



eduresourceza.com

Q. Define the term *allele*.

Q. Define the term gene (2)

Chromosome	A thread of DNA, made up of genes.
Allele	An alternative form of a gene. Pairs of alleles occupy the same relative positions on chromosome pairs.
Gene	A section of DNA, which codes for the formation of a protein controlling a specific characteristic of the organism.
Haploid nucleus	A nucleus containing a single set of unpaired chromosomes, e.g. in sperm and ova (eggs). In humans, the haploid number is 23.
Diploid nucleus	A nucleus containing pairs of chromosomes, e.g. in somatic (body) cells. In humans the diploid number is 46.
Genotype	The genetic make-up of an organism, e.g. Tt, where T and t are alleles of a gene.
Phenotype	The characteristics visible in an organism, controlled by the genotype, e.g. a tall plant or a dwarf plant.
Homozygous	Having a pair of identical alleles controlling the same characteristics, e.g. TT, where T=tall. The organism will be pure-breeding for that characteristics.
Heterozygous	Having a pair of dissimilar alleles for a characteristic, e.g. Tt.
Dominant	A gene, e.g. T, that always shows in the phenotype of an organism whether the organism is heterozygous (Tt) or homozygous (TT).
Recessive	A gene, e.g. t, that only has an effect on the phenotype when the organism is homozygous (tt)

maybe dominant and recessive

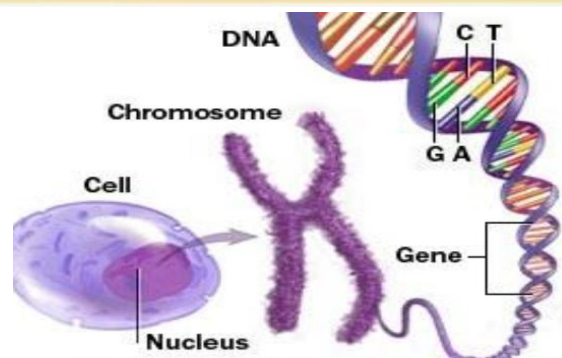
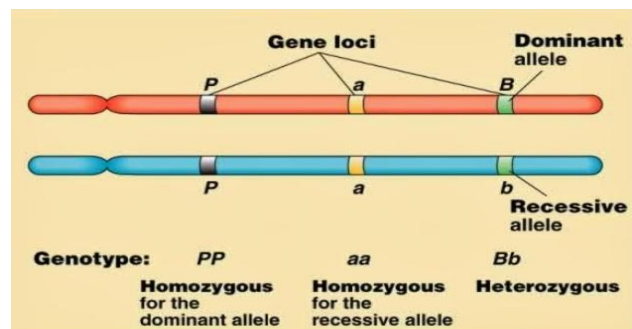
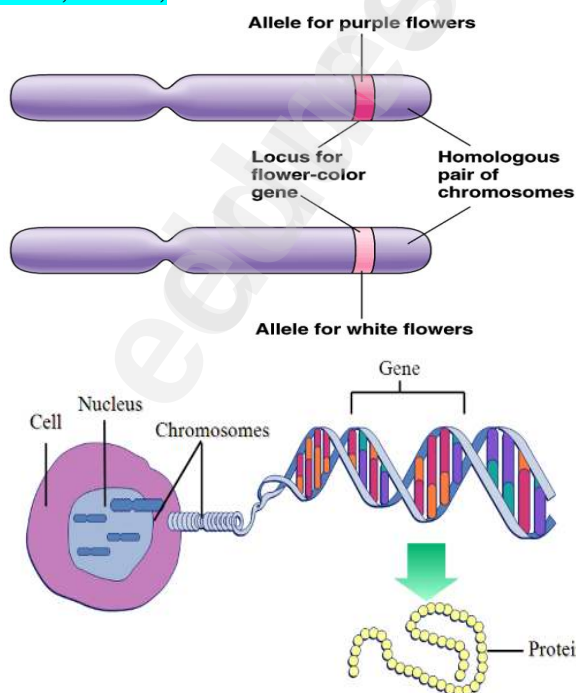
Gametes have only one set of chromosomes, and so they have only one copy of each gene.

DNA = Deoxyribonucleic acid, or DNA, is a biological macromolecule that carries genetic information in many organisms. DNA is necessary for proteins synthesis, the regulation, metabolism, and reproduction of the cell.

Q. Describe the structure of a DNA molecule.

It is a double helix; strands contain, bases Adenine (A) and Thymine (T) and Cytosine (C) and Guanine (G); A joins with T / C joins with G; bases pair up by crosslinks /hydrogen bonds;

A+T; C+G;



Chromosomes are long thread of **DNA** made up of strings of **genes**. In a diploid cell, each of a pair of homologous chromosomes carries the same genes in the same position. A diploid cell therefore has 2 copies of each gene.

- Different forms of a particular gene are called **alleles**. They may be **dominant** of **recessive**. The genotype of an organism tells us the alleles of genes that it carries
- If **2 heterozygous** organisms breed together, we expect a **3:1 ratio** of offspring showing the dominant characteristic to offspring showing the recessive characteristic. If one parent is **heterozygous** and the other is **homozygous** recessive, we expect to see a **1:1 ratio** in the offspring.

Q. Genes and alleles are made of = DNA

Q. State the function of a gene. = codes for a protein;

**Q. The ancestors of red and blue cichlid fish were brown.
State how the different body colours of the males first happened. = mutation**

Q. Some scientists believe that washing the salts out of the soil using even more water is a better alternative to genetic engineering. State two problems that could be caused by washing the soil with extra water.

Leaching of minerals; eutrophication of rivers / lakes; soil erosion;
creation of water shortage; soil becomes infertile / lacks minerals

Q. Suggest two reasons for the difference in life expectancy in two countries

Better health care or medical facilities in developed countries;
more disease in developing countries; better diet in developed countries;
Less food available in developing countries; more wars in developing countries;

Q. (i) Name the process that can give rise to different alleles for wing colour in a population of moths.= mutation

(ii) Suggest one factor which might increase the rate of mutation

UV light / ionising radiation / X rays / (named radioactive) chemical(s); A nuclear fall out

Inheritance

Inheritance is the **transmission of genetic information** from one generation to the next, leading to continuity of the species and variation within it.

Evolution = This gradual change in the species through natural selection over time, in response to changes in the environment, is a possible **mechanism for evolution.**

Monohybrid cross and the punnett square

A **monohybrid cross** involves the crossing of individuals and the examination of **one (mono) character** (flower colour, pod shape...) and **different (hybrid) traits** (red colour, white colour) in their offspring.

Punnett square = The Punnett square is a useful tool for predicting the genotypes and phenotypes of offspring in a genetic cross involving Mendelian traits.

1. A cross between a pure-breeding tall pea plant and a pure-breeding dwarf pea plant.

As tall is dominant to dwarf, and both plants are pure-breeding, their genotypes must be **TT** and **tt**.

phenotypes of parents	tall		dwarf									
genotypes of parents	TT	×	tt									
gametes	T	T	t									
punnett square	<table><tr><td></td><td>T</td><td>T</td></tr><tr><td>t</td><td>Tt</td><td>Tt</td></tr><tr><td>t</td><td>Tt</td><td>Tt</td></tr></table>				T	T	t	Tt	Tt	t	Tt	Tt
	T	T										
t	Tt	Tt										
t	Tt	Tt										
F ₁ genotypes	all Tt											
F ₁ phenotypes	all tall											

2. A cross between two heterozygous tall pea plant.

The genotype of both plants must be **Tt**.

phenotypes of parents	tall		dwarf										
genotypes of parents	Tt	×	Tt										
gametes	T	t	T	t									
punnett square	<table><tr><td></td><td>T</td><td>t</td></tr><tr><td>T</td><td>TT</td><td>Tt</td></tr><tr><td>t</td><td>Tt</td><td>tt</td></tr></table>					T	t	T	TT	Tt	t	Tt	tt
	T	t											
T	TT	Tt											
t	Tt	tt											
F ₁ genotypes	1 TT, 2 Tt, 1 tt												
F ₁ phenotypes	tall tall dwarf												
ratio	3 tall : 1 dwarf												

3. A cross between two heterozygous tall pea plant.

The heterozygous tall pea plants must be **Tt**.
The dwarf pea plants must be **tt**.

phenotypes of parents	tall		dwarf											
genotypes of parents	Tt	×	tt											
gametes	(T)	(t)	×	(t)	(t)									
punnett square	<table><tr><td></td><td>(T)</td><td>(t)</td></tr><tr><td>(t)</td><td>Tt</td><td>tt</td></tr><tr><td>(t)</td><td>Tt</td><td>tt</td></tr></table>						(T)	(t)	(t)	Tt	tt	(t)	Tt	tt
	(T)	(t)												
(t)	Tt	tt												
(t)	Tt	tt												
F ₁ genotypes	2 Tt, 2 tt													
F ₁ phenotypes	tall dwarf													
ratio	1 tall : 1 dwarf													

Q. Define the term mutation

Mutation is an unpredictable change in the DNA / genes or chromosome number, as a result of fault copying when DNA is replicated, faulty separation of chromosomes during cell division, or exposure to radiation or some chemicals.

Q. Gene mutation = gene mutation a change in base sequence of DNA

(b) Complete the genetic diagrams to show how flower colour is inherited in snapdragon plants.

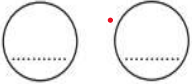
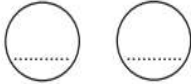
Use the symbol **I^R** for the allele for red flowers and **I^W** for the allele for white flowers.

cross 1	parental phenotypes	red flowers	×	white flowers	
	parental genotypes		×		offspring genotypes
	gametes				offspring phenotypes
					pink flowers

no dominant
no recessive

cross 1
 $I^R I^R \times I^W I^W$
 $I^R + I^W$
 $I^R I^W$; $I^R I^R, I^R I^W, (I^R I^W), I^W I^W$; **R** if two different ratios given

cross 2
 $I^R I^W \times I^R I^W$
 $I^R, I^W + I^R, I^W$;
 1 red : 2 pink : 1 white ; **A** 25% red : 50% pink : 25% white
A multiples, e.g. 2 red: 4 pink : 2 white

cross 2 parental phenotypes pink flowers x pink flowers
 parental genotypes x
 gametes   offspring genotypes
 ratio of offspring phenotypes

(c) Another student cross-pollinated pink-flowered plants with white-flowered plants.

Complete the genetic diagram to show the results that the student would expect.

phenotypes pink flowers x white flowers
 genotypes x
 gametes   
 offspring genotypes
 ratio of offspring phenotypes
 $I^R I^W \times I^W I^W$
 $I^R, I^W + I^W$;
 $I^R I^W, I^W I^W$;
 1 (pink) : 1 (white) ;
R if two different ratios given

Q. Occasionally, zebras are born that are almost completely black. The change in appearance is the result of mutation.

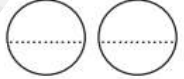
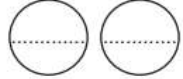
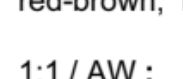
(i) State the term that is used to describe the appearance of an organism.
 phenotype

There is a gene in *T. confusum* which controls body colour.

A represents the dominant allele for red-brown body colour.

a represents the recessive allele for black body colour.

(c) Complete the genetic diagram below to show the colour of beetles produced when heterozygous beetles are crossed with beetles that are homozygous recessive for this gene.

parental phenotypes x
 parental genotypes x
 gametes   + 
 offspring genotypes
 offspring phenotypes
 ratio of phenotypes
 red-brown Aa x black aa ;
 Aa , a + a / a,a ;
 Aa , aa
 red-brown, black ;
 1:1 / AW ;

There are many different varieties of haemoglobin. The gene for haemoglobin exists as two alleles, HbA and HbS. People with the genotype HbSHbS have a condition called sickle cell anaemia.

Q. The parents of people with sickle cell anaemia rarely have this condition.

Explain, using a genetic diagram, how two parents who do not have sickle cell anaemia may have a child with the condition.

Hb^A is dominant / Hb^S is recessive / (both) parents are, carriers / heterozygous

$$\text{Hb}^A\text{Hb}^S \times \text{Hb}^A\text{Hb}^S$$

$$\text{Hb}^A, \text{Hb}^S + \text{Hb}^A, \text{Hb}^S$$

$$(\text{Hb}^A\text{Hb}^A, \text{Hb}^A\text{Hb}^S, \text{Hb}^A\text{Hb}^S) \text{Hb}^S\text{Hb}^S$$

(e) Sickle cell anaemia is an example of variation in humans. There are many causes of variation, including nuclear fall-out. Suggest **how nuclear fall-out could cause variation in humans.**

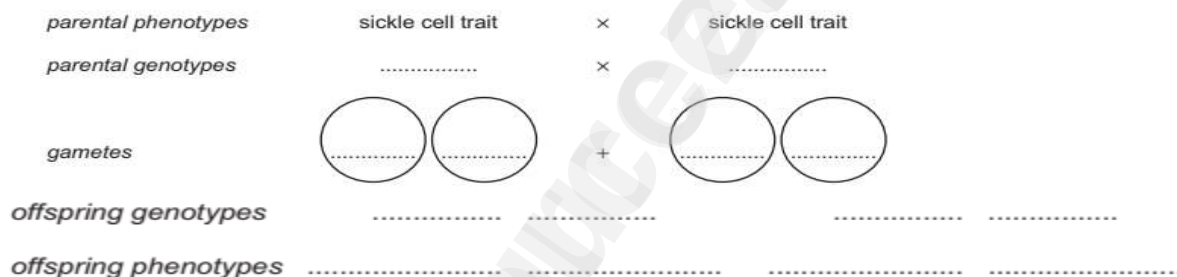
Ionising radiation causes increased risk, mutation change to DNA / genes

Q. Haemoglobin is a large protein molecule. The structure of each haemoglobin molecule is controlled by a gene that has two alleles:

- Hb^A codes for the normal form of haemoglobin,
- Hb^S codes for an abnormal form of haemoglobin.

Red blood cells containing only the abnormal form of haemoglobin become a stiff, sickle shape in conditions of low oxygen concentration. This gives rise to sickle cell anaemia.

(b) (i) Complete the genetic diagram to show how a couple who are both heterozygous may have a child with sickle cell anaemia.



Hb^AHb^S	×	Hb^AHb^S
Hb^A, Hb^S	+	Hb^A, Hb^S
;		
$\text{Hb}^A\text{Hb}^A, \text{Hb}^A\text{Hb}^S, \text{Hb}^A\text{Hb}^S, \text{Hb}^S\text{Hb}^S$		
normal, sickle cell trait, sickle cell anaemia		

(ii) What is the chance of a child born to this couple having sickle cell anaemia?

chance is 1 in 4 / 25% / 0.25 / 0,25 ;

Q. In some parts of the world, up to 25% of the population have sickle cell trait.

State the advantage of having sickle cell trait.

Resistance to malaria

Q. Discuss whether sickle cell trait is an example of codominance

Both alleles, Hb^A and Hb^S , are expressed; both alleles make two different forms of haemoglobin; if dominant / recessive, then only one form of haemoglobin in heterozygous people; three phenotypes (not two) / sickle cell trait is a different phenotype from normal and sickle cell anemia

Q. Explain how natural selection is responsible for the distribution of the allele for the abnormal form of haemoglobin (Hb^S).

- 1 idea that areas with high percentage of sickle cell (allele) are places with malaria ;
- 2 $H^S H^S$ / homozygous recessive, reduced life span because of sickle cell anaemia ;
- 3 $H^N H^N$ / homozygous dominant / without H^S , susceptible to malaria / AW ;
- 4 $H^N H^S$ / heterozygous / carrier/ with H^S , resistant / not affected / less susceptible ;
 $A H^S H^S$ R immune / immunity
- 5 $H^N H^S$ (carrier) survive and have children / $H^N H^N$ or $H^S H^S$ do not ;
- 6 $H^N H^S$ / carrier, pass on the allele / H^S ;
- 7 (if $H^N H^S \times H^N H^S$) 1 in 4 chance of, $H^S H^S$ / homozygous recessive ;
- 8 2 in 4 / 50% / $\frac{1}{2}$, have advantage of resistance to malaria ;

Q. The eyes of Tribolium species are usually black. A very small number of flour beetles have white eyes. Explain how this happens and why they are so rare.

Mutation; mutation, rare event; (white) allele is recessive; only expressed in homozygote recessive ; selection ; disadvantage

Q. Suggest and explain what happens to the seeds when they are exposed to ionising radiation. = Mutation; change in, gene(s) / DNA

Q. Evolutionary relationships between different species are investigated by examining DNA. State precisely where DNA is found in a cell.

Chromosome, nucleus, mitochondria, chloroplast, plasmid, nucleolus

✓ **Q. Two brothers have to make a difficult decision. One brother, with blood group AB, has kidney failure and is on dialysis. The healthy brother has agreed to donate one of his kidneys to his brother. He has to have a blood test. Their father has blood group A and their mother has blood group B. The brothers have a sister who has blood group O. Explain how this girl has blood group O when her parents have different blood groups. You must use the space below for a genetic diagram to help your answer Use the symbols I^A , I^B and I^O to represent the alleles involved in the inheritance of blood groups.**

$I^A I^O \times I^B I^O$; I^A , I^O + I^B , I^O ; $I^O I^O$, (blood group) O ; (allele) I^O recessive to I^A <u>and</u> I^B ;	accept: $A O \times B O$; A , O + B , O ; $O O$, (blood group) O ; (allele) O recessive to A <u>and</u> B ;
--	---

parents must both, have I^O / O / be heterozygous ;

(ii) The healthy brother can only donate the kidney to his brother if they both have the same blood group.

What is the probability that the healthy brother also has blood group AB?

25% / 0.25 / $\frac{1}{4}$ / 1 in 4 ;

Q. Insects 1 and 2 are more closely related to each other than to insect 3. Explain how the binomial names indicate that insects 1 and 2 are more closely related.

Either

insects 1 and 2, are in the same genus / have the same generic name ; (both have) Vespa ;

or

insect 3 is in a different genus ; (its name is) *Callicera*

Q. Explain how the appearance of the three insects suggests that insects 1 and 2 are more closely related.

insects 1 and 2

have two pairs of wings ; have antennae that are, long(er) / same shape / thick ; have small(er) eyes ; have stripes / have a pattern / have similar markings ; any correct reference to size ; e.g. 'they have similar size'; similar shape of abdomen

Q. *Chrysotoxum cautum* is very similar in appearance to *Vespula flavopilosa*. Explain how this is an advantage.

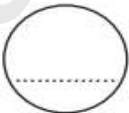
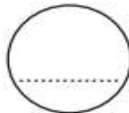
Predators mistake *Chrysotoxum cautum* for *V. flavopilosa* ; predators recognise, warning appearance / stripes; frightened of being stung ; do not eat it / do not attack it.

Q. It is thought that *Chrysotoxum cautum* evolved from an insect that did not have any stripes. Suggest how these insects became striped

Mutation gives stripes ; some stripey insects were not, eaten by, predators / other animals) ; survived to, breed; pass on the allele(s) for stripes to next generation; non-stripey insects, did not survive / became extinct; natural selection ; to selected for / selected against

- (a) A student crossed some crimson-flowered plants with some yellow-flowered plants (cross 1). She collected the seeds and grew them. All of the plants that grew from these seeds had orange-red flowers.

Complete the genetic diagram to explain the result of cross 1.

parental phenotypes	crimson flowers	×	yellow flowers
parental genotypes	$A^C A^C$	×	$A^Y A^Y$
gametes		+	
offspring genotype			
offspring phenotype			

	cross	genotypes of offspring
A^C	2 offspring x offspring	$A^C A^C$, $A^Y A^Y$, $A^C A^Y$;
$A^C A^Y$;	3 offspring x crimson-flowered plant	$A^C A^C$, $A^C A^Y$;
orange-red ;	4 offspring x yellow-flowered plant	$A^Y A^Y$, $A^C A^Y$;

Q. Explain how boys can have haemophilia when the condition has not previously existed in their family.

Mutation in DNA in the gene, for blood clotting protein on X chromosome in the mother.

Mother is a carrier; haemophilia is sex linked, shows sex linkage ; the mother's egg with the mutant allele fuses with a Y bearing sperm ; e.g. cause of mutation ; ionising radiation / chemical(s)

Q. Define the term *sex-linked characteristic*.

Gene is located on, a sex chromosome/X or Y/X/Y; characteristic is more common in, males/one sex than the other

Q. The gene responsible for colour vision is located on the X chromosome. There are two alleles for this gene on the X chromosome:

- XB – normal colour vision
- Xb – colour blindness.

(i) People that are heterozygous for colour blindness are called carriers.

State the genotype of a heterozygous female carrier. = $XBXb$

Q. There is no gene for colour vision on the male sex chromosome.

State the genotype of a colour-blind male = XbY

Q. Colour blindness is a sex-linked characteristic. Explain why females 4 and 5 are carriers even though their mother is not a carrier. =

One X chromosome from each parent/an X from father;
mother does not have any colour-blind alleles/father passes on one colour blind allele ;
all female offspring are heterozygous/ $XBXb$

Q. A farmer wanted to identify the genotype of tall pea plants as either homozygous dominant or heterozygous. He used a homozygous recessive dwarf pea plant to determine the genotype of the tall pea plants.

State the name of this type of genetic cross. = test cross

Another farmer wants to produce pure-breeding dwarf pea plants.

State the genotypes of both of the parent pea plants the farmer should use.

Give a reason for your choice.

genotypes tt ;.....

reason = so that no dominant allele is present/all alleles are recessive;

recessive alleles only expressed if no dominant allele present

Q. Explain how a mutation in DNA results in an abnormal enzyme which does not catalyse the reaction

Change in base sequence of DNA; DNA base sequence, codes for, protein/enzyme;

mRNA; different sequence of amino acids in, protein/enzyme;

mutant enzyme has different, shape; active site of enzyme not complementary to substrate.

enzyme-substrate complexes cannot form

Q. Two tall sunflower plants were crossed. 25% of the offspring produced were dwarf. Explain how it is possible for two tall parent plants to have this percentage of dwarf offspring.

The allele for dwarfism is, recessive/ t ; both parents are heterozygous, so do not express the allele;

CODOMINANCE

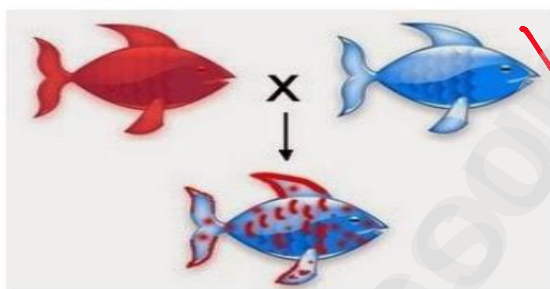
Q. Explain what is meant by **codominance**. You may refer to the genetic diagram in (b) to help you with your answer.

Sometimes, neither of a pair of **alleles** is completely dominant or completely recessive. Instead, they **both have an effect on the phenotype**. This is called **codominance**.

- There are three alleles for blood group given by the symbols I^A , I^B and I^O .
- I^A and I^B are co-dominant giving blood group AB or $I^A I^B$, and both dominant to I^O .

Inheritance of A, B, AB and O blood group - an example of codominance

- In humans, there are 4 blood types (phenotypes): A, B, AB, and O
- Blood type is controlled by **3 alleles**: I^A , I^B , I^O (the base letter = I stands for immunoglobulin)
- I^O is **recessive**, two I^O alleles must be present for the person to have type O blood
- I^A and I^B are **codominant** but both are dominant to I^O . If a person receives an I^A allele and an I^B allele, their blood type is type AB, in which characteristics of both A and B antigens are expressed. Because I^O is dominated by both I^A and I^B alleles, a person with blood group A could have the genotype $I^A I^O$ or $I^A I^A$. This has implication when having children because, if both parents carry the I^O allele, a child could be born with the genotype $I^O I^O$ (blood group O), even though neither of the parents have this phenotype.



Blood type	Genotype	
A	I^A, I^O	AO
	I^A, I^A	AA
B	I^B, I^O	BO
	I^B, I^B	BB
AB	I^A, I^B	AB
O	$I^O I^O$	OO

Q. Flower colour in *M. jalapa* is not an example of the inheritance of dominant and recessive alleles. Explain how the results of the crosses show that these alleles for flower colour are not dominant or recessive.

phenotype of ACAY (offspring of cross 1) is different from either parent / homozygote genotype; the phenotype, was intermediate / mixture of two colours ; both alleles are expressed ; co / incomplete dominance ; offspring of cross 2 gives three phenotypes not two ; offspring of crosses 3 and 4 both give two phenotypes ; if dominance then cross 3 or 4 would give one phenotype only

Q. Carnation plants show **co-dominance** for the anthocyanin gene. There are two alleles: F_A – allele for anthocyanin pigment (red flowers); F_N – allele for no anthocyanin pigment (white flowers). State the genotype of a carnation plant that is heterozygous for this gene. = $F_A F_N$

(ii) Describe the phenotype of a **heterozygous** carnation plant for this gene.
Pink (flowers)

Q. Explain what is meant by the term **adaptive feature**? (3)

Inherited feature that helps an organism survive and reproduce in its environment. Adaptive feature increases organism's fitness, survival and chance of reproducing to leave offspring. e.g. camouflage/warning signal/scares predators/lure for prey/sexual attractant

Q. Why is it **important to prevent the extinction of plant and animal species**?

- to **maintain the gene pool**
- **to provide** chemicals that may be useful in development of **medicines**
- the species may be an important part of a **food chain**
- rare species may **provide tourism** to supply poor communities with money

Monohybrid cross and the punnett square

Mendel crossed true-breeding plants that differed for a given character.

Pollen from true-breeding pea plants with **purple** flowers (one trait) was placed on stigmas of true-breeding plants with **white** flowers (another trait). The **F₁** seeds were **all purple**; the white flower trait failed to appear at all. Because the purple flower trait completely masks the white flower trait when true-breeding plants are crossed, the purple flower trait is called **dominant**, and the white flower trait is called **recessive**. The F₁ plants were allowed to self-pollinate. This step was the monohybrid cross. (or the F₁ cross). The progeny, called **F₂**, were examined: roughly **1/4** were white, and **3/4** were purple. All the genetic crosses shown below will involve examples using pea plants, which can be tall (T) of dwarf (t) – tall is dominant to dwarf.

