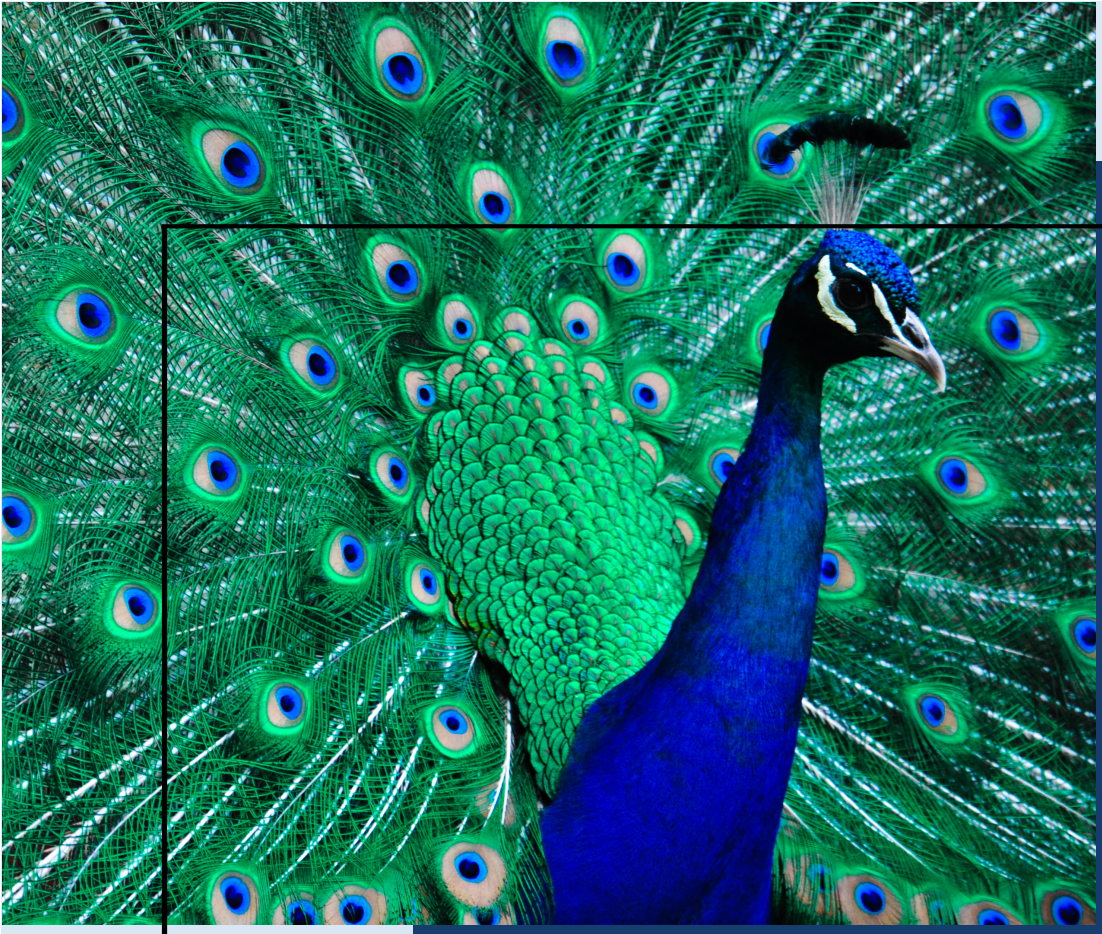


Unit Preparation Booklet

B2.3 Life Diversity

Teacher name:

Science **Mastery**

Ark Curriculum+

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Steps to Success

		What?	Why?	Who?	Page #
Preparing to teach	**1**	☐ Print this booklet or save a copy in a personal folder	To allow for engagement during planning and co-planning	*All teachers*	
	2	☐ Engage with the unit preparation checklist	To prepare for delivering the sequence of lessons	*All teachers*	3
	3	☐ Read the scope and sequence for the unit	To review the scope and sequence of the unit	*All teachers*	5
	4	☐ Complete the pre-unit quiz reflections task after administering to class	To plan how to remedy prior knowledge gaps	*New to teaching the unit only*	9
	6	☐ Complete the Mastery Quiz and exam-style questions activity	To learn/revisit the key assessment objectives of the unit	*New to teaching the unit only*	10-16
	7	☐ Complete the misconception activities	To develop a strong understanding of the most common misconceptions for the unit and how to address them	*New to teaching the unit only*	17-21
Delivering the unit	**8**	☐ Use the lesson by lesson objectives to monitor progression through the unit	To maintain a record of completion and to recognise what needs to be reviewed after each lesson	*Novice teachers only*	22-32
Utilise other features of the booklet	**9**	☐ Complete the advanced subject knowledge activity	To develop an understanding of where the unit can lead	*Non A-level specialists*	33
	10	☐ Engage in the keywords and new scientists for the unit	To identify the correct definitions for keywords throughout the unit	*Novice teachers only*	34-36

Unit preparation checklist

Resources can and should be tailored to meet your pupils' needs. We have aimed to do as much resourcing as possible so that teachers' time can be spent on co-planning and preparation; however, they are only ready for your pupils once you have decided how to make use of them.

Here is a suggested checklist:

Locate:

- ☐ **Find** the unit resources using MyMastery or SharePoint

Engage:

- ☐ Work through the preparation booklet. Complete the pre-unit quiz and mastery quiz yourself and reflect (all enclosed)
- ☐ Set your class the **pre-unit quiz** (in advance of the unit).
- ☐ Note which topics are **areas of weakness** for the class (space available in this booklet or on the planning pro-forma)
- ☐ **Decide** which topics you will re-visit 'in advance' and which to tackle during the unit (space available in this booklet or on the planning pro-forma)
- ☐ Identify where in the sequence of learning there are opportunities for embedding **guided reading**
- ☐ Use the **lesson planning guidance** to develop a grasp of the purpose of each lesson element

Adapt:

- ☐ Consider key timings for each lesson. Identify which lessons may need to be adapted to account for the length of your lessons or ability level of your class
- ☐ Identify what could be used as **homework** activities to support in-class learning in line with school policy
- ☐ Review the resources ahead of each lesson and ensure you are clear on the objectives of each lesson
- ☐ **Select** appropriate activities for each lesson from the selection within each lesson folder/on the slide deck
- ☐ **Administer** exit tickets and use outcomes of this to plan 'fix-it' tasks to tackle misunderstanding or misconception.
- ☐ Set the **mastery quiz** for your class. Use the information to plan a suitable re-teach lesson and further response, using the resources available.

Scope and Sequence

Scope

This unit introduces pupils to the types of variation and how this leads to diversity under the big idea 'species show variation'. Pupils will learn that variation is caused by inherited characteristics and interaction with the environment. Pupils will be provided with the opportunity to investigate continuous and discontinuous variation within their class and draw frequency tables or graphs to represent this.

This unit will be the first time pupils learn how different environments exert different selection pressures that result in diversity. Pupils will consider how organisms are adapted to suit the environment in which they live in order that they are able to survive and reproduce. Pupils will also be introduced to human practices that control the selection process in order to produce organisms with desirable characteristics.

This unit also introduces pupils to the concept of evolution, allowing pupils to develop an appreciation of how different species change over time. Pupils will also look at examples of when extinction has occurred, before reflecting on how human activity is accelerating the rate of extinction.

Sequence

Prior to this unit, pupils will have learnt how sexual reproduction results in variation as part of B1.1. Pupils will also have developed an appreciation of how species rely on each other for survival in B1.3. Pupils are likely to be able to describe some examples of variation in humans and may have carried out simple investigations into these differences at KS2.

Pupils will begin this unit learning about variation. They will consider how variation is affected by both the environment and heredity, how DNA controls inherited characteristics, and how variation can be either continuous or discontinuous. Pupils will have the opportunity to investigate variation amongst their peers. Pupils will then learn about artificial selection as a way of controlling variation, before studying natural selection. Pupils will finish this unit learning about how natural selection gives rise to evolution. Pupils will learn how species that do not evolve can become extinct if their environment becomes unfavourable, look at some examples of extinction events from history and consider how humans are affecting extinction rates today.

This unit provides pupils with a basic understanding of the importance of variation and how humans are impacting the diversity of life on Earth. This is essential in helping them appreciate their role as responsible citizens of Earth. Pupils will take this learning further at KS4 when they revisit the concepts of natural selection, evolution, speciation and extinction.

A full set of knowledge objectives for this unit can be found as **Appendix 5.**

1	2	3	4
Prior Knowledge Review	Variation	Inheritance	Maths in Science Lesson 10 Fractions
5	**6**	**7**	**8**
Maths in Science Lesson 11 Percentages	Artificial Selection	Natural Selection	Evolution
9	**10**		
Human Impact on Natural Selection	Feedback Lesson		

TASKS:

New teachers: Organise the lesson titles into those you feel most to least confident about *Experienced teachers:* Reflect on prior experience of teaching this unit. Which lessons have gone well? Which would you like to target for improvement this year?

Pre-unit quiz

TASK: Below is the pre-unit quiz available for your pupils. Complete yourself and set for your pupils ahead of starting the unit. There is space to record the key outcomes from marking the quiz for your class. **See Appendix 1 for the mark scheme.**

1. Choose the correct function of the nucleus of a cell. [1]
   Tick (✓) **one** box.
   - (a) Releases energy for the cell to use ☐
   - (b) Controls the cell's activities because it contains DNA ☐
   - (c) The nuclei of gametes fuse in sexual reproduction ☐

2. Choose which part is found in both plant and animal cells. [1]
   Tick (✓) **one** box.
   - (a) Cell wall ☐
   - (b) Chloroplast ☐
   - (c) Nucleus ☐

3. Choose which organisms use sexual reproduction. [1]
   Tick (✓) **one** box.
   - (a) Animals and plants ☐
   - (b) All organisms ☐
   - (c) Only animals ☐

4. Choose the best description of **gametes**. [1]
   Tick (✓) **one** box.
   - (a) Egg and sperm cells ☐
   - (b) When cells fuse together in sexual reproduction ☐
   - (c) Cells involved in sexual reproduction ☐

5. Choose the only correct feature of **sexual reproduction**. [1]
   Tick (✓) **one** box.
   - (a) The offspring look different to their parents ☐
   - (b) Only one parent is needed to make offspring ☐
   - (c) The offspring contains a nucleus from the female gamete and the male gamete ☐

6. Within a particular habitat, a **population** is… [1]

Tick (✓) **one** box.

(a) all the humans in the world. ☐

(b) a group of the same type of animal. ☐

(c) a group of the same type of organism. ☐

7. Choose which is an abiotic factor. [1]

Tick (✓) **one** box.

(a) Intensity of sunlight ☐

(b) Biomass of plants ☐

(c) A new predator in the community ☐

8. A population of palm trees would compete for… [1]

Tick (✓) **one** box.

(a) water. ☐

(b) predators. ☐

(c) mates. ☐

9. There can be many different… [1]

Tick (✓) **one** box.

(a) populations in a community. ☐

(b) ecosystems in a habitat. ☐

(c) types of organism in a population. ☐

10. Choose which of the following describes interdependence in a desert ecosystem. [1]

Tick (✓) **one** box.

(a) A snake eats a lizard ☐

(b) The cactus plant reproduces sexually ☐

(c) Snakes, lizards and cacti populations live in the desert ecosystem ☐

Total = ___ /10

Pre-unit quiz reflections

To be completed once you have reviewed your pupils' response to the pre-unit quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout the unit?

Other notes

Mastery Quiz

TASK: Below is the mastery quiz available for your pupils to sit at the end of the unit. Complete yourself and consider the key misconceptions this quiz aims to address. See **Appendix 2** for the mark scheme.

Section A

1. Extinction is … [1]
   Tick (✓) **one** box.
   A. when organism can survive in an extreme environment. For example, somewhere very hot. ☐
   B. when no living individuals of a species are alive. ☐
   C. when the only species alive are in captivity. ☐

2. All pet dogs are the same species.

   The best evidence to support this is that all dog breeds …[1]
   Tick (✓) **one** box.
   A. have similar characteristics. ☐
   B. can breed to produce fertile offspring. ☐
   C. share a common ancestor. ☐

3. Orange trees grow in tropical climates. Tropical climates have lots of sunlight, very hot temperatures, and low levels of rain.

   Choose an adaptation that orange trees have to the abiotic factors in their habitat. [1]
   Tick (✓) **one** box.
   A. Long roots to absorb water ☐
   B. Many large leaves to absorb sunlight ☐
   C. Make orange fruit for seed dispersal ☐

4. Sexual reproduction produces offspring that are not exact copies of their parents.

   Choose the best explanation for this.[1]
   Tick (✓) **one** box.
   A. Mutations in DNA cause new characteristics ☐
   B. The DNA is copied from parents to offspring ☐
   C. Fusion of gametes forms a new individual ☐

5. Choose which of the following is an example of artificial selection.[1]

Tick (✓) **one** box.

A. Dandelion seeds are adapted for wind dispersal ☐

B. A breed of cow that has more muscle mass to produce more meat ☐

C. A farmer has chickens that lay smaller than average eggs ☐

6. Within a population there is variation.

This means that there are …[1]

Tick (✓) **one** box.

A. different species in a particular environment. ☐

B. different characteristics between individuals of the same species in a group. ☐

C. similar characteristics between species in a group. ☐

7. In a sample of sheep, 14 % had a dark wool colour.

Choose which fraction shows the number of sheep with dark wool in the sample. [1]

Tick (✓) **one** box.

A. $\frac{14}{100}$ ☐

B. $\frac{1}{14}$ ☐

C. $\frac{14}{10}$ ☐

8. In a group of 96 students, 16 of them have blue eyes.

Choose the simplest possible fraction that represents how many students have blue eyes. [1]

Tick (✓) **one** box.

A. $\frac{16}{96}$ ☐

B. $\frac{8}{48}$ ☐

C. $\frac{1}{6}$ ☐

9. The number of petals on 250 different rose plants were counted.

The results are shown below.

Number of petals	Number of rose plants
5	235
6	15

Choose the correct analysis of these results.m[1]

Tick (✓) **one** box.

A. 106 % of the roses counted had 5 petals ☐

B. 94 % of the roses counted had 5 petals ☐

C. 40 % of the roses counted had 6 petals ☐

10. Choose the option that describes how a new characteristic appears within a population. [1]

Tick (✓) **one** box.

A. Characteristics appear when needed and disappear when not needed ☐

B. Organisms mutate to survive a change in their environment ☐

C. Random mutations in DNA result in new characteristics forming ☐

11. Choose the correct statement about genotypes and phenotypes. [1]

Tick (✓) **one** box.

A. The genotype is DNA that codes for a phenotype ☐

B. The phenotype produces the genotype ☐

C. The phenotype and genotype are both sections of DNA that produce a characteristic ☐

12. Evolution can cause…[1]

Tick (✓) **one** box.

A. an individual to adapt to the environment. ☐

B. a new species to form. ☐

C. a new characteristic to form over one generation, from parents to offspring. ☐

13. The theory of evolution by natural selection states that all life has evolved from simple organisms more than…[1]

Tick (✓) **one** box.

A. three thousand years ago. ☐

B. three million years ago. ☐

C. three billion years ago. ☐

14. Artificial selection of closely related individuals can cause inbreeding.

Choose the result of inbreeding. [1]

Tick (✓) **one** box.

A. Offspring could have an inherited disease ☐

B. Offspring have a desirable characteristic ☐

C. A new breed could be formed ☐

15. The table below shows average number of breeding cycles per year for different animals.

Each breeding cycle produces new offspring.

Animal	Average number of breeding cycles per year
Mouse	8
Hedgehog	2
Tortoise	1

Choose which animal would be able to adapt to a change in the environment the fastest. [1]

Tick (✓) **one** box.

A. Mouse ☐

B. Tortoise ☐

C. All animals can adapt to a change in the environment at the same speed ☐

15

Section B

1. State two causes of variation in a species.

   _____

2. Describe one factor that could cause a species to become extinct.

   _____

   _____

3. Explain how artificial selection is carried out using an example organism.

   _____

   _____

   _____

4. Charles Darwin proposed that evolution happened by natural selection.

   Explain how natural selection occurs.

   _____

   _____

   _____

   _____

   _____

   _____

   _____

   _____

Mastery quiz reflections

Which aspects of genetics are likely to be the most challenging to teach?	
What are your pupils likely to find most challenging and why?	
Challenging.....	Because....
E.g. The number of new keywords	*They are abstract words that aren't used in other areas of science*
How can you pre-empt some of the key misconceptions the mastery quiz aims to identify?	
Misconception	**How to avoid**

Exam-style questions

TASK: Using exampro (or the software used by your exam board), look through the typical exam-style questions for this topic. These sorts of questions are posed throughout the unit and pupils should be prepared to answer similar questions in the end-of-year assessments.

Suggested questions to guide this process:

How is knowledge from this unit typically assessed? What are the most common questions?
Which question types are the most challenging?
What general trends can you spot in the typical errors pupils make (from examiner reports/notes)?
How could you help prepare your students for answering these types of questions?

Common mistakes, errors and misconceptions

How would you tackle the following common mistakes, errors and misconceptions by pupils?

TASK: Consider why each of the following typically seen statements is a mistake/misconception. What possible approaches can you plan to pre-empt and respond to this? Which lessons do these correlate to?

CHALLENGE: Cover the middle column and explain yourself why each is a mistake.

Mistake	**Reason why it's a mistake**	**Possible approaches to pre-empt and respond?**
There is no variation in plants.	There is variation within all species. Many examples that are used in classrooms focus on variation between humans or other animals.	
Variation refers to differences between species.	Variation refers specifically to variation within a species.	
The idea of essentialism is the belief that each species as a 'norm' or standard type and that any variation from this standard is unusual.	There is no 'model' organism for a species. Variation is all the differences within the species.	
Children look similar to their parents because they inherit all of their DNA.	Children inherit 50% of their DNA from each parent through paired chromosomes.	
Children look more similar to one parent because they inherit more DNA from that parent.	Genes can be dominant or recessive, so some genes from one parent may be expressed more than the other parent.	
Adaptations are physical features.	Adaptations can be structural, physiological or behavioural.	
Artificial selection is only used for animal production.	Many crops have been artificially selected by humans to be resistant to disease or have higher crop yield.	
Organisms can develop/change/choose their adaptations over their lifetime (acquired characteristics).	Adaptations are predetermined by genetics so cannot be changed throughout an organism's life as it is not possible to alter the DNA.	
Survival of the fittest means that the strongest or biggest organism will survive.	Evolutionary 'fitness' is not the same as physical fitness (i.e. strength or speed). Evolutionary fitness refers to how well a species is able to reproduce in	

	its environment.	
Plants do not undergo evolution and natural selection does not act on plants as they cannot move so cannot compete with each other.	This is linked to not recognising variation within plant species, an assumption that plants are not living things. Natural selection acts on plants but they compete for different resources.	
Evolution through natural selection occurs over a short time frame.	Evolution is a long process of natural selection through many, many generations and thousands (or more) years.	
Life on earth has evolved in a relatively short time.	All life on earth has evolved from simple life forms, but this is an ongoing process and has been going on for at least 3.5 billion years. Students often find it difficult to imagine or understand this time frame.	
A theory (e.g. the theory of evolution) is similar to a hunch or a guess.	A scientific theory is an explanation that is widely accepted because it has been tested and evidenced.	
Humans are separate from the animal kingdom and therefore are not subject to evolution, and/or are a 'final finished product'.	Humans are mammals and part of the animal kingdom and are therefore subject to evolution.	

Planning for the misconceptions

Misconception: Organisms can change/develop/choose their adaptations during their lifetime.
This misconception is linked to Lamarckism or 'soft inheritance'. The key misunderstanding is that all characteristics are passed from parents to child, including acquired characteristics, or variation resulting from environmental factors.
Supporting pupil understanding
Understanding the difference between observable characteristics and adaptations is key. The difference between inherited and acquired characteristics can be quite difficult for some students to understand, so it can be useful to use concrete examples that students can relate to. Students need to be able to understand the difference between characteristics that are inherited, characteristics that are affected by the environment and characteristics that involve both. An easy example to explain the difference is hair colour. Hair colour is affected by both inheritance and the environment. A person's natural hair colour may be brown, but they could dye it pink. Some questions can then be used to probe understanding: - If this person then had their own children, would their hair be more likely to be brown or pink? Why? - Would it make a difference if the person had never dyed their hair? Other examples to refer to could be muscle mass. What happens if a person becomes a body builder during their lifetime? Would their children also have increased muscle mass? Why? What about if a person had an injury or operation? Would their scars or injuries be inherited by their children? These changes may affect the individual's characteristics but they do not consitute adaptation or evolution. Adaptation and evolution refer to the process of natural selection in a population over generations, not the change in observable characteristics of one individual. It is also important to be mindful of how language is used. The word 'adapt' can often be confused with a scientific adaptation and the two are often used incorrectly and interchangeably. In everyday language, it is common to describe a person or thing as 'adapting to change', which is the root of the issue. It is worth explicitly describing the difference between the verb *adapting* and the noun *adaptation*.
Taking it further
To help pupils appreciate that this process does not just apply to humans, it would be useful to include examples of other animals and plants.

Misconception: Plants do not show variation so therefore natural selection does not act on plants.

It is much easier for students to see and understand variation within animal species, to help explain the process of natural selection. However, this often means that because there are the examples used, students assume that plants are not subject to natural selection. This can also be because students find it more difficult to identify variation within plant species.

Supporting pupil understanding

For students to understand and explain the process of natural selection in plants, they first need to recognise variation within plants. Ideally this can be done with live plants and students being outside, but picture examples may also be suitable.



Some examples:

- A species of cactus with different lengths of spikes
- Green plants with different sized leaves/numbers of leaves
- Size of fruits on different plants

Once students have been able to recognise variation within plant species, they can follow the same structure as they do when describing the process of natural selection within any other species:

- there is **variation** within the population
- some organisms have **adaptations** that make them better suited to the environment
- these organisms are more likely to survive and **reproduce**
- the adaptations are passed on to the next **generation**

Taking it further

Students often struggle to identify or explain how natural selection may act on different species. To help students practice this, it can be useful to provide them with different images of examples to identify the variation and describe how the process of natural selection would act on the population.

Mistake: Evolution is a quick process and happens within a generation.

Students often confuse the process of natural selection with evolution. Evolution is the change in inherited characteristics of a population over time, and natural selection is the method by which it happens. Many examples that are used to show natural selection focus on competition with a few individual organisms, leading to students assuming that the next generation has evolved from the previous one. There is no specific time for how long it takes evolution to happen as it is an ongoing process but different researchers have found that it takes approximately one million years for any significant changes to accumulate. The shorter the life cycle of the organism, the faster evolution will happen through natural selection, as there are more generations produced in a given time period.

Supporting pupil understanding

The hardest concept for students to grasp here is the time frame of evolution, which comes from not understanding how large numbers relate to each other, such as a million and a billion. One way of getting students to think about this can be in terms of seconds:
One million seconds is 11 days, 13 hours, 46 minutes.
One billion seconds is 31.69 years (11,574 days).

Life has evolved from simple organisms over 3.5 billion years ago, and different species can take over one million years to evolve. For a species to have evolved, the inherited characteristics need to be different enough. Some students will assume that because some characteristics have been passed on to the next generation, this generation is different enough from the previous so we can say it has evolved. This is not the case.

To demonstrate the relative time frames involved, it can be worth using an example that students may recognise and going through some of the evolutionary stages (linking back to the fossil record). A good example is the evolution of the horse:
https://www.britannica.com/animal/horse/Evolution-of-the-horse

The modern horse has evolved from some of the following ancestors (with relative time frames noted so that students can see how long the process takes):
The evolutionary lineage of the modern horse can be related back to:

- *Equus*: approximately 1 million years ago. Height of approximately 1.6 m and a single hoof
- *Pliohippus*: approximately 10 million years ago. Height of approximately 1.0 m and a single hoof
- *Merychippus*: approximately 30 million years ago. Height of approximately 1.0 m and a large middle toe/hoof
- *Mesohippus*: approximately 40 million years ago. Height of 0.6 m and 3 toes
- *Hyracotherium*: approximately 60 million years ago. Height of 0.4 m and 4 toed hoof

There is still 60 million years of evolution of horse in this example, which seems like a very long time. However this only represents 1.7% of the time from the beginning of life on earth.

Unit objectives: knowledge, skills and concepts

As you teach the lessons, track here the objectives you meet.

TKT = to know that TBAT = to be able to

Critical: it is critical that all pupils become proficient; future learning will be very challenging for them if they do not and it is likely they will not come across this content again. These are priority objectives for reteaching, revision, and intervention. Before moving on, discuss a strategy with your HOD if some pupils are not making progress with these objectives.
Core: it is important for all pupils to learn this, and it will be essential for success at GCSE. However, it will not impede them in other units if they are not (yet) proficient in it as they are likely to revisit it again in subsequent units.
Stretch: pupils should have the opportunity to be work on this aspect of science. This content is crucial for pupils to achieve the highest GCSE grades and to succeed at A-level.
Key skill: pupils should have the opportunity to develop this key skill as part of this unit.

Intended outcome for separate sciences pupils are denoted in blue and italised.

Lesson 1: Prior Knowledge Review

Intended outcome	Example questions
*This lesson is a review of content from previously studied units relating to this big idea	
TBAT define a population.	Define a population. Explain the difference between a population and a community. Identify a population in the jungle ecosystem.
TBAT define fertilisation.	Define fertilisation. State the gametes found in animals and plants. Describe the process of fertilisation. Explain how genetic material is mixed during fertilisation. Compare the amount of genetic material in a gamete and a body cell.
TBAT describe how biotic and abiotic factors affect a community.	Give an example of a biotic factor. Give an example of an abiotic factor. Describe what effect a new predator will have on the population of prey. Explain what effect a new predator will have on the population of prey. Explain what effect a lack of rainfall will have on a food chain.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 2: Variation

Intended outcome	Example questions
TKT a species is a group of similar organisms that can reproduce to make fertile offspring.	Define a species. Explain why two lions are part of the same species. Explain why a lion and a tiger are not the same species.
TKT variation is the different characteristics between individual organisms.	Explain what is meant by variation.
TKT there is variation within a population.	Give examples of variation in humans. Give examples of variation in dogs. Give examples of variation in daisies.
TKT variation can be caused by inherited factors, environmental factors or a combination of the two.	Describe the different sources of variation in a population. Explain whether hair colour, eye colour and height are caused by inherited or environmental factors, or both.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 3: Inheritance

Intended outcome	Example questions
TKT a genotype codes for a particular phenotype.	Define a genotype. Define a phenotype. Identify the genotype and phenotype of a person with blue eyes.
TBAT describe the function of DNA and the effect of DNA mutations.	State the organelle that contains DNA. Define a mutation. Describe the possible effects of DNA mutations.
TBAT explain how fertilisation produces a zygote that is genetically distinct.	Define fertilisation. Compare the DNA in parent body cells, gametes and zygotes. Explain why offspring look similar to both parents. Explain why offspring do not look identical to either parent.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 4: Maths in Science Lesson 10 Fractions

Intended outcome	Example questions
TBAT use fractions to describe parts of a whole.	Explain what is meant by a fraction. What does 'half' of something mean?
TBAT compare sizes of fractions.	Which is bigger, ½ or ¼?
TBAT convert between fractions and decimals.	Write 0.4 as a fraction. Write $\frac{1}{5}$ as a decimal.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 5: Maths in Science Lesson 11 Percentages

Intended outcome	Example questions
TBAT use percentages to describe parts of a whole.	Explain what is meant by a percentage of something. What does 70% of something mean?
TBAT compare sizes of percentages.	Which is bigger, 10% or 5%?
TBAT convert between fractions, decimals and percentages.	Write 0.2 as a percentage. Write $\frac{1}{5}$ as a percentage. Write 40% as a fraction and a decimal.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 6: Artificial Selection

Intended outcome	Example questions
TKT crops and domesticated animals are the result of artificial selection.	Give an example of an organism that has been selectively bred by humans.
TBAT describe the process of artificial selection.	Describe how humans have selectively bred cows to produce more milk. Describe how humans have selectively bred crops to produce greater yields.
TBAT explain why artificial selection can cause inbreeding.	Explain what is meant by inbreeding. Explain why artificial selection can cause inbreeding. Give an example of an inherited disease that was passed on by inbreeding.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 7: Natural Selection

Intended outcome	Example questions
TBAT state the definition of an adaptation.	Define an adaptation. Describe an adaptation of animals in the Arctic ecosystem. Describe some adaptations of plants in hot climates. Describe the different types of adaptations.
TBAT describe factors that plants and animals compete for.	State the factors that animals compete for. State the factors that plants compete for. In a desert, what resource are plants likely to compete for? Describe how competition may change with a changing factor.
TBAT describe the process of natural selection.	Describe the process of natural selection. Describe how natural selection would act on a population of giraffes. Explain why some organisms may be more likely to survive and reproduce in their environment.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 8: Evolution

Intended outcome	Example questions
TBAT define a species.	Define a species. Explain how you could determine whether or not two organisms belong to the same species.
TBAT describe the theory of evolution.	Describe the theory of evolution. Define evolution. Explain the difference between evolution and natural selection.
TBAT explain how new species can be formed.	Describe the process of speciation. Describe the requirements for speciation to occur. Explain how you would be able to tell whether or not a new species had been formed.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 9: Human Impact on Natural Selection

Intended outcome	Example questions
TBAT state the meaning of extinction.	Explain what it means for a species to be extinct. Give an example of a species that has gone extinct. Explain the difference between extinct species and endangered species.
TBAT describe the causes of extinction.	Describe the causes of extinction. Suggest how human activities could be affecting the rate of extinction. Suggest how humans could reduce their impact.
TBAT explain the term extremophile.	Define an extremophile. Give an example of an extremophile. Suggest why being an extremophile is an advantage with global warming of the Earth.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Mastery Quiz re-teach planning

To be completed once you have reviewed your pupils' response to the mastery quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout another unit? When will that be taught?

Other notes

Lesson 10: Feedback lesson

Intended outcome	Example questions
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Advanced subject knowledge

Where does this learning lead?

At GCSE, pupils will be introduced to genetics as well as natural selection and evolution in more detail. At A-level, pupils will be expected to know the two different forces that affect genetic variation; genetic drift and natural selection. They will also be expected to relate their knowledge of ecosystems more complex environmental relationships and the process of succession.

Have a look at the questions below and think about what this means for this unit.

How does learning from this unit develop at KS4?
What content from this unit is fundamental to student understanding at KS4?
How could you check that students have grasped these fundamentals?

Vocabulary and literacy

Tier 3 vocabulary and phrases in this unit that pupils are likely to already know:

Word	Definition	Example in context
Abiotic	Something that is not to do with a living thing.	Light, temperature and water availability are all abiotic factors.
Biotic	Something to do with a living thing.	Food availability, disease and predators are all biotic factors.
Community	Two or more populations of organisms in the same habitat.	A group of seals and sharks form a community in the ocean.
Competition	Where organisms need a resource that has a limited supply.	In the desert habitat, there is competition between plants for water.
DNA	The molecule that contains all the genetic information (code) for each organism.	We inherit half our DNA from each parent.
Ecosystem	Interaction between a community of living organisms and their environment.	An ecosystem is two or more populations of organisms (usually many more) in their environment.
Environment	All the factors that make up the habitat where an organism lives.	Extremophiles can survive in their extreme environment
Gamete	A sex cell	The male gamete in animals is the sperm.
Population	A group of organisms from the same species.	Within a forest, there is a population of fir trees.
Predator	An animal that hunts other animals for food.	Lions are a predator of antelope.

Tier 3 vocabulary that will need to be explicitly taught in context:

Word	Definition	Example in context
Adaptation	A characteristic that allows an organism to survive and reproduce in its habitat.	Some prey animals camouflage to their surroundings, which is an adaptation.
Artificial Selection	The process by which humans choose desirable characteristics and only allow organisms with the characteristic to reproduce, also called selective breeding.	Humans have used artificial selection to produce cows that produce a lot of milk, as well as all domesticated dogs.

Evolution	The change in inherited characteristics of a population over time caused by natural selection.	Charles Darwin proposed the theory of Evolution.
Extinction	When there are no living individuals of a species left in the wild and/or in captivity.	Global warming is putting many different species at risk of extinction.
Extremophile	Organisms that live in extreme conditions of temperature, pH, salt or pressure.	Some extremophile fish are able to live under great pressure deep in the sea.
Fossil	The preserved remains or traces of ancient organisms.	Fossils are used as a record to discover the different species that have lived on Earth.
Generation	A stage in the life cycle of an organism, a group of organisms that were born and are living at the same time.	Parents produce offspring as the next generation.
Genotype	The DNA inherited that causes a characteristic.	The girl's genotype is having DNA that codes for brown hair.
Inbreeding	When organisms that are closely related reproduce.	Inherited diseases can be passed on through inbreeding.
Inherit	When something is passed on through genetics.	Offspring inherit characteristics from their parents.
Inherited Disease	A condition or disorder that is passed on through DNA.	Some pug dogs suffer from a respiratory inherited disease.
Mutation	A random change to the DNA.	Blue eyes is a characteristic that can be traced back to a single mutation.
Natural Selection	The process by which variation in a population means that some organisms are better suited to the environment so will be more likely to survive and reproduce.	Ladybirds that are most camouflaged will be less likely to be eaten by predators. This is natural selection.
Phenotype	The physical characteristic that an organism has.	The girl's phenotype is having brown hair.
Speciation	The process by which populations are isolated and natural selection acts differently on each population, making them so different that they can no longer interbreed.	Darwin's finches provided evidence for speciation as they were isolated on different islands and natural selection acted differently on each.
Variation	The difference in characteristics within a population.	In humans, there is variation is eye colour, skin colour, hair colour, blood type etc.

New scientists:

Scientist	Famous for	Background
Darwin	✓ Proposing the theory of evolution by natural selection ✓ Studied finches and other organisms on the Galapagos islands	Charles Darwin (1809-1882) was an English naturalist and biologist who published his findings in his 1859 book *On the Origin of Species*.

Appendices

Appendix 1: Mark scheme for pre-unit quiz

Qu	Answer	Marks	Supporting information for fix-it tasks
1	B	1	Answering A shows a confusion between the functions of the nucleus and mitochondria. *To fix it, give students organelle functions and ask them to write out which part of the cell is being described.* Answering C shows the misconception that the sole function of the nucleus is for sexual reproduction. *To fix it, reteach that there is a nucleus in all cells of organisms (you could refer to red blood cells not having a nucleus as an adaptation for carrying oxygen as a stretch here) and they all contain DNA which is a code for controlling the activities of the cell.*
2	C	1	Answering A or B shows a gap in knowledge about which parts are in plant cells and which are in both plant and animal cells. *To fix it, recap using cell diagrams, which parts are common to both plant and animal cells and which are just in plant cells. Then ask students to describe the parts of a plant cell and parts in both animal and plant cells.*
3	A	1	If students answer B, this suggests a gap in knowledge that asexual reproduction is also a type of reproduction used by organisms. *To fix it, ask students to state the two different types of reproduction.* If students answer C, this suggests the common misconception that only animals use sexual reproduction. *To fix-it, ask students to describe sexual reproduction in plants, including the names of plant gametes.*
4	C	1	If students answer A, this suggests that students have the misconception that gametes only refer to egg and sperm cells in animals. *To fix-it, ask students to list the two types of gametes in animals and in plants.* If students answer B, this suggests that students have confused gametes with the process of fertilisation. *To fix-it, ask students describe what happens during fertilisation using the term 'gametes'.*
5	A	1	If students answer B, this suggests a confusion between sexual and asexual reproduction. *To fix-it, ask students to state whether one or two parents is needed for sexual and asexual reproduction.* If students answer C this suggests a gap in knowledge about fertilisation. *To fix it, ask students to describe what happens to the nucleus of the sperm cell and the egg cell after fertilisation.*

6	C	1	Answering A suggests the misconception that population only refers to humans, which could be the result of non-scientific use of the word population. *To fix it, reteach the definitions of population, organism and habitat. Then ask students to describe an example of a population.* Answering B suggests the misconception that population only refers to animals. *To fix it, reteach the definitions of population, organism and habitat. Then ask students to describe an example of a population that is either a plant or bacteria.*
7	A	1	Answering B could suggest the misconception that plants are not living things. *To fix it, ask students to explain how plants reproduce, respire and get nutrition.* Answering B or C shows a gap in knowledge about what biotic and abiotic factors are. *To fix it, reteach the difference between biotic and abiotic factors, using examples and then ask students to list the biotic and abiotic factors in a food web (see lesson B1.3.6 for some food web images).*
8	A	1	Answering B suggests the misconception that plants compete for predators. *To fix it, reteach that plants may be adapted to avoid being eaten by predators, but they do not compete for predators. Then ask students to write out the definitions for predator and prey. Then to state an example of an organism that would be affected by the introduction of a new predator in the community.* Answering C suggests the misconception that plants reproducing using 'mates'. *To fix it, briefly recap plant sexual reproduction and then ask students to discuss how animal and plant sexual reproduction are different.*
9	A	1	Answering B suggests a gap in knowledge of the terms ecosystem and habitat. *To fix it, reteach these key terms using examples: ecosystem, habitat, community and population. Then ask students to write their own definitions using a desert ecosystem.* Answering C suggests the misconception that a population contains different species/types of organism. To *fix it, reteach the definition population and community and emphasise how important this knowledge is for understanding this unit. Then ask students to describe populations you might find in a woodland community.*
10	A	1	Answering B suggests the misconception that the reproduction of an organism is an example of interdependence. *To fix it, reteach the definitions: ecosystem, population and interdependence. Then ask students to explain what interdependence is using example organisms.*

			Answering C suggests the misconception that naming populations in an ecosystem is the same as describing interdependence. *To fix it, reteach the definitions: ecosystem, population and interdependence. Then ask students to explain what interdependence is using example organisms.*

Appendix 2: Mark scheme for mastery quiz

Section A

Qu	Answer	Marks	Supporting information ***Suggestions for fix-it tasks***
1	B	1	Answering A suggests a confusion of extinction and extremophiles. *To fix it, reteach the definitions of extinction and extremophiles. Then ask students to describe what it means if a species extremophile bacteria goes extinct because the temperature of its habitat has changed.* Answering C suggests a misconception that extinction means that some individuals are alive in captivity. This may have arisen due to general knowledge about zoos and conservation efforts that act to prevent extinction of endangered species. *To fix it, ask students to define extinction and then explain one way that humans can prevent an endangered species from going extinct.*
2	B	1	Answering A suggests some understanding that there are some similar characteristics between individuals of a species but it shows the gap in knowledge that definition of a species is that they reproduce to make fertile offspring. *To fix it, tell students that a donkey and a horse look similar and can reproduce, BUT the offspring are infertile (which means they cannot reproduce). Then ask students to explain whether donkeys and horses are the same species or not.* Answering C suggests a misconception that a common ancestor shared by individuals means that they are the same species. *To fix it, reteach that a common ancestor can go back millions of years and do not determine what a species is. Then ask students to write out the definition of a species, using chimpanzees and humans as examples.*
3	A	1	Answering B suggests a misconception that many large leaves is an adaptation to lots of sunlight. *To fix it, ask students to predict what the leaves of an orange tree might look like, considering the amount of sunlight in the environment.* Answering C suggests a gap in knowledge about abiotic factors, because seed dispersal is not an adaptation to the sunlight, temperature or rain. *To fix it, ask students to explain how the following adaptations allows the orange tree to survive in its habitat: small leaves, waxy leaves, very branched roots.*
4	C	1	Answering A suggests the misconception that mutations in DNA are the main source of variation produced from

			sexual reproduction. *To fix it, reteach that random mutations can happen in both sexual and asexual reproduction, so the main source of variation in offspring is produced by fusion of gametes. Then ask students to describe two ways that inherited variation can occur.* Answering B suggests the misconception that sexual reproduction involves simply copying DNA from parent to offspring. This could be a confusion between asexual and sexual reproduction. *To fix it, reteach the differences between sexual and asexual reproduction and then ask students to state definitions for gametes, fertilisation and sexual reproduction.*
5	B	1	Answering A suggests the misconception that any adaptation is due to selective breeding, rather than natural selection. *To fix it, ask students to explain the difference between artificial and natural selection, using examples.* Answering C suggests the misconception that artificial selection is carried out for an undesirable characteristic. *To fix it, ask students to recall the definition of artificial selection, including an example. They should use key words: characteristic, desirable, generations.*
6	B	1	Answering A suggests a misconception that variation in the population refers to variation between species. *To fix it, reteach the key words from B1.3 Interdependence: population, community, ecosystem, abiotic, biotic. Then ask students to explain the difference between a population and a community.* Answering C suggests a misconception that variation is a similarity of characteristics. *To fix it, show students images of different dog breeds and reteach that this is one species that shows great variation in characteristics. Then ask students to compare a population of a species that had lots of variation and one that had less.*
7	A	1	Answering B suggests the common misconception that converting a fraction to a percentage is 1/the percentage. *To fix it, reteach that a percentage is x/100 and then give some simple practice questions to apply this.* Answering C suggests the misconception that when converting a percentage to a fraction, the denominator is 10. *To fix it, model how this fraction is greater than 1 because the numerator is greater than the denominator and a percentage below 100% must have a value of less than 1. Then give some simple practice questions to apply this.*
8	C	1	Answering A suggests a misconception that the simplest

			fraction uses the numbers given, rather than to simplify the fraction. *To fix it, model how to simplify this fraction and then give more practice examples.* Answering B shows some understanding that the simplest fraction must contain numbers lower than the original fraction, however, it shows the error of simply halving the numerator and denominator, rather than dividing by the greatest common factor. *To fix it, show that all these options are equivalent but C is the simplest. Then give students more practice examples of calculating the simplest possible fraction.*
9	B	1	Answering A suggests that the numbers selected are correct but the division calculation is incorrect, because this is 250/235 x 100. *To fix it, model how to perform this calculation and then give more practice questions for calculating percentage.* Answering C suggests that the table has not been interpreted correctly because this shows the calculation of 6/15 x 100. *To fix it, ask students to state how many rose plants had 5 petals and how many had 6 petals. Then ask them to calculate the percentage of the total number counted had 5 petal, showing their working.*
10	C	1	Answering A suggests the misconception we can 'control' our evolution. To fix it, *ask students if one of them loses a finger, will their children also be born without a finger? Use your discretion because some classes may find this example too extreme, but it illustrates the point effectively. Then ask students to explain why an organism cannot control its own evolution using the term 'natural selection' in their answer.* Answering B shows the misconception that evolution is a 'reaction' to a change in the environment and a gap in knowledge about what mutations are in this context. *To fix it, ask students to state two ways that inherited variation is caused in a population.*
11	A	1	Answering B suggests a confusion of the terms genotype and phenotype because the converse of this statement is true. Give students the following and ask them to sort them into two columns for genotype and phenotype: DNA that codes for blonde hair, blonde hair colour, DNA the codes for brown eyes, brown eye colour, etc. Answering C suggests a misconception that the genotype and the phenotype are both made from DNA. *To fix it, reteach the difference between the two and then ask students to explain how the genotype for brown eyes and the corresponding phenotype are different.*
12	B	1	Answering A suggests the misconception that an individual

			evolves (rather than a population of a species changing over many generations). *To fix it, reteach that evolution is a change in the inherited characteristics of a population over time caused by natural selection. Then ask students to write out definitions for natural selection and evolution.* Answering C suggests the misconception that evolution only happens over one generation. *To fix it, reteach the definition of evolution and then ask students to explain why evolution cannot happen when parents pass on inherited characteristics to offspring following sexual reproduction.*
13	C	1	Answering A or B suggests a gap in knowledge that all live evolved from simple organisms more than three billion years ago. *To fix it, explain to students that 3000 years ago there were civilizations of humans who used writing and built structures! About 200 million years ago there were dinosaurs, showing a vast amount of evolution compared to the simple cells that were the first organisms. Then ask students to write out from memory, how many years ago did life start to evolve from simple organisms.*
14	A	1	Answering B suggests the misconception that inbreeding and artificial selection are synonymous. *To fix it, reteach that inbreeding is a possible effect of artificial selection. Then ask students to write out definitions of artificial selection and inbreeding.* Answering C suggests a gap in knowledge about inbreeding. *To fix it, reteach what artificial selection is and how inbreeding can result (breeding of dogs is a good example here) and then ask students to describe how you would perform artificial selection to make a new dog breed, ensuring that inbreeding didn't happen.*
15	A	1	Answering B suggests a misconception that a lower frequency of breeding results in faster natural selection. *To fix it, ask students to explain why the mouse can undergo natural selection faster than a tortoise using the terms: natural selection, breeding cycles, inherited factors, mutations.* Answering C suggests a misconception that reproducing doesn't affect the rate of natural selection. *To fix it, ask students to state two ways that inherited variation is caused during sexual reproduction.*

Section B

Qu	Model answer	Supporting information ***Suggestions for fix-it tasks***
1	Inherited/genetic factors; Environmental factors; A combination of inherited/genetic factors and environmental factors	A common error could be to simply state that all variation is inherited and to exclude environmental factors. *To fix it, give students a list of characteristics and ask them to sort them into categories: 'caused by: inherited factors/environmental factors/both'.*
2	Extinction can be caused by: - changes to habitats. - new predators. - new competitors. - new diseases.	Students may struggle with this recall question because they may think that extinction is simply caused by 'all the organisms dying out'. *To fix it, share examples of animal or plant extinction and ask students to suggest which factors causes the extinction (e.g. dodo.*
3	**Exceptional model answer** A desirable characteristic in a dairy cow is a large amount of milk production. A cow that produces the most milk will be selected for breeding. Then the offspring that produce the most milk will be selected for breeding. This is repeated for many generations, which means that all the cows produce a large amount of milk. **Minimally acceptable answer** A cow that makes the most milk is always chosen to breed so the farmer can get the most milk.	A common error when writing about artificial selection is incorrect usage of key words. This is because there are many key words in this unit that are applied in this question. *To fix it, either ask students to write definitions or ask them to link up the definitions for: selective breeding/artificial selection, breeding, reproduction, characteristic, offspring. Then students should answer the question again using a different example.*
4	**Exceptional model answer** There is variation in a population. This means that individuals within a group of the same species have different characteristics. Some individuals are better suited to survive in an environment because they have a particular characteristic. These individuals are then more likely to survive and reproduce. This means that they will pass on this beneficial characteristic to their offspring. **Minimally acceptable answer** If organisms have are better suited to their environment, then they are more likely to live and pass on their characteristics.	A common error when describing the steps in natural selection is writing steps in the incorrect order, so that the response is illogical. *To fix it, give students the steps in a random order and then discuss the correct or they should be in. Then they should answer the question again.* Another possible issue with this 'explain' question is to simply state some steps rather than explain the effect of the steps. *To fix this, show students the following success criteria for an 'explain' question and ask them to rewrite their answer or discuss how the exception model answer addresses the success criteria.* • *Begin with a **scientific statement**.* • *Use 'this means that', 'because' or 'so' **to link your statement to the question**.*

Appendix 3: Core knowledge statements

Variation

- *A species is a group of similar organisms that reproduce to make fertile offspring*
- *A fertile organism is capable of reproduction*
- *Variation is the difference in characteristics between individual organisms*
- *There is variation within a population*
- *Variation can be caused by inherited (genetic) factors, environmental factors or a combination of the two*
- *DNA is a chemical substance that determines inherited characteristics*
- *Inherited variation is caused by the fusion of gametes in sexual reproduction and by random mutations in DNA*
- *Heredity is the process by which genetic information is transmitted from one generation to the next*
- *Variation between individuals within a species can be continuous or discontinuous*
- *Continuous variation results in characteristics that can be measured across a range (e.g. height)*
- *Discontinuous variation results in characteristics that have a limited number of values (e.g. sex)*
- *Measurements of discontinuous variation result in discrete data*
- *Frequency tables are used to record characteristics controlled by discontinuous variation*
- *When graphed, measurements of a feature with continuous variation follow a typical pattern*

Artificial and Natural Selection

- *Artificial selection is when humans choose plants or animals with particular characteristics to breed*
- *Artificial selection is continued over many generations until the desired characteristic in the offspring are present*
- *These characteristics are chosen for appearance or for their usefulness to humans*
- *Crops and domesticated animals are the result of selective breeding. Examples include pet dogs, crops resistance to disease and cows that make a lot of milk*
- *Artificial selection can cause inbreeding if closely related individuals are used so that offspring have inherited disease*
- *Within a community, organisms compete for biotic and abiotic factors to survive and reproduce*
- *Adaptations are characteristics that allow an organism to survive and reproduce*
- *Structural adaptations refer to physical features of an organism that allow it to survive and reproduce*
- *Behavioural adaptations refer to actions of an organism that allow it to survive and reproduce*
- *Physiological adaptations refer to processes that take place in an organism that allow it to survive and reproduce*
- *Extremophiles are organisms that are well adapted to live in extreme conditions of temperature, pH, salt or pressure*

- *Variation between individuals within a species makes some organisms able to compete more successfully*
- *Natural selection occurs when variation in the population makes some organisms better suited to live and reproduce in a particular environment*

Evolution and Extinction

- *Charles Darwin proposed the theory of evolution*
- *Evolution is a change in the inherited characteristics of a population over time caused by natural selection*
- *Evolution occurs faster in organisms that reproduce rapidly*
- *Fossils provide evidence for the theory of evolution*
- *Evolution can cause the formation of a new species*
- *Changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction*
- *Extinction is when there are no living individuals of a species left in the wild and/or in captivity*
- *Extinction can be caused by changes to habitats, new predators or competitors or new diseases*
- *Human activity can accelerate environmental change and cause extinction*

Disciplinary knowledge

83. Use fractions

84. a. Use percentages

b. Calculate percentage increase and decrease

55. a. Construct and interpret frequency tables and results tables

b. Considering the best way to present data