AS 90715 Describe the role of DNA in relation to gene expression

Other Types of Crosses

(2015, 2)

Blood Types

There are multiple alleles that determine a human's blood type. These are known as I^A, I^B and i^O. Alleles I^A and I^B are dominant over i^O. However, when IA and IB are inherited together, they show co-dominance.

(a)   Describe what multiple alleles are.

(b)   The pedigree chart below shows the two children and their phenotypes that result from a male with phenotype B and a female with phenotype AB.

Blood Types

Phenotype	Genotype
A	$I^A I^A$, $I^A i^O$
B	$I^B I^B$, $I^B i^O$
AB	$I^A I^B$
O	$i^O i^O$
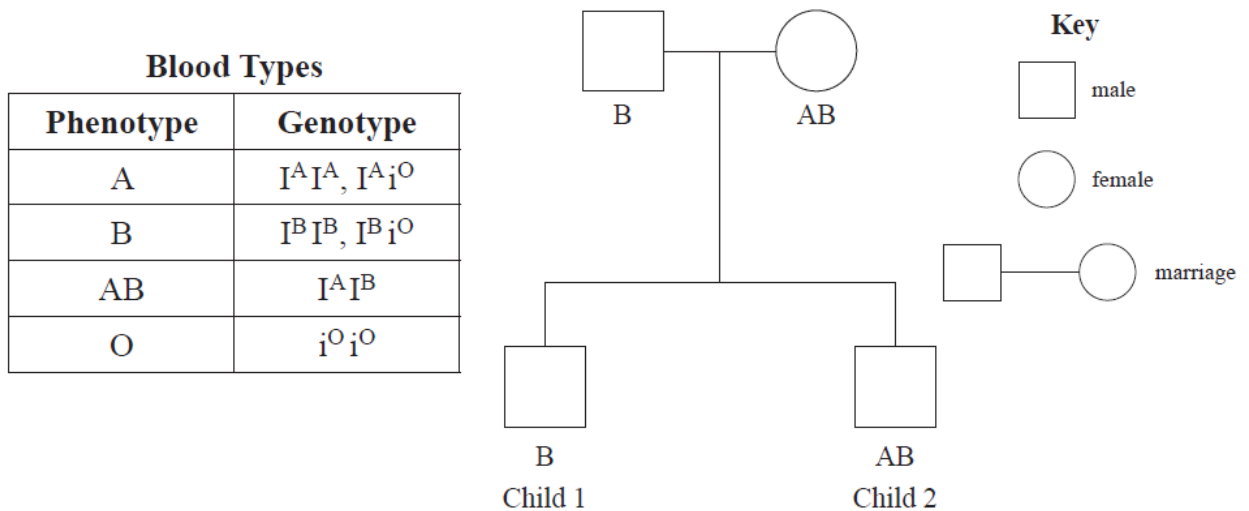
Explain why Child 1 has two possible genotypes while Child 2 has only one possible genotype.

You may use diagrams in your answer.

(c)   Child 2 (AB) in the pedigree chart on the previous page has children with a female having homozygous O blood type.

Discuss the inheritance of their offspring.

In your answer include:

*   the possible phenotypes AND genotypes of the offspring

*   an explanation of the difference between dominance and co-dominance

*   a discussion of why none of their children will have the blood type O or AB.

You may use diagrams in your answer.

(2015, 3)

Coat colour

In 1905, Lucien Cuénot observed unusual ratios when studying inheritance of coat colour in mice. After mating two heterozygous yellow mice (Yy), he observed that the offspring never showed a normal 3:1 phenotypic ratio. Instead, he always observed a 2:1 ratio, with two yellow mice for every grey mouse. He concluded that yellow coat colour (Y) was dominant over grey coat colour (y), and by using test crosses he showed that all his yellow mice were heterozygotes. However, from his many crosses, Cuénot never produced a single homozygous dominant yellow mouse.

Subsequently, it was confirmed that no homozygous dominant yellow mice were present because of a lethal allele.

(a)   Describe a lethal allele(s).

(b)   Discuss how Cuénot used test crosses to determine that all the live yellow mice were heterozygous.

In your answer include:

•   a description of homozygous AND heterozygous

•   an explanation of what a test cross is

•   a discussion of how Cuénot used the test crosses to observe a 2:1 ratio (two yellow mice for every grey mouse), and determine that all live yellow mice were heterozygous.

You may use diagrams in your answer.

(2013, 2)

Variation

The phenotype of a cat's coat is determined by different genes and alleles.

[picture of two kittens]

Co-dominance	Incomplete dominance	Complete dominance
BB black coat	SS extensive spotting in coat	LL short hair coat
Bb black and tan coat (tabby)	Ss medium spotting in coat	Ll short hair coat
bb tan coat	ss no spotting in coat	ll long hair coat

(a)   Using the table above, explain why co-dominance, incomplete dominance, and complete dominance produce different phenotypes in cats.

In your answer include:

- a **description** of co-dominance, incomplete dominance, and complete dominance

- an **explanation** of how genotypes for each gene produce the different phenotypes.

(2012, 2)

Multiple Alleles

An example of multiple alleles is one that determines the feather pattern of mallard ducks. One allele M, produces the wild-type mallard pattern. A second allele MR, produces a different pattern called restricted, and a third allele, md, produces a pattern termed dusky.

White duck with a brownish chest	Brown duck with lightish edged feathers	Mid brown duck – no obvious feather patterns
Restricted	**Mallard**	**Dusky**

In this series, restricted is dominant over mallard and dusky, and mallard is dominant over dusky:

MR (Restricted) > M (Mallard) > md (Dusky)

There are six genotypes possible with these three alleles to produce the three phenotypes.

Discuss why there is only one combination of parental genotypes which can produce offspring that show all three phenotypes in the F_1 offspring.

In your answer you should complete the Punnett square to show the cross, and clearly identify the genotype and phenotype proportions expressed as a percentage or ratio. Refer to your completed Punnett square in your discussion.

F1 gametes

F1 gametes
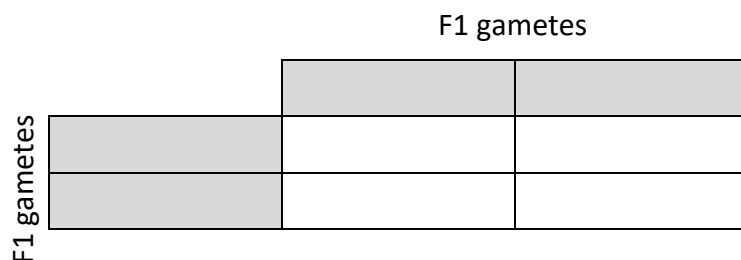
Genotype	
Phenotype	

The questions that follow came from the now expired level 3 AS 90715, Describe the role of DNA in relation to gene expression.

(2011:3)
William Bateson and Reginald Punnett studied two traits in sweet pea plants: flower colour (purple = P, red = p) and pollen shape (long = L, round = l).
A dihybrid cross was carried out between two heterozygous purple, long-pollen grain plants (PpLl × PpLl).
The **observed** results were NOT as **expected**.
The actual results were as follows:

Phenotype	Observed	Ratio	Expected	Ratio
Purple, long	288	12	216	9
Purple, round	24	1	72	3
Red, long	24	1	72	3
Red, round	48	2	24	1

They deduced that the two genes show linkage.
Discuss the results of the dihybrid cross (PpLl × PpLl).
Include in your answer:
- a description of "linkage"
- how the **observed** outcome of the dihybrid cross differs from the **expected** outcome
- the reasons for any variation from the expected outcomes.
  You may use diagrams if you wish.

(2010:3)
(a) Colour blindness and haemophilia are both **linked** genes. They are both **sex-linked** genes.
   Explain why both these statements can be true.
(b) Justify why a dihybrid cross between two black guinea pigs regularly produces offspring in the ratio 9 black : 3 brown : 4 albino.
   Your justification may include:
   - a **Punnett square**
   - an explanation of the **outcomes**
   - an explanation of the **metabolic pathways** involved.

(2009:2)
There are three coat colours in Labrador retriever dogs: black, brown and yellow.
Black coat and brown coat colours are due to the interaction between two separate genes.
Black coat and brown coat colours are determined at the B locus, and black is dominant. Yellow coat colour is determined at the E locus, and is recessive (ee).

(a)   Describe the gene interaction controlling coat colour in Labrador retrievers.
(b)   A black male Labrador (genotype EEBB) was mated with a yellow female Labrador (genotype eebb). All eight puppies (F1 generation) were black.
       Determine the possible F2 phenotype ratios expected in the offspring when two of these F1 black puppies are mated. Use a Punnett square in your answer.

F2 phenotype ratios:_____

(c)   Labrador coat colours are due to the presence of different forms of melanin. Melanin is produced from the amino acid tyrosine. There are two forms of melanin. Pheomelanin gives a yellow pigment and eumelanin produces black or brown pigment. Labradors that have the dominant E allele are able to produce eumelanin, so the dog will appear black or brown. Labradors that are homozygous recessive for this gene will produce only pheomelanin and will have yellow coats.

       Discuss the gene interactions and the metabolic pathways involved in producing yellow Labradors and brown Labradors.
   In your discussion you should focus on:
       •   describing the genotypes that will produce both brown Labradors and yellow Labradors;
       •   explaining how the genes interact to control the production of each coat colour;
       •   discussing the metabolic pathways involved in production of yellow coat `and brown coat colours.

2008:3

A particular mutant allele produces mice with yellow fur. Scientists studying this mutation crossed yellow mice with pure-breeding grey mice. In the F1 generation, they obtained a phenotypic ratio of 1 yellow : 1 grey.

(a)   Explain whether the yellow mice used in this cross were homozygous or heterozygous. You may use a Punnett square in your answer.

(b)   Explain whether yellow fur is a dominant or a recessive trait.

(c)   The scientists crossed two heterozygous yellow mice and examined their offspring. They expected to see a 3:1 yellow : grey phenotypic ratio. However, they found a 2:1 yellow : grey phenotypic ratio. Discuss why the phenotypic ratio differed from what was expected.

(d)   Scientists studying the inheritance of skin colour in humans graphed their data as shown below. Identify and explain the pattern of inheritance shown in this graph.

pale - - - - - - - - - - - - - - - - - - --> dark

Skin shade category
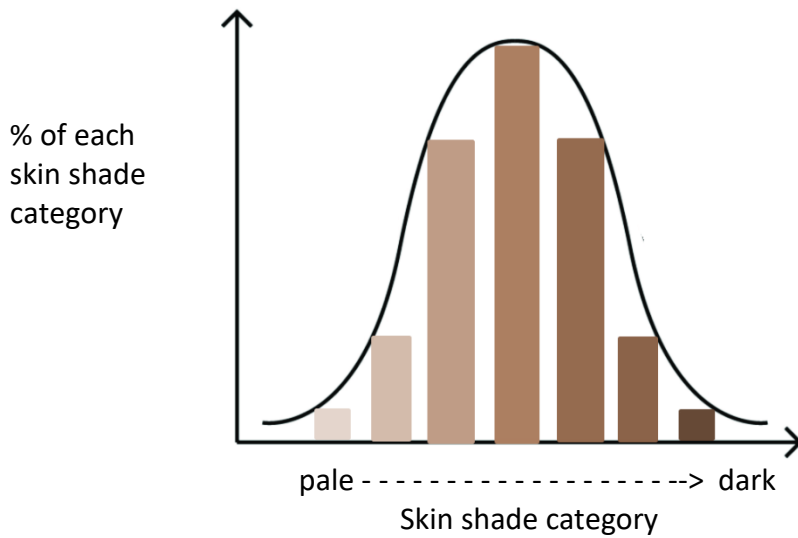
(2007:2(d)-(g))

The allele coding for normal β-globin is called Hb^A, and the allele coding for mutant β-globin is Hb^S. People who are homozygous for the mutant allele ($Hb^S Hb^S$) suffer from sickle-cell anaemia. A person who is heterozygous ($Hb^A Hb^S$) has a mixture of normal red cells and sickle-shaped cells.

(d)   Explain why this pattern of gene expression is an example of co-dominance, **and not** incomplete dominance.

A man is homozygous for the sickle cell allele, and a woman is heterozygous.

(e)   Complete a Punnett square to show the possible genotypes for their children.

		Parent 1 gametes	
Parent 2 gametes			

(f)   (i)   What proportion of the children in (e) are likely to have sickle cell anaemia?
       (ii)   What proportion of the children in (e) are likely to be homozygous for normal haemoglobin?
(g)   The mutation that causes sickle cell anaemia is described as **pleiotropic**.
   Describe what is meant by **pleiotropy**.

(2007:3)
Coat colour in poodles (black or white) is controlled by two genes.
A white female poodle (with the genotype AAbb) was mated with a white male poodle (aaBB). This mating produced six puppies (the F_1 generation), which were all black.

(a)   State the possible F_2 phenotypic ratio expected in the offspring if two of these F_1 black puppies are mated with each other. You may use a Punnett square in your answer.
       F_2 phenotypic ratio:

	Parent 2 gametes			
Parent 1 gametes				

(b)   Name **and** describe the gene interaction that produces this phenotypic ratio.

(c)   In poodles, white and black coat colours are controlled by a metabolic pathway.
       This pathway is controlled by two genes, as shown below:
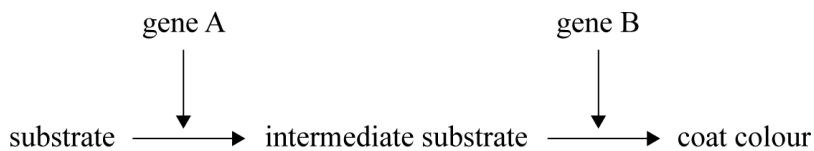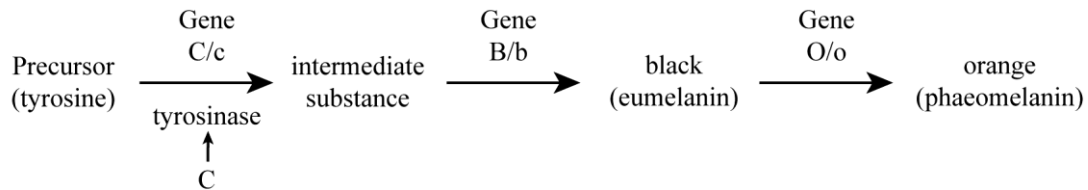

       Discuss how the **two** genes **control** this pathway to produce both black, **and** white poodles.

(2005:3)

The development of coat colour patterns in cats is very complex. It involves at least 10 genes, each of which has a different effect on the phenotype. Effects include different colours, spots, different intensities, stripes, colour in different parts of the body and texture.

(a) Explain why the 10 genes involved in coat colour patterns in cats could not really be called an example of polygene inheritance.

(b) There are 3 main genes that control the metabolic pathway that produces the pigment melanin in cats. Melanin production starts with the amino acid tyrosine. There are two forms of melanin: eumelanin (black) and phaeomelanin (orange/yellow).
     The metabolic pathway for this is shown below.

Precursor (tyrosine) → [Gene C/c, tyrosinase, C] → intermediate substance → [Gene B/b] → black (eumelanin) → [Gene O/o] → orange (phaeomelanin)

Dominant alleles are needed at each locus to complete all steps of the pathway to produce phaeomelanin (orange).
Discuss how this pathway shows epistasis. In your discussion include the effect on the phenotype if one of the genes was homozygous recessive.

The first gene in the pathway has four alleles. Allele C produces an enzyme that gives full coat colour. It is dominant over the alleles c^b (Burmese) and c^s (Siamese). There is another allele, c, recessive to all three other alleles, that does not produce an active enzyme at all so the cats are albino. The alleles c^b and c^s are incompletely dominant with respect to each other.

(c) Describe the term incomplete dominance with reference to this series of alleles.

(d) Explain how four alleles can be involved in the first step of the metabolic pathway.

(e) Consider the other two genes from this pathway.

  •   The allele B produces eumelanin (black pigment) and is dominant to b. Homozygous recessive bb cats are brown or chocolate.

  •   The orange gene (O or o) is located on the X chromosome. X with O produces an enzyme that results in the conversion of eumelanin (black) to phaeomelanin (red/orange/yellow). The X with o cannot carry out this conversion.

  (i)   Use this information to explain why male cats are nearly always either orange or black whereas females are often an orange-black mixture called tortoiseshell.

  (ii) Occasionally a male cat with tortoiseshell features is born. Such male cats are sterile. Discuss how male tortoiseshell cats can occur and why they are sterile. You may use Punnett diagrams in your answer.