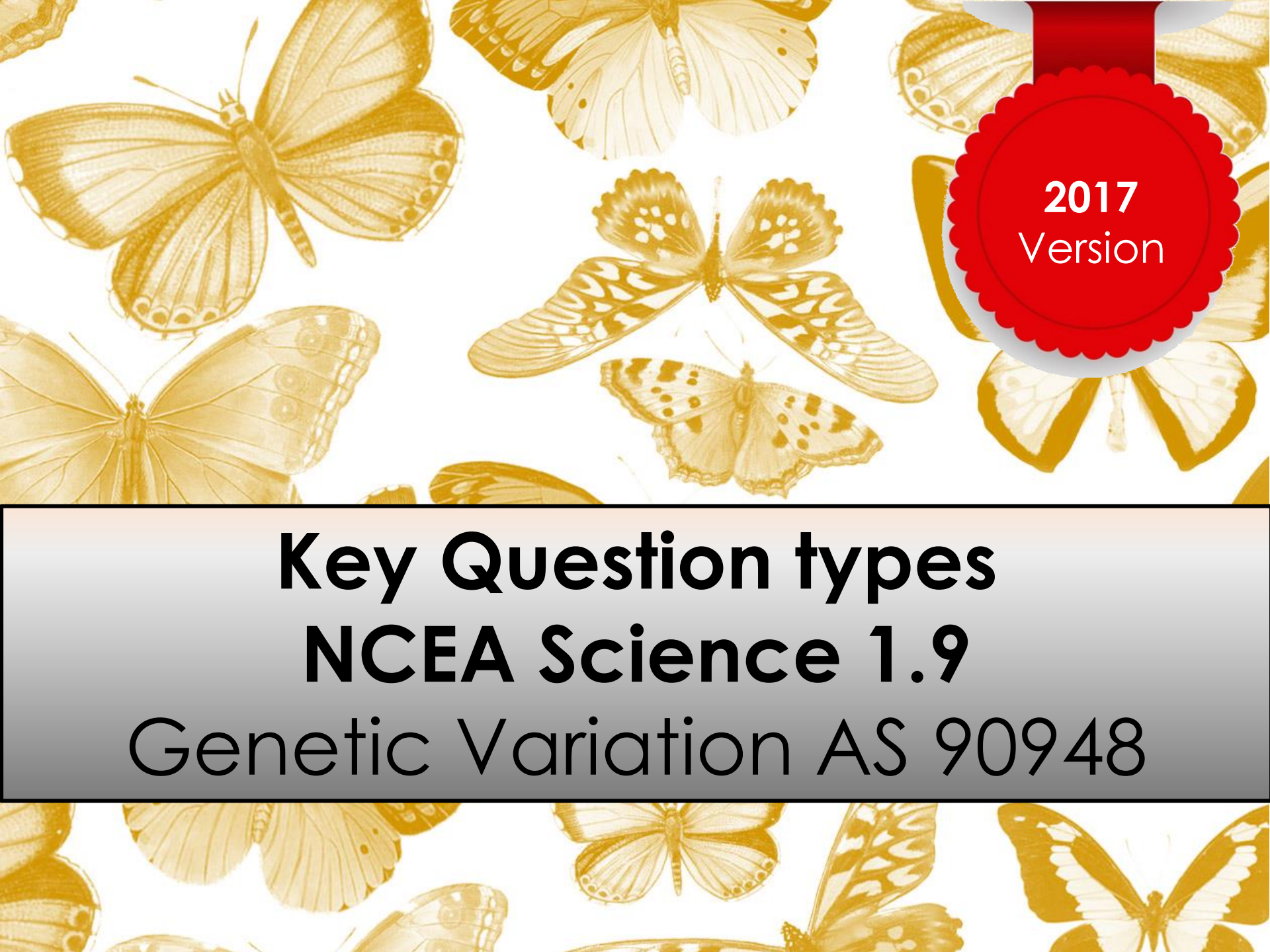
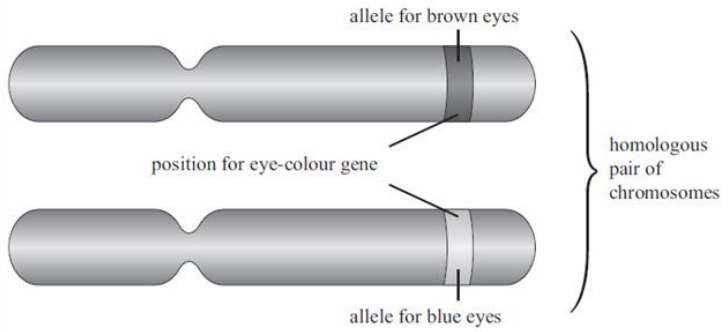


Key Question types
NCEA Science 1.9
Genetic Variation AS 90948

Linking DNA, Alleles and Chromosomes

Question 2a: Use the diagram below to help you explain the relationship between chromosomes, genes, alleles, phenotype, genotype, and the molecule DNA.



How do we answer this question?

Chromosomes are made up of DNA. DNA is a large molecule that is coiled into a double helix (twisted ladder structure). It is responsible for determining the phenotype of an organism. Along this molecule are bases. These bases pair up; A always pairs with T, and G with C.

1. Describe DNA and Base pairing rule.

A sequence of bases which codes for a particular trait (eg, eye colour) is called a gene. The different versions of each gene are called alleles, and these show the different variations of each characteristic, eg brown / blue eyes. Because chromosomes come in pairs for each trait, there will be two possible alleles. These different versions of genes (alleles) occur as the DNA base sequence is different.

2. Link base sequence to different alleles and their traits

This combination of alleles for each trait is called the genotype; this can be any combination of two of the available alleles. The genotype determines the phenotype (the physical appearance).

3. Link the pair of alleles to genotype and then to phenotype

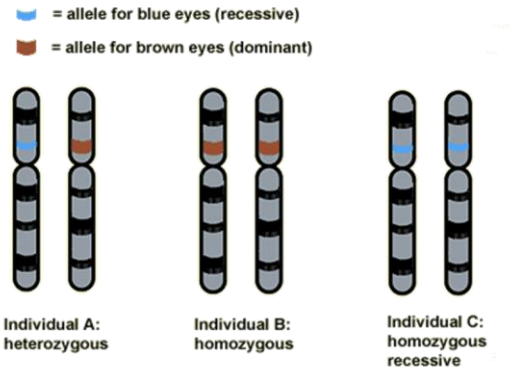
Whichever alleles are present may be expressed. Dominant alleles (B) will be expressed over recessive alleles (b).

4. Link phenotype to dominant and recessive

Inheritance of alleles

Question 2c: These two snails were produced by sexual reproduction from the same male and female.
Discuss how they have inherited different alleles for shell pattern.
In your answer you should:
• explain where the homologous chromosomes have come from
• give the possible genotypes of both parents and explain how you determined these possible genotypes.

The allele that is expressed as a trait when there is at least one allele is called the **dominant** allele. The allele that is expressed if the dominant allele is not present is called the **recessive** allele. When there are two of the same allele this genotype is called **homozygous**. When there are 2 different alleles in a genotype this is called **heterozygous** and the dominant allele is always expressed.



Can also use Punnett squares to explain

How do we answer this question?
The snails have inherited different shell patterns because they have inherited one homologous chromosome from their mother and one from their father.

Link variation of offspring to different alleles inherited from both parents

The banded snail shows the recessive trait and is homozygous recessive for shell pattern; therefore each parent must have contributed a banded allele.

Link recessive phenotype to a recessive allele inherited from both parents.

The plain snail has one plain allele; therefore at least one of the parents must have a plain allele. This means there are two possibilities for the parents: they are either both heterozygous; or one parent is heterozygous and the other is homozygous recessive.

Link dominant phenotype to only one dominant allele required either parent.

Punnett square probabilities

Question 1d: In the pedigree chart the phenotype ratio of Huntington's disease in the children of parents 9 and 10 is not the same as the predicted ratio in the Punnett square
Give reasons why the predicted ratio in the Punnett square and the observed ratio in the children may NOT be the same.

		parent 10	
		H	h
parent 9	h	Hh	hh
	h	Hh	hh

Fraction of children with Huntington's disease is 1/2
Fraction of children without Huntington's disease is 1/2
Phenotype ratio is 1:1.

How do we answer this question?
Punnett squares **predict** probable offspring genotypes (thence the expected phenotypes) based on the gametes of the parents. [Pedigree charts give the observed (actual) phenotypes.]

Link Punnett square to being a prediction only

Each fertilisation is a random event, and each new fertilisation is a new event and not affected by the fertilisation previously

Explain fertilisation as random/new event

It is by chance whether the offspring of number 10 inherits the dominant H allele and therefore has Huntington's or the recessive h allele and does not have the disease.

Give possible phenotypes of offspring

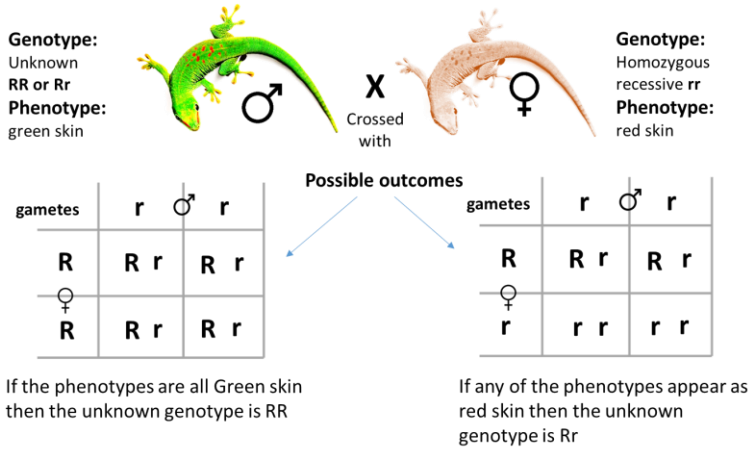
In the pedigree chart 3 of the 4 offspring have the disease but only 2 out of 4 would have been predicted from the Punnett square.

Compare predicted to actual phenotype ratio

Test crosses

Question 3b: Discuss how a farmer could develop a group of sheep that are pure breeding for white wool.
In your answer you should:
• state the genotypes of the male and female sheep the farmer should use to breed from
• explain how the animal breeder can determine the genotypes of the male and female to produce sheep that all have white wool.
You should include at least two Punnett squares with your explanation
• explain how the animal breeder could make sure that the offspring would always be pure breeding.

The test cross is used to determine the genotype of an unknown individual that displays the dominant phenotype. The individual is crossed with a known homozygous recessive.



If the phenotypes are all Green skin then the unknown genotype is RR

If any of the phenotypes appear as red skin then the unknown genotype is Rr

How do we answer this question?

To breed a group of white sheep, a breeder should use sheep that are both AA (pure breeding).

Explain a pure breeding population needs to be homozygous (only one type of allele present)

The breeder can determine if a white sheep is AA by crossing a white sheep with a black sheep aa. If the white sheep is AA, none of the offspring will be black. If there is one or more black sheep produced then the white sheep in Aa (Heterozygous)

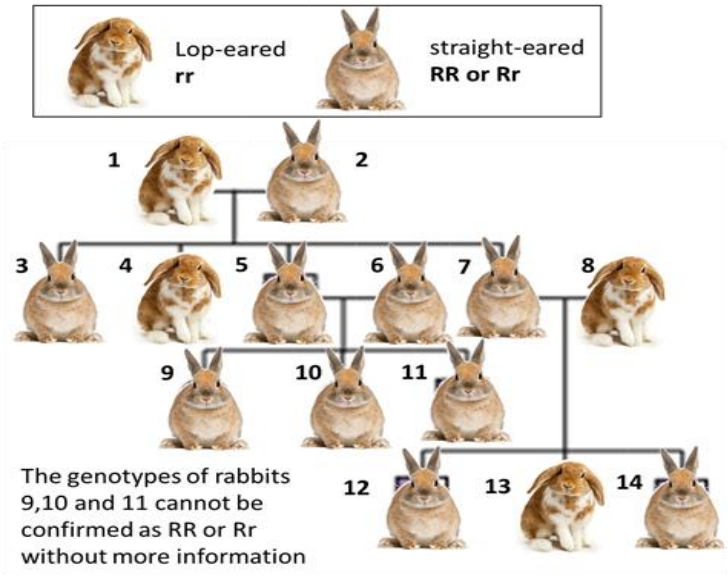
Link test cross (breed with recessive) outcome to genotype of individual tested

The breeder would need to carry out many crosses to show that it was not just due to chance that a black sheep had not been produced. The farmer should breed only with an AA male and white wool females, as this will ensure that all offspring are white. If a heterozygous individual is discovered then this animal must be removed and not breed from, as this would remove the recessive allele from the group.

State requirements for repeating test crosses and removing heterozygous individuals

Pedigree charts and genotypes

Give the possible genotype of rabbit 7 using evidence from both parents and offspring



How do we answer this question?

Rabbit 7 has a dominant phenotype of straight ears.

State the phenotype of the individual which you are explaining the genotype of.

Rabbit 7 is straight eared but had one parent who was a lop-eared rr so must have one r allele – genotype Rr. Therefore be heterozygous.

Link having a recessive parent to receiving at 1 recessive allele (both not a recessive allele from both otherwise would be recessive itself)

Also offspring 13 is an rr (lop-eared phenotype) When an individual has a recessive phenotype on a pedigree chart then the **genotype must always be homozygous recessive** so rabbit 7 must have at least one r allele to pass onto 13.

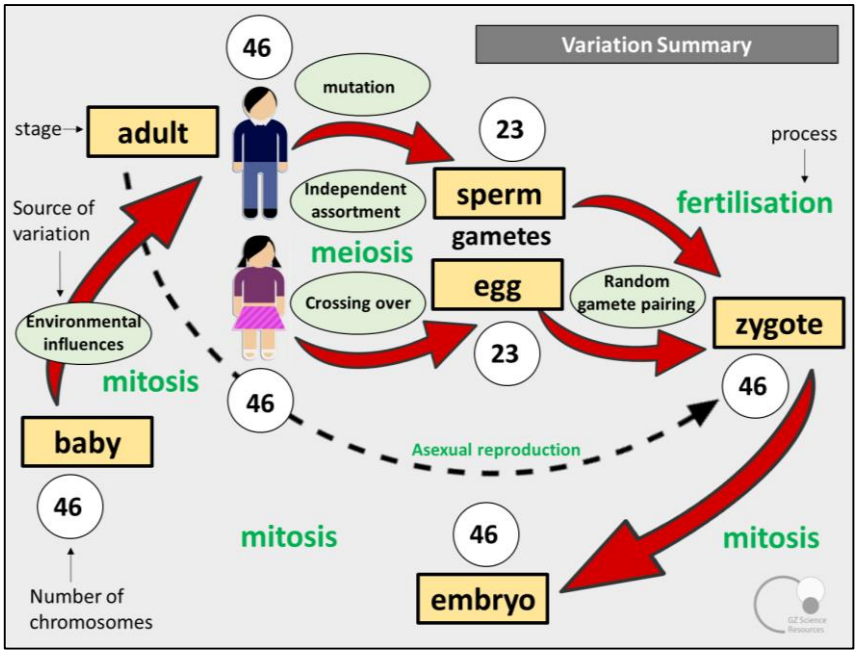
Link having a recessive offspring as evidence that the individual MUST have a recessive allele. Recessive phenotypes only occur if both parents pass down a recessive allele

Sources of variation

Q: Explain how sexual reproduction causes genetic variation AND how this leads to increased survival of the species.

In your answer you should consider:

- the processes of gamete formation (meiosis) and fertilisation
- how sexual reproduction leads to variation in the population
- the link between genetic variation and survival of a species.



How do we answer this question?

Meiosis produces gametes which have half the normal number of chromosomes as body cells. In **fertilisation random male and female gametes join** and produce a unique zygote.

Define meiosis and fertilisation linking to chromosome numbers

The role of sexual reproduction is creating variation in offspring by the **independent assortment of chromosomes** and **crossing over in meiosis** and **random fertilisation** of the gametes.

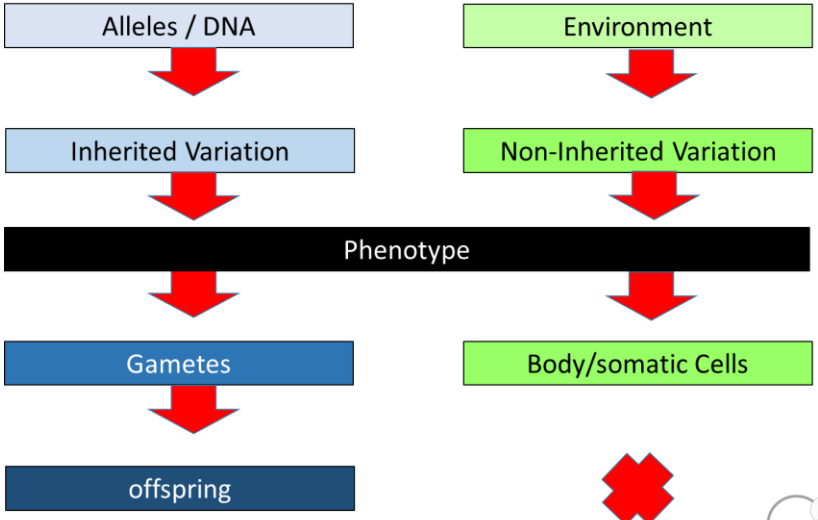
State the processes that create variation (the processes may require more explanation)

Genetic variation refers to a variety of **different genotypes for a particular trait** within a population. The advantage of variation to a species is that it may enable some individuals to survive if some threatening event or sudden change in the environment occurs, eg disease or drought, as they will reproduce and pass on favourable phenotypes to strengthen the species.

Link variation to increased chance of survival of a species if there is environmental change

Inherited and Non-inherited variation

Question 3b: The Venus flytrap plants come in a number of different types,
such as the "B-52" with a red leaf.
A teacher brought two identical plants to class and put them in different parts of the classroom. The Venus flytrap put near a window grew short leaves and the Venus flytrap in the shade grew long leaves. Colour variation in the leaves of the Venus flytraps can be passed on to a plant's offspring, but the different leaf length cannot. **Explain why.** In your answer you should:
- define inheritable and non-inheritable variation
- explain what causes inheritable and non-inheritable variations.



How do we answer this question?

Inheritable variation can be passed on to offspring and involves a change / mutation / information in the DNA,

Define inheritable variation and the cause

whereas non-inheritable variation may be due to the environment (or only occurs in body cells) and so affects only that organism, not its offspring.

Define non-inheritable variation and that it does not affect offspring

Lack of light has caused the fly trap in the shade to grow longer leaves. This is not due to a change in the DNA, and so cannot be passed on.

Identify non-inherited variation and link to definition

The red colouration is due to DNA differences, and so can be passed on – as long as the DNA in the gametes is also affected.

Identify inherited variation and link to definition

Advantages and disadvantages of Sexual reproduction

The Raggiana bird-of-paradise lives in Papua New Guinea. The male bird has colourful long feathers and competes for females in a lek where it displays its plumage along with many other males to a watching group of female birds. The female is a comparatively dull reddish-brown bird with no long tail feathers. The males with the longest, most colourful displays attract the females who then allow the males to mate and pass along their genes. Feather colour and length along with dance behaviour are controlled by alleles that are genetically inherited but variable in a population.
Q: What are the advantages and disadvantages of sexual reproduction?

Advantages and disadvantages of Sexual Reproduction	
Advantages	**Disadvantages**
Increases genetic diversity (meiosis)	Involves energy in producing reproductive structures or phenotypes to attract mates
Provides protection against pest and disease	If pollination is unsuccessful, then no seeds are produced – i.e. a waste of energy and time, as no genetic material will be passed on to future generations
Some organisms may die but there will be some that survive due to their genetic makeup	Time consuming compared to asexual reproduction (takes time to produce reproductive structures, attract pollinators etc)
Individuals that have a resistance are more likely to survive and pass on their genetic material to future generations	
Can produce beneficial mutations	

Advantages and disadvantages of Asexual Reproduction	
Advantages	**Disadvantages**
Fast – do not have to spend time producing flowers or attracting mates	
No need to spend energy producing flowers or finding a mate	
No need to rely on pollinators/males	
Guaranteed success of producing offspring	
Can make numerous copies of plants through cuttings	Population overruns a food source quickly
All desirable traits are passed down	If parents have an undesirable trait then all offspring inherit it
All offspring are genetically identical and best suited to an environment if conditions remain stable	All offspring are identical so this creates vulnerability if the environment changes or pests/ diseases occur

How do we answer this question?

The advantages of sexual reproduction is that **variation occurs in the population**. Females can use this variation in feathers and dance to determine the health of the male and select the individual that will best carry their genes into the next generation.

Link advantage of sexual reproduction to variation AND give an example using information provided in the question

The disadvantage of this form of sexual reproduction is the **energy extended by the male to attract the female** and the lack of adaptation of the feathers for flight

Link disadvantage of sexual reproduction to extra energy/structures required for attracting a mate and/or mating AND link to example given as the advantage

The question may also ask about advantages/ disadvantages of **asexual reproduction** so make sure to give a point for each.

Mutation – inherited and non-inherited

Q: One process that produces genetic variation is mutation. Explain what mutations are and how they contribute to genetic variation.

In your answer you should include:

- what a mutation is
- the effect of mutations on genes, alleles and DNA
- whether all mutations are passed on to the next generation.

- A mutation is a **permanent change in the base sequence** of a DNA strand, either single bases or segments of chromosomes.
- A base sequence change can result in the **formation of new alleles.**
- A new allele can code for a new protein that leads onto a new trait.
- A organism with a mutation may have a new structure or function and as a result will have a new phenotype.
- Most mutations are harmful, which reduce the chance or survival or reproduction.
- Some new phenotypes (mutation) may increase an organism's chances or survival or successful reproduction. A mutated allele that increases survival/reproduction will increase in frequency rapidly in a population.

Indicate **most mutations are harmful** but a beneficial mutation may increase survival and therefore more offspring

How do we answer this question?

A mutation is a change in genetic material / DNA / genes of an organism. When a mutation occurs, the base sequence of the gene changes; this results in completely new alleles.

Define mutation and link to new allele

If mutations occur in the **gametes**, these new alleles have the possibility of being **passed on to offspring**. If mutation occurs in **body cells, only the one individual will show variation** – will not be passed on to their offspring.

Link where mutation occurs (gametes / body) to whether it is passed on to offspring or not

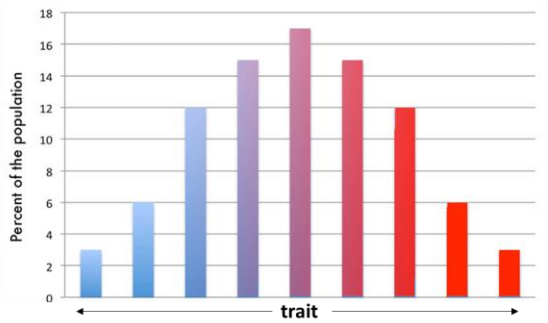
Mutations are more often than not harmful if they occur in part of the DNA that codes for traits. Individuals born with mutations will often die before they pass the mutant allele on.

Mutations do not always result in variation, but when they do, the variation is often in the form of entirely new alleles. If the new allele is beneficial, and increases survival and production of offspring, it is often spread quite quickly.

Variation and species survival

Question 3b (ii) : Discuss the advantages of sexual reproduction for a species when the environment changes.
In your answer you should:
• give examples of a changing environment
• explain the impact of changing environments on a population
• consider the importance of variation in a population in a changing environment.

Why is variation so important for a species survival?



During a "typical" season in any environment, an average phenotype for any particular trait is most likely to be best adapted to the environment and therefore the organism having it will have the best chance for survival. Those "average" phenotypes are likely to make up the largest percent of the population.
In an "atypical" season that may be drier/wetter, or hotter/colder, then individuals with more extreme versions of a phenotype (alleles) may have the advantage of survival. If the conditions have a very large change then sometimes only those with extreme phenotypes survive. Permanent shifts in the frequency of alleles to either end is called evolution.

How do we answer this question?
Genetic variation is variety within a population, eg different alleles possible for each gene. Sexual reproduction results in variation, which is important in a changing environment.

Define variation and link to sexual reproduction in a species

As the environment changes some individuals may not survive. If there is variation in their alleles / DNA / genes, some individuals may have phenotypes that are more suited to the environment; therefore they will be more likely to survive. Because of variation, not all individuals will be wiped out.

Link survival of some individuals if environment changes

Those individuals with favourable alleles / traits / phenotypes will survive when they reproduce will pass these alleles / DNA / genes to the next generation, helping to ensure the survival of the species.

Link surviving individuals passing on genetic material to next generation and species survival