

AS91159 Demonstrate understanding of gene expression

Mutations and Metabolic Pathways

(2015,2)

In 1941 biologists George Beadle and Edward Tatum exposed the bread mould *Neurospora crassa* to radiation. The mutated moulds lost their ability to produce an amino acid (arginine), and this slowed or stopped their growth. However, they found when they provided the mould with the amino acid arginine, growth was restored. They concluded that a gene mutation inactivates an enzyme needed to synthesise the amino acid in a metabolic pathway.



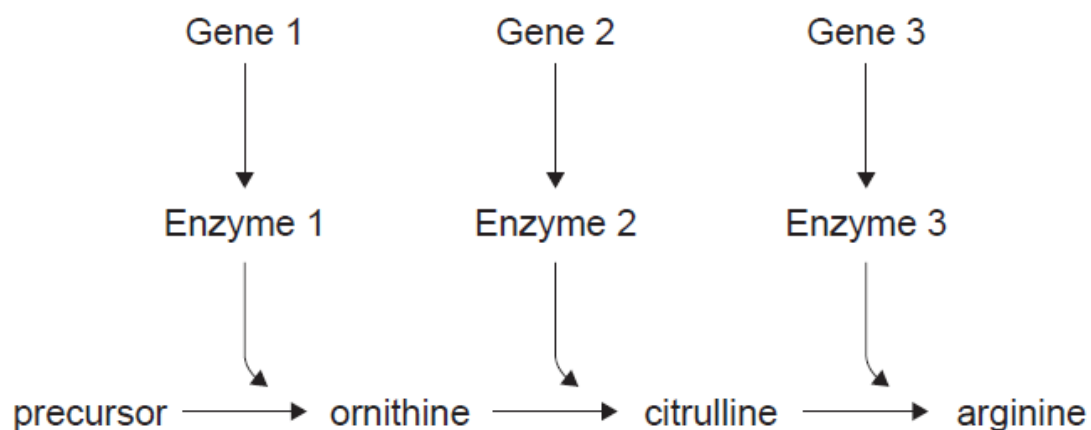
(a) Describe what a gene mutation is.

(b) The biologists carried out further experiments and found three mutations prevented the amino acid arginine from being made.

Using the *Neurospora crassa* metabolic pathway below, discuss why there are three mutations that can occur for the amino acid arginine not to be produced.

In your answer:

- explain what a metabolic pathway is
- discuss why a mutation to any one of the genes can result in arginine not being produced
- discuss why the biologists concluded 'One Gene Codes for One Protein'.



(2014, 3)

TABLE OF mRNA CODONS

		SECOND CODON ELEMENT				
FIRST CODON ELEMENT		U	C	A	G	
	U	PHE	SER	TYR	CYS	U
		PHE	SER	TYR	CYS	C
		LEU	SER	STOP	STOP	A
		LEU	SER	STOP	TRP	G
	C	LEU	PRO	HIS	ARG	U
		LEU	PRO	HIS	ARG	C
		LEU	PRO	GLU	ARG	A
		LEU	PRO	GLU	ARG	G
	A	ILE	THR	ASPN	SER	U
		ILE	THR	ASPN	SER	C
		ILE	THR	LYS	ARG	A
		MET	THR	LYS	ARG	G
	G	VAL	ALA	ASP	GLY	U
		VAL	ALA	ASP	GLY	C
		VAL	ALA	GLU	GLY	A
		VAL	ALA	GLU	GLY	G

ASSESSOR'S USE ONLY

- (a) The mRNA codon sequence for part of a normal haemoglobin protein is shown in the table below.
- Complete the normal template DNA sequence in the table below.
 - Complete the normal amino acid sequence using the mRNA Amino Acid table above

Normal template DNA								
Normal mRNA	AUG	GUG	CAC	CUG	ACU	CCU	GAG	UUG
Normal amino acid								

Sickle cell disease (previously known as sickle cell anaemia) is an inherited disorder caused by a mutation on the haemoglobin (red blood cell) gene. The 20th nucleotide in the DNA sequence, has a T nucleotide substituted with an A nucleotide base on the DNA strand.

- (b) Using the table below, describe the mutated amino acid sequence resulting from T being replaced at the 20th nucleotide position.

Mutated DNA	---	---	---	---	---	---	<div style="border: 1px solid black; width: 20px; height: 20px; display: flex; align-items: center; justify-content: center;"> <div style="width: 10px; height: 10px; background-color: white; border: 1px solid black;"></div> </div>	---
Mutated mRNA								
Mutated amino acid								

20th nucleotide

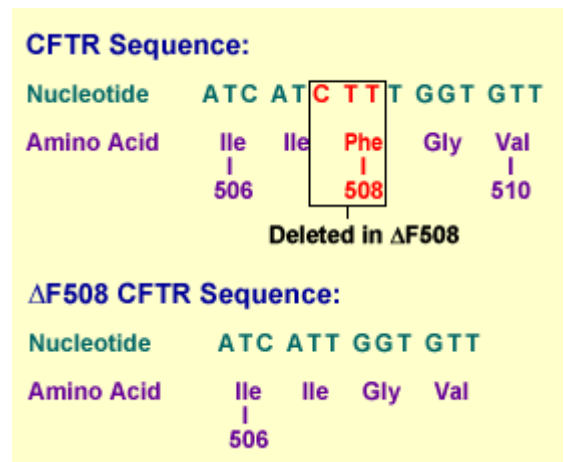
(c) Discuss what happens to the final protein as a result of this mutation.

In your answer:

- explain how the substitution mutation affects the sequence of bases and the final protein
- discuss what would happen to the DNA base sequence and final protein if an additional nucleotide was inserted into the sequence as an extra, rather than being substituted for another, and
- link this to the degeneracy of the genetic code.

(2013, 3)

Cystic fibrosis is caused by a mutation in the gene CFTR (cystic fibrosis transmembrane conductance regulator). The most common mutation is a deletion of three nucleotides that results in a loss of an amino acid at the 508th position on the protein. This mutation accounts for approximately 66–70% of cystic fibrosis cases worldwide. **It is an inheritable recessive condition.**



- (a) Define the term **mutation**.
- (b) Identify the differences between substitution, insertion and deletion mutations, and explain which type of mutation has the most significant effect on an organism's phenotype.
- (c) With reference to cystic fibrosis and another named disease, compare and contrast inherited mutations with mutations that occur during the organism's lifespan.

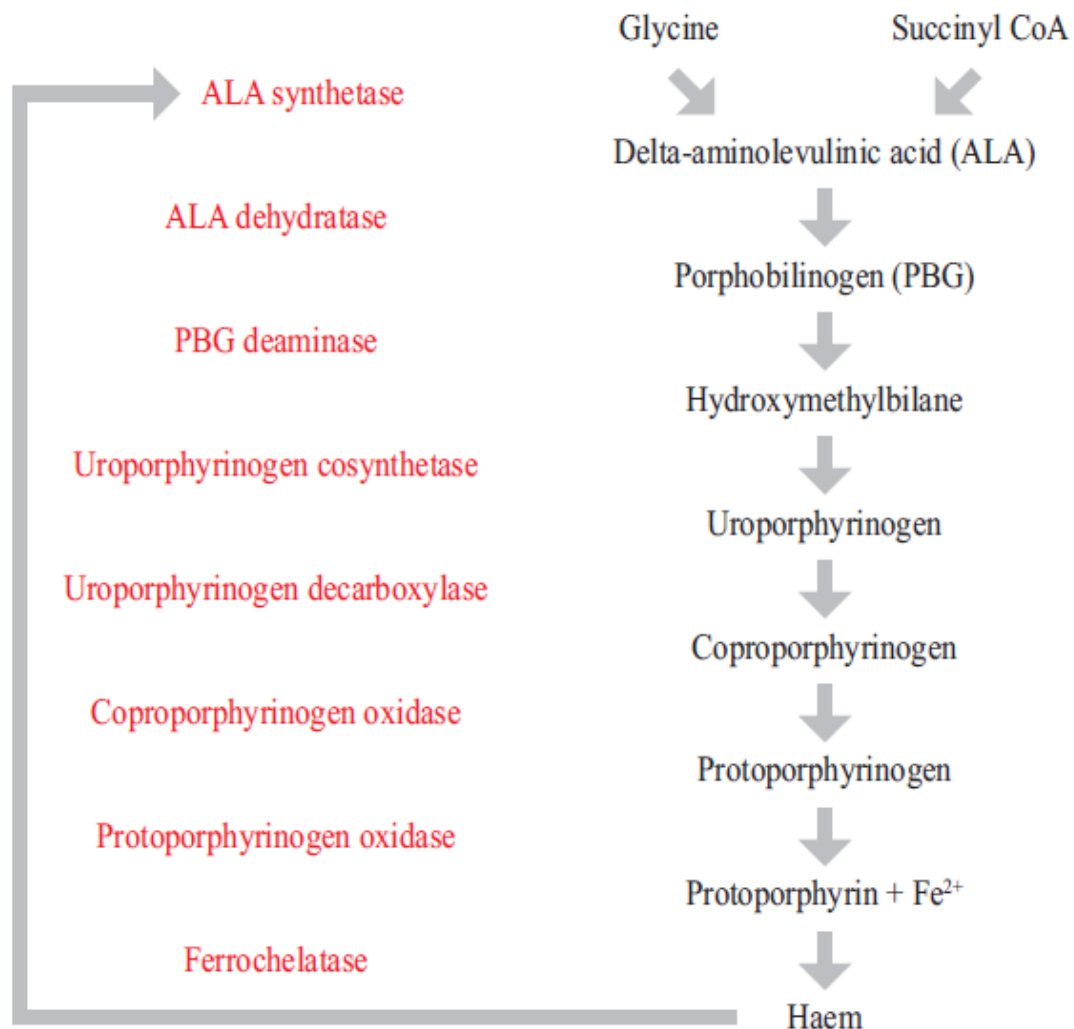
In your answer include:

- a description of both types of mutation
- an explanation of possible causes of these mutations and why they are different in terms of their effect on the organism
- a discussion of each type of mutation, in relation to the two diseases, and whether the diseases are inherited.

(2012, 3)

Porphyrias are a group of rare disorders passed down through families, in which an important part of haemoglobin, called haem, is not made properly.

Normally, the body makes haem in a multi-step process. Porphyrins are made during several steps of this process. Patients with porphyria have a deficiency of certain enzymes needed for this process. This causes abnormal amounts of porphyrins or related chemicals to build up in the body.



In the above diagram, the enzymes are shown in red.

Discuss why patients with Porphyria may have different causes of the disorder, and how two parents with Porphyria could give birth to children who do not have it.

In your answer you should consider:

- a **description** of what is meant by the term 'metabolic pathway'.
- an **explanation** of why some enzymes might be deficient.
- an **evaluation** of the diagram to **justify** how there can be different causes of the disorder, AND how normal children could be born from affected parents.

Previously from Level 3 AS 90715

(2010, 2b)

		Second Letter					
		U	C	A	G		
First Letter	U	Phe	Ser	Tyr	Cys	U	Third Letter
		Phe	Ser	Tyr	Cys	C	
		Leu	Ser	STOP	STOP	A	
		Leu	Ser	STOP	Trp	G	
	C	Leu	Pro	His	Arg	U	
		Leu	Pro	His	Arg	C	
		Leu	Pro	Gln	Arg	A	
		Leu	Pro	Gln	Arg	G	
	A	Iso	Thr	Asn	Ser	U	
		Iso	Thr	Asn	Ser	C	
		Iso	Thr	Lys	Arg	A	
		Met	Thr	Lys	Arg	G	
	G	Val	Ala	Asp	Gly	U	
		Val	Ala	Asp	Gly	C	
		Val	Ala	Glu	Gly	A	
		Val	Ala	Glu	Gly	G	

- (b) A single **substitution** mutation in the DNA **may or may not** lead to a change in the functional protein.

Discuss the effect a single substitution mutation in the DNA may have on the formation of a functional protein.

You should include in your answer:

- how a mutation would be **passed on** during protein synthesis
- **redundancy** of the genetic code
- the **position** of the mutation in the DNA strand.

(2006, 3)

People affected by Duchenne muscular dystrophy (DMD) lose muscle function from an early age and rarely survive to adulthood. The disease is caused by a mutation in a gene found on the short arm of the human X chromosome. The dominant allele (M) results in normal muscle function, while the recessive allele (m) produces the slow, irreversible muscle wasting that is characteristic of this disease.

- (b) Give ALL the possible genotypes for the phenotypes listed below:

- female not affected
- female affected
- male affected
- male not affected

- (c) (i) A female who is heterozygous for the DMD allele has children with an affected male. Use a Punnett square to show all possible genotypes for the offspring of this couple.

- (ii) From your Punnett square, list the phenotypic and genotypic proportions for male and for female offspring.

Phenotypic proportions

male:

female:

Genotypic proportions

male:

female:

- (d) Explain why more males than females are affected by Duchenne muscular dystrophy.

Many metabolic pathways are controlled by multiple genes. An example is the metabolic pathway that produces normal skin pigmentation. Albinism, which is the total lack of pigment, can be caused by a mutation in any one of the genes controlling this pathway.

- (e) Discuss the fact that it is possible for two albino parents to have a child with normal skin pigmentation.