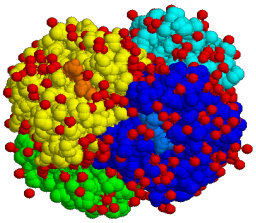
13 Mutations & COVID-19

Links:
• *Edexcel 9-1* SB3d/e/j

haemoglobin contains four folded polypeptide chains



Gene sequencing

Proteins contain one or more **polypeptide chains**. The order of **amino acids** in a chain controls what shape it forms. A protein's shape controls what it does.

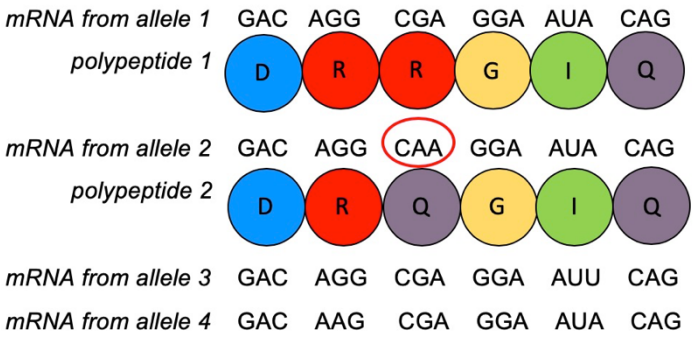
The order of amino acids in a polypeptide chain is controlled by a **gene**. Scientists use **gene sequencing** to work out the order of bases in a gene. From this they can determine the order of amino acids in the polypeptide chain that the gene makes, using an **mRNA codon** chart.

Mutations

When cells in the body make copies of themselves, all their DNA is copied. Sometimes mistakes occur in the copying. These mistakes are **mutations** (which radiation and chemicals can also cause).

A common mutation is for a base in a gene to be replaced by a different one. If the mutation alters the sequence of amino acids in a polypeptide chain, it sometimes changes its protein's final shape.

Mutations produce versions (or **alleles**) of the same gene. The *F5* gene produces factor V (which helps blood to clot). Parts of the mRNA of four *F5* alleles are shown on the right. Polypeptide 1 is normal. Polypeptide 2 has an amino acid change that stops the protein folding properly and causes painful blood clots.



A mutation when part of a gene is *deleted* usually causes a big change in the protein. The *CCR5* gene produces a protein that sticks out of some white blood cells. HIV locks onto this protein. One allele (CCR5-delta 32) contains a deletion of 32 bases in the gene. This produces a smaller protein, which does not stick out of cells. People with this deletion are often protected from HIV infection.

The reason why COVID-19 causes a serious illness in some people but not others may be due to mutations. Scientists are looking at the DNA of people who have had serious COVID-19 and mild COVID-19 to see if they can find a match between the severity of the disease and certain mutations.

Find out

I. 1. Find the name of the disease caused by allele 2 above. _____

2. Write SB (single base) or D (deletion) to show common mutations for these disorders.

a. sickle cell disease ____ b. colour blindness _____ c. Duchenne muscular dystrophy ___

d. phenylketonuria _____ e. DiGeorge syndrome ___ f. cri du chat syndrome _____

3. What disease is caused by a mutation in the sonic hedgehog gene? _____

Text © Mark Levesley 5/2020
Top artwork: public domain.

Test yourself

This mRNA codon chart is needed for some questions.

1st base	2nd base U		2nd base C		2nd base A		2nd base G		3rd base
U	UUU	phenylalanine (F)	UCU	serine (S)	UAU	tyrosine (Y)	UGU	cysteine (C)	U
	UUC		UCC		UAC		UGC		C
	UUA	leucine (L)	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	tryptophan (W)	G
C	CUU	leucine (L)	CCU	proline (P)	CAU	histidine (H)	CGU	arginine (R)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	glutamine (Q)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	isoleucine (I)	ACU	threonine (T)	AAU	asparagine (N)	AGU	serine (S)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lysine (K)	AGA	arginine (R)	A
	AUG	methionine (M)	ACG		AAG		AGG		G
G	GUU	valine (V)	GCU	alanine (A)	GAU	aspartic acid (D)	GGU	glycine (G)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glutamic acid (E)	GGA		A
	GUG		GCG		GAG		GGG		G

4. Name the amino acids in polypeptide 1 (page 1).

_____

_____

_____

_____

_____

5. Complete the table on the right.

DNA codon	mRNA codon	Amino acid name	Amino acid letter code
A A G			
		tryptophan	
	G C U		

6. UAA stops translation. Explain the effect on polypeptide 1 if mutations change AUA to UAA.

_____

_____

7. Look at alleles 3 and 4 on page 1. Explain which allele is more likely to cause a disorder.

_____

_____

8. The SARS-CoV-2 virus gets into cells in the lungs by attaching to a surface protein called ACE-2. Explain how mutations in the *ACE-2* gene could protect someone from COVID-19.

_____

_____

Check-up

I. Check your answers.

II. Origami is the art of folding paper to make models. Describe how you could use origami to model the way in which mutations can affect proteins. If you have time, try out your model by making some origami models.

Text © Mark Levesley 5/2020

Answers

Note to home educators

This worksheet is designed to support understanding of genes and mutations. You may wish to share these objectives with students:

- Describe what a mutation is. (GCSE Biology Higher Tier)
- Recall some ways in which mutations occur. (GCSE Biology Higher Tier)
- Describe possible effects of mutations on amino acid sequences. (GCSE Biology Higher Tier)
- Explain the effects of mutations on protein activity. (GCSE Biology Higher Tier)

To access this sheet, students will need a knowledge of DNA, transcription and translation. It may be helpful for students to use Worksheets 6, 11 and 12 before this one. Other sheets in the series are available: https://shwca.se/covid19science

It is suggested that students complete the worksheet independently, using the internet for questions 1 - 3. Questions 4 - 8 should be completed without help from additional sources.

This sheet is designed for students in Years 10 and 11, and the material is drawn from the Higher Tier of the GCSE 9-1 Biology specifications.

If you wish to check the answers, keep this part of the sheet away from the questions!

I.
1. factor V Leiden thrombophilia
2. a. SB b. SB c. D d. SB e. D f. D
3. holoprosencephaly
4. aspartic acid, arginine, glycine, isoleucine, glutamine
5.

DNA codon	mRNA codon	Amino acid name	Amino acid letter code
A A G	U U C	phenylalanine	F
A C C	U G G	tryptophan	W
C G A	G C U	alanine	A

6. The codon stops isoleucine (I) and glutamine (Q) being added to the polypeptide chain, which is then shortened.
7. Allele 4 is more likely to cause a disorder because it is the only mutation that causes a change in the amino acid sequence.
   (allele 3 AUA → AUU (isoleucine [I] → Isoleucine [I],
   allele 4 AGG → AAG (arginine [R] → lysine [K])
8. A mutation could change the shape of ACE-2 or a mutation could make the ACE-2 protein smaller. In both cases it may mean that the SARS-CoV-2 virus cannot lock onto it or locks onto it less well.

II. The model could include the following ideas:
- proteins need to fold into a certain shape to become active (represented by the final paper model)
- proteins are made from polypeptide chains (represented by the piece of paper used at the start)
- if there is a mistake in the polypeptide chain the protein may not fold correctly (represented by a piece of paper that has a cut in it or is too small or is the wrong shape).