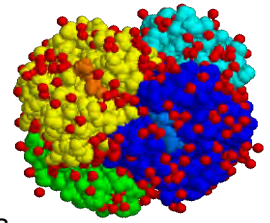


haemoglobin contains four folded polypeptide chains

## 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.

<i>mRNA from allele 1</i>	GAC	AGG	CGA	GGA	AUA	CAG
<i>polypeptide 1</i>	D	R	R	G	I	Q
<i>mRNA from allele 2</i>	GAC	AGG	CAA	GGA	AUA	CAG
<i>polypeptide 2</i>	D	R	Q	G	I	Q
<i>mRNA from allele 3</i>	GAC	AGG	CGA	GGA	AUU	CAG
<i>mRNA from allele 4</i>	GAC	AAG	CGA	GGA	AUA	CAG

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? \_\_\_\_\_

## Test yourself

This mRNA codon chart is needed for some questions.

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

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

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

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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.

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1st base	2nd base								3rd base
	U		C		A		G		
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
CUU	CCU		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

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

## 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.

