raises funds for Genetic Disorders UK

TEACHER'S NOTES
CRYPTIC CODES

OVERVIEW

Aimed at key stage 4 pupils. This activity introduces the genetic code – how DNA contains the instructions to make proteins.

LEARNING OBJECTIVES

- To understand that DNA can be considered as a set of instructions that help organisms develop and function
- To understand that DNA is comprised of four chemical 'building blocks' called nucleotides
- To understand that genes are short sections of DNA whose purpose is to encode proteins
- To understand that at their most basic level, proteins are a string of amino acids and the order of the amino acids is determined by a gene
- To understand that a group of three nucleotides in a gene is called a codon and that a codon specifies a single amino acid

CURRICULUM LINKS

- **KS4:** The ways in which organisms function are related to the genes in their cells

YOU WILL NEED

- Elastic thread (5 pieces about 30cm in length)
- Coloured beads (approximately 40 of each colour - red, yellow, green and blue)

PREPARATION

- Before the lesson you could prepare five cryptic messages for the pupils to decipher. These messages will be 'spelt' using the four coloured beads and stored on the elastic. The 'genetic code' table in the student worksheet will help you translate your message into 'DNA sequence'.

Activity

- Introduce the relationship between DNA and proteins. Explain that the order of the nucleotides in the DNA determines the amino acids in the protein
- Give pupils the worksheet to read through and answer the questions
- *Optional: give groups of pupils the message you have created using the beads and ask them to translate it*
- *Optional: you could show a film from the Genes Are Us website. This would encourage pupils to think about different genetic disorders and the consequences of changes to the DNA*

ANSWERS

1. In what year did Watson and Crick identify the structure of DNA?

a) 1953

2. Approximately how many genes do humans have?

b) 20,000

3. Approximately how long would it take you to read all 3 billion letters if you read non-stop at a rate of one letter per second?

c) 95 years

4. For every 1,000 letters of DNA, roughly how many are the same between two people?

c) 999

5. Use our genetic code to encode your name in DNA.

For example, 'Fred' would be TTTCGTGAAGAT

Pupils' answers will vary

6. How would you encode the sequence 'FATE' using our genetic code?

TTTGCTACTGAA

ANSWERS continued

7. How many letters in the DNA sequence would you need to change to encode 'LATE' instead?

This would change by only a single letter (in bold) to: TT**A**GCTACTGAA

8. What does the following DNA sequence encode? ATGAACACGTCTGAA

MOUSE

9. What does the following DNA sequence encode? ATGAACAACTCTGAA

MOOSE

10. Explain how mutations in the DNA can cause genetic disorders

Pupils need to articulate that sometimes small changes in DNA can have significant effects. Many genetic disorders are caused by minor changes to the DNA sequence, but the mutations can cause major changes to the protein produced. Sometimes the protein no longer functions or has a toxic effect.

FURTHER information

There are various websites that cover genes and protein synthesis, but they tend to do so at a slightly higher level, including transcription and mRNA. However, the University of Utah has particularly good online learning tools for genetics: **http://learn.genetics.utah.edu/**

Note: many articles refer to the 'genetic code' as the instructions carried within DNA. However, the term 'genetic code' is quite specific and should only refer to how codons encode amino acids.

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CRYPTIC CODES

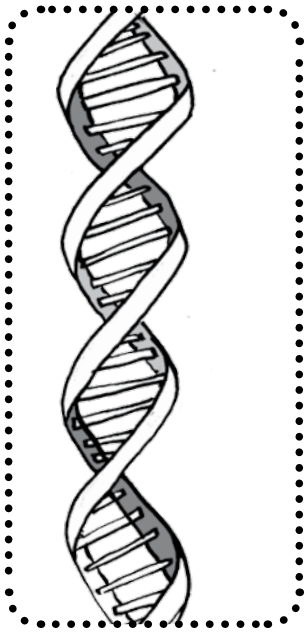
As recently as the mid 1900s, scientists were still unsure of the role of two key types of chemicals in cells: DNA and proteins. They knew that DNA and proteins were important, but they still didn't know whether genes were made of DNA or protein, nor how genes actually worked!

1 ***In what year did Watson and Crick identify the structure of DNA?***

a) 1953
b) 1983
c) 2003

2 ***Approximately how many genes do humans have?***

a) 20
b) 20,000
c) 20,000,000



In the last century, huge advances have been made in our understanding of DNA. We now know that genes are stretches of DNA which carry information; many (but not all) genes are instructions for how to make proteins. To understand how genes are able to encode proteins, we need to understand what DNA is.

DNA, or deoxyribonucleic acid, is a special type of chemical. It provides instructions to help your body to grow and function.

Like many chemicals in biology it is a '**polymer**', which means it is made out of lots of smaller parts ('poly' = many, 'mer' = parts).

The smaller parts in DNA are called '**nucleotides**' and these join up to make two long chains. These two strands are linked together and twisted to make a double helix structure.

There are four different nucleotides, which are referred to as A, T, C and G used, so we can simply think about DNA as being a long string of letters, for example:

...ATGTTACGCCATGGCCAGCAGCAGTTA...

This is also known as DNA sequence. There are over 3 billion (3,000,000,000) letters of DNA inside your cells and most of it is the same as the DNA inside the person next to you, but there are crucial differences that help to make you unique.

3 ***Approximately how long would it take you to read all 3 billion letters if you read non-stop at a rate of one letter per second?***

a) 9 years
b) 19 years
c) 95 years

4 ***For every 1,000 letters of DNA, roughly how many are the same between two people?***

a) 600
b) 900
c) 999

Seconds in...	one minute	one hour	one day	one year
	60	3,600	86,400	31,536,000

CRYPTIC CODES

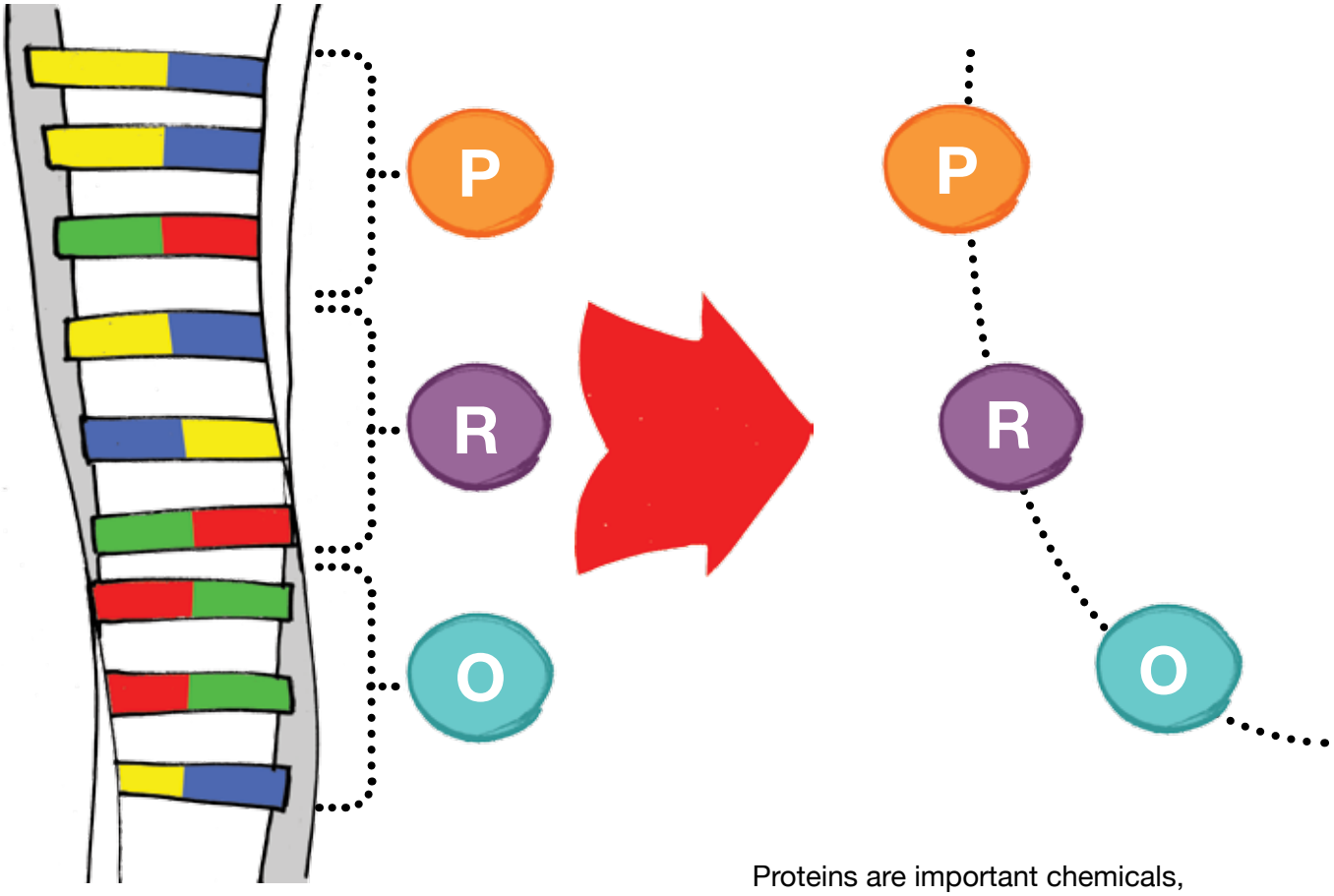
HOW DO GENES ENCODE PROTEINS ?

Proteins are also polymers, made of long chains of amino acids. The long chains fold into specific shapes to allow the protein to perform its job. If one of the amino acids is changed, it can alter the structure and function of the protein.

There are 20 different amino acids used to build proteins. In order for the DNA to specify which amino acid is needed, three nucleotides are read together as a group. A group of three nucleotides is called a 'codon'. This relationship – how a codon in DNA determines an amino acid in a protein – is called 'the genetic code'.

The order of the nucleotides in DNA….

…determines the order of the amino acids in the protein



DNA is an important chemical, as it provides our body with instructions

Proteins are important chemicals, as they act as:

- structural components
- hormones
- antibodies
- enzymes

CRYPTIC CODES

We've made our own genetic code in the table below – it's based on the real genetic code, but it is a little different.

Amino acid	DNA sequence
A	GCT
B	GCG
C	TGT
D	GAT
E	GAA
F	TTT
G	GGT
H	CAT
I	ATT
J	ATA
K	AAA
L	TTA
M	ATG
N	AAT
O	AAC
P	CCT
Q	CAG
R	CGT
S	TCT
T	ACT
U	ACG
V	GTT
W	TGG
X	GTG
Y	TAT
Z	TAC

5 ***Use our genetic code to encode your name in DNA.***
For example, 'Fred' would be TTTCGTGAAGAT

6 ***How would you encode the sequence 'FATE' using our genetic code?***

7 ***How many letters in the last DNA sequence would you need to change to encode 'LATE' instead?***

8 ***What does the following DNA sequence encode?***
ATGAACACGTCTGAA

9 ***What does the following DNA sequence encode?***
ATGAACAACTCTGAA

10 ***Explain how mutations in the DNA can cause genetic disorders***