so there will be a maximum population size that can be sustained in any given environment
- [ ] populations can only grow linearly, not exponentially
- [ ] harmful mutations build up in large populations, which limits population size or causes it to decrease
- [ ] if a population exceeds the carrying capacity, it goes extinct
- [ ] consumers/predators may limit population numbers
- [ ] a larger population will produce more waste products (e.g. carbon dioxide, ammonia, etc.), which may make the environment less suitable

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Created for isaacphysics.org by Lewis Thomson

Collared Doves

A Level

The collared dove, *Streptopelia decaocto*, is a recent addition to the British list of breeding birds. At the start of the 20th century, this bird was a rare visitor. It spread across northern Europe and breeding pairs were first seen in Britain in the early 1950s. The collared dove is now widespread throughout Britain.

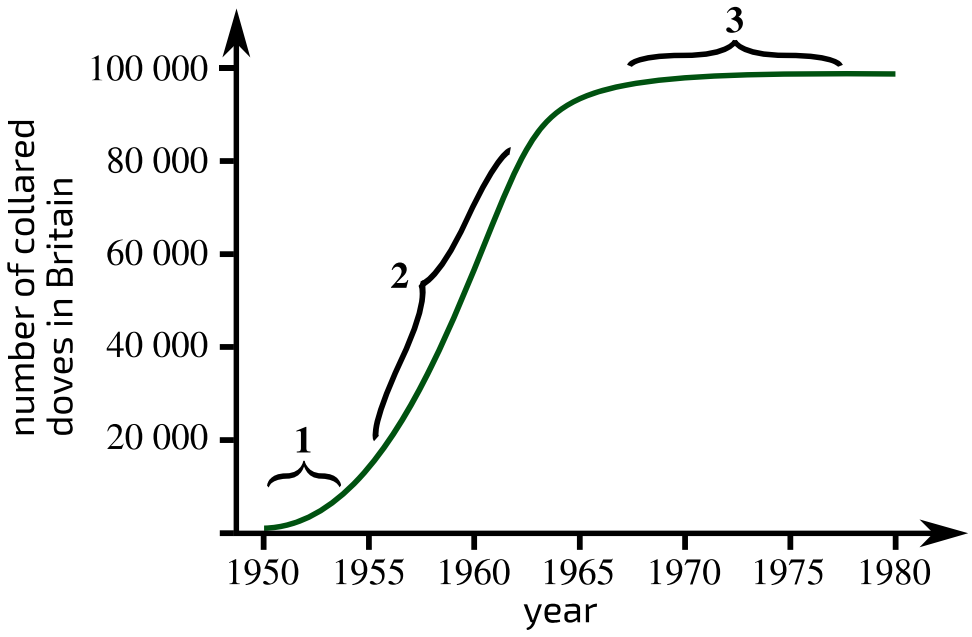

Figure 1: A record of collared dove population growth between 1950 and 1980. Three phases of population change are labelled.

Part A Phase names

Match the phases to the labelled regions in Figure 1.

- 1: [ ]
- 2: [ ]
- 3: [ ]

Items:

log phase (rapid growth) **lag phase (slow growth)** **stationary phase (no growth)**

Part B Phase 1 vs phase 2

Why is growth more rapid in phase 2 than in phase 1?

- The carrying capacity is higher in phase 2 than in phase 1.
- Population growth rate is proportional to population size, and so the larger a population is, the faster it will grow (up to a point).
- In phase 1, death rate is higher than birth rate. Whereas in phase 2, birth rate is higher than death rate.
- The population is more affected by density-dependent limiting factors in phase 1.

Part C Phase 3

Why does growth slow down and stop in phase 3? Select all that may apply.

- [ ] Density-independent limiting factors are affecting the population more now.
- [ ] Collared dove numbers are being limited by predators.
- [ ] There is only enough food in the ecosystem to support this number of collared doves.
- [ ] The population has reached extinction
- [ ] The population has reached its carrying capacity.
- [ ] Collared dove death rates are now greater than birth rates.

Part D Carrying capacity

Based on Figure 1, what was the carrying capacity of collared doves in Britain between 1950 and 1980? Give your answer to 1 significant figure.

Part E Increasing the carrying capacity

Which of the following might **increase** the carrying capacity of collared doves in Britain? Select all that apply.

- [ ] An increase in predator numbers.
- [ ] An increase in food availability.
- [ ] Emigration of part of the population out of Britain.
- [ ] Migration of more collared doves into Britain.
- [ ] A decrease in predator numbers.

Adapted with permission from OCR A Level January 2003, Central Concepts, Question 3

Gameboard:

STEM SMART Biology Week 28 - Population Dynamics

Algal Population Changes

A Level

Not all populations follow sigmoidal growth curves. Some may show large fluctuations, particularly in seasonal environments. **Figure 1** shows one such population.

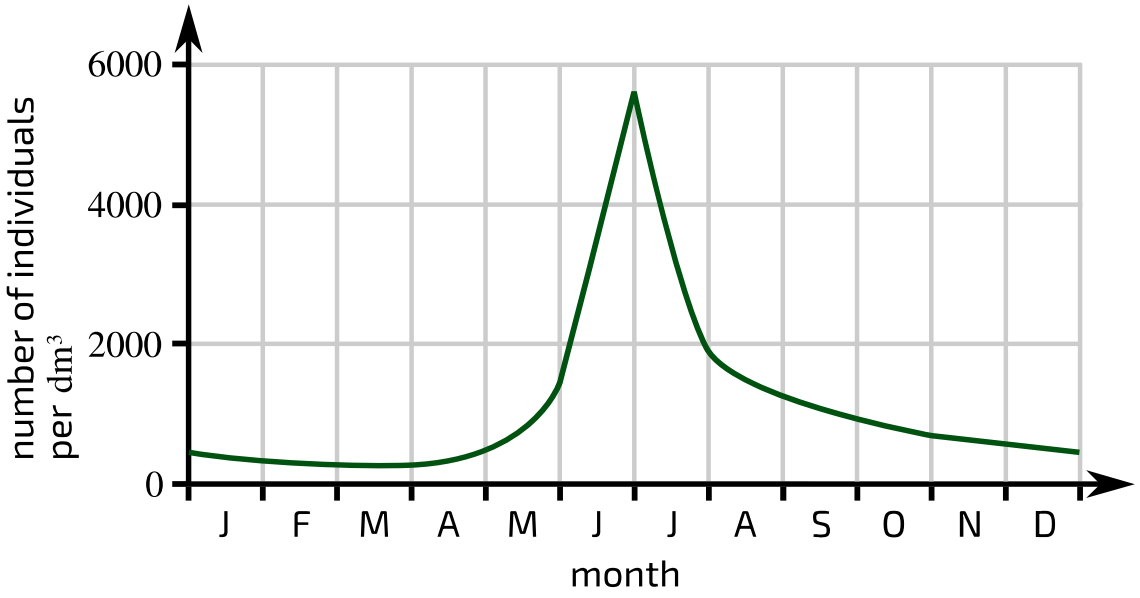

Figure 1: The population curve of an algal species in a freshwater lake in southern England.

Part A Population increase

Which of the following may explain the rapid population growth from May to July? Select all that apply.

- [ ] increasing day length
- [ ] an increase in the number of consumers
- [ ] decreasing temperature
- [ ] increasing water availability in the soil
- [ ] decreasing nutrient availability
- [ ] decreasing day length
- [ ] increasing temperature

Part B Population decrease

Which of the following may explain the rapid population decrease from July to September? Select all that apply.

- [ ] increasing temperature
- [ ] increasing water availability in the soil
- [ ] an increase in the number of consumers
- [ ] decreasing nutrient availability
- [ ] increasing day length
- [ ] decreasing temperature
- [ ] decreasing day length

Part C Carrying capacity statements

Which of the following statements are correct? Select all that apply.

- [ ] The reason that this population does not follow a sigmoidal growth curve is that its carrying capacity is **higher** in the summer than in the other seasons.
- [ ] The carrying capacity in the summer must be the same as (or greater than) the maximum population size reached.
- [ ] The carrying capacity of this population is the same all year, because carrying capacities do not change.
- [ ] The carrying capacity in the summer may be lower than the maximum population size reached, and this could account for the dramatic population decrease in July.
- [ ] The reason that this population does not follow a sigmoidal growth curve is that its carrying capacity is **lower** in the summer than in the other seasons.

Adapted with permission from OCR A Level January 2003, Central Concepts, Question 3

Gameboard:
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Predatory Mites

A Level

Two species of mite were kept in a laboratory. One species (the prey species) feeds on oranges, and other is a predator of the first species.

Figure 1 shows the changes in the populations of these two species over time in a particular experiment.

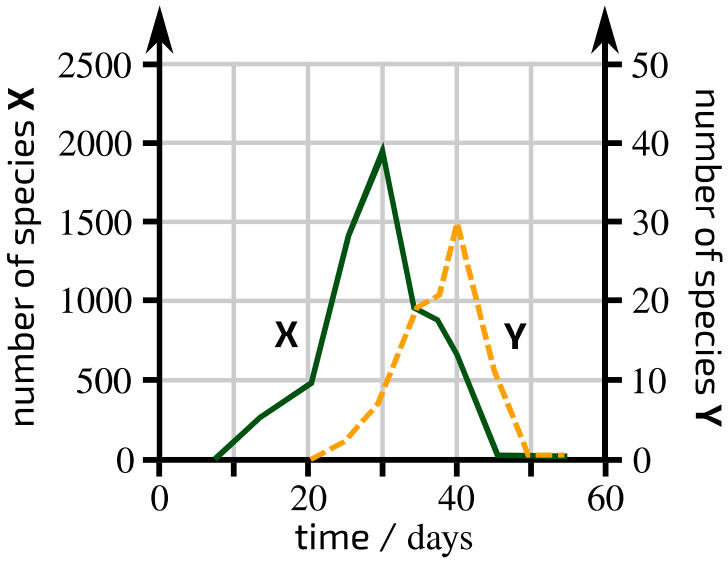

Figure 1: Population changes of species **X** and **Y** over the course of a 60-day experiment.

Part A Identify the prey

Which species in **Figure 1** is the **prey** species?

- X
- Y

Which of the following statements support your answer above?

- The population of **Y** is always lower than the population of **X**, which suggests that species **Y** occupies a ***lower*** trophic level.
- The population of **Y** is always lower than the population of **X**, which suggests that species **Y** occupies a ***higher*** trophic level.
- When the population of **X** decreases, the population of **Y** decreases soon after, which suggests that species **Y** is dependent on species **X.**
- From day 30 to day 40, the population of **X** decreases while the population of **Y** increases, which suggests that species **Y** is negatively affected by species **X**
- When the population of **Y** increases, the population of **X** decreases, which suggests that species **X** is negatively affected by species **Y.**
- From day 40 onwards, the population of **Y** is decreasing, and the population of **X** is also decreasing, which suggests that species **X** is dependent on species **Y.**

Part B Population maximum of X

What is the maximum population size of **X**? Give your answer to two significant figures.

On what day does population **X** reach its maximum size?

Part C Population maximum of Y

What is the maximum population size of **Y**? Give your answer to one significant figure.

On what day does population **Y** reach its maximum size?

Adapted with permission from OCR A Level June 2003, Central Concepts, Question 7

Gameboard:

STEM SMART Biology Week 28 - Population Dynamics

Human Population Projections

A Level

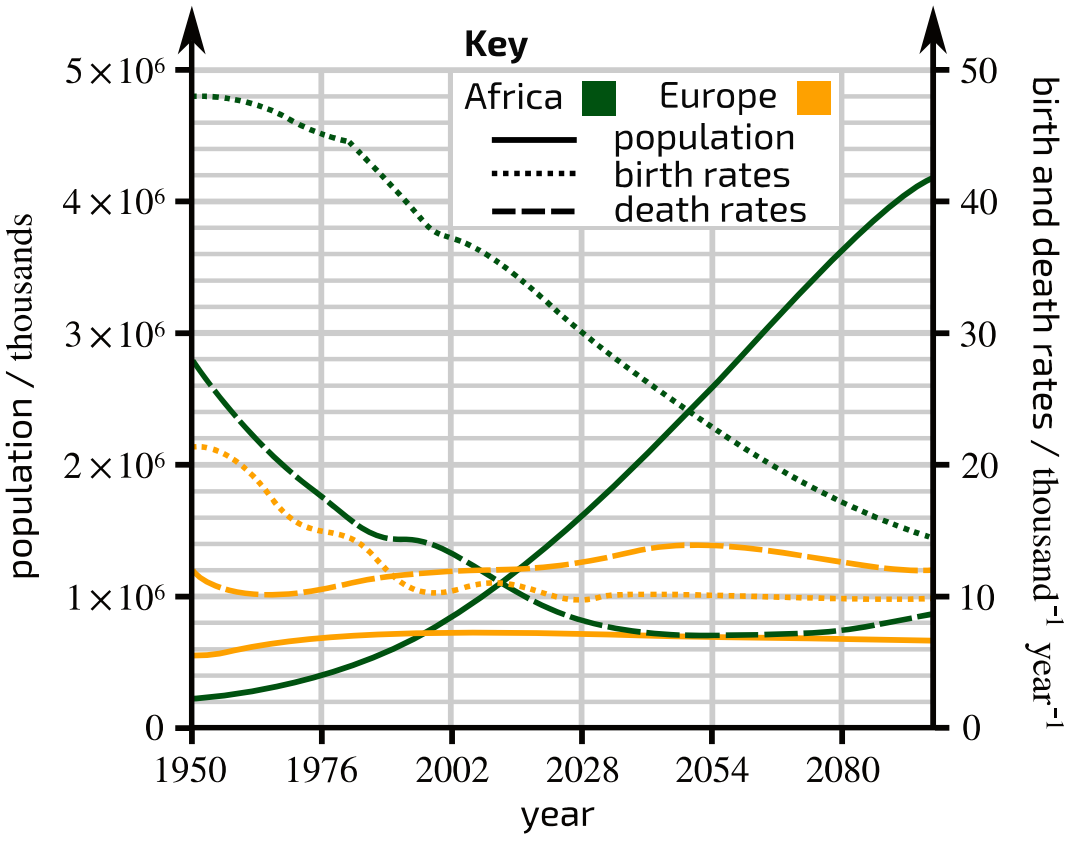

Figure 1: The changes in population, annual birth rate, and annual death rate in Europe and Africa since 1950 and projected beyond 2080.

Part A Population increase rate in Africa

Calculate the projected average yearly rate of increase in the population of Africa from 2028 to 2080.

Give your answer to two significant figures.

Part B Birth rates and death rates in Europe

What is the projected birth rate in Europe in 2054? Give your answer to two significant figures.

What is the projected death rate in Europe in 2054? Give your answer to two significant figures.

Part C Number of births and deaths in Europe

If the population of Europe in 2054 is 7×10^5 thousands, how many births will there be this year?

Use your answer from the previous section.

If the population of Europe in 2054 is 7×10^5 thousands, how many deaths will there be this year?

Use your answer from the previous section.

Part D Population changes

Which of the following statements are correct? Select all that apply.

- [ ] A population will be increasing in size if the birth rate is increasing and the death rate is constant or decreasing.
- [ ] A population will decrease in size if the death rate is higher than the birth rate.
- [ ] A population will increase in size if the birth rate is higher than the death rate.
- [ ] A population will be decreasing in size if the death rate is increasing and the birth rate is constant or decreasing.
- [ ] A population will remain the same size if the birth rate is constant and the death rate is constant.
- [ ] A population will remain the same size if the birth rate is equal to the death rate.

Part E Another factor in population increase

Which of the following could explain an increase in the size of a population in which death rates are **higher** than birth rates?

- ( ) an improvement in food quality and availability
- ( ) an increased life expectancy in the population
- ( ) migration into the population
- ( ) a beneficial mutation spreading throughout the population

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Adapted with permission from OCR A Level Biology B June 2018, Scientific Literacy in Biology, Question 5

Gameboard:
STEM SMART Biology Week 28 - Population Dynamics

Plotting Exponential Growth

A Level

A student plotted their prediction of the exponential growth of a bacterial population over 24 hours. Their graph is shown below.

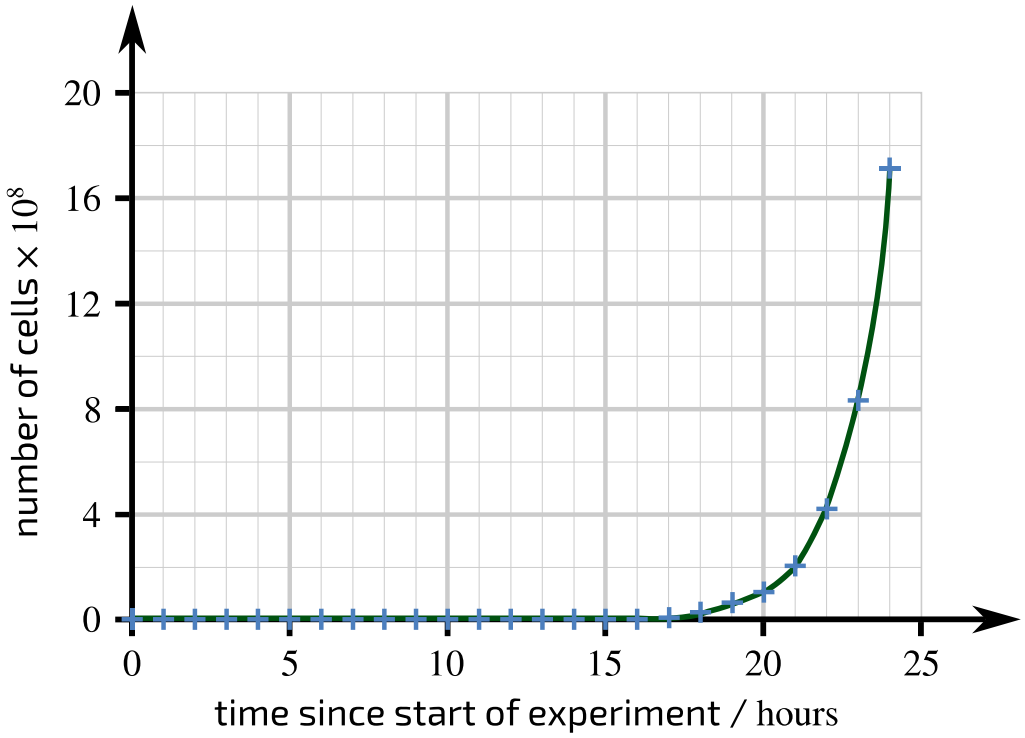

Figure 1: A student's graph showing their prediction of the exponential growth of a bacterial population over 24 hours.

Part A Plotting problem

What is the problem with plotting exponential growth as the student has done in **Figure 1**?

- The graph shows logistic growth, not exponential growth.
- The y-axis is too small, which makes it hard to read the smaller values.
- In order to fit the larger y-axis values on the graph, the scale must be so large that smaller values cannot be read.
- The x-axis should start at 15 rather than at 0, because there is no growth from 0 hours to 15 hours.

Part B Plotting solution

What change could the student make to fix the problem identified in the previous section?

- Use a logarithmic scale for the x-axis
- Use a logarithmic scale for the y-axis
- Use a logarithmic scale for the x-axis **and** a logarithmic scale for the y-axis.
- Remove the later values from the graph.

Part C An improved graph

The student recreated their graph using a logarithmic scale for the y-axis, as shown below.

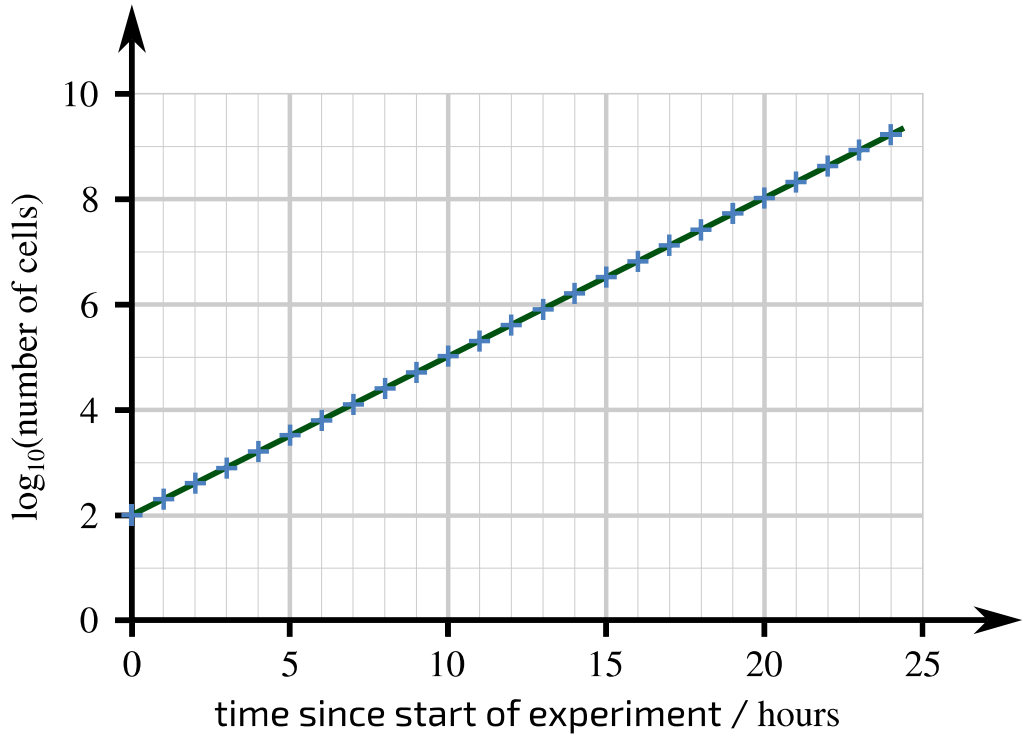

Figure 2: The student's graph showing their prediction of the exponential growth of a bacterial population over 24 hours, using a logarithmic scale for the y-axis.

Estimate the number of cells at each timepoint below, using **Figure 2**. Give your answers to 1 s.f.

0 hours: ____

10 hours: ____

20 hours: ____

Part D Growth equation

The student's prediction was that the number of cells would double every hour.

Use this information and your answer in the previous section to give the student's formula for the number of cells over time, where y is the number of cells and x is the time in hours.

The following symbols may be useful: `x, y`

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