Biology

Genetics: The Code Broken?

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Science Press

Contents

Use the table of contents to record your progress through this book. As you complete each topic, write the date completed, then tick one of the three remaining columns to guide your revision for later. The column headers use the following codes:

?? = Don't understand this very well at all. RR = Need to revise this. OK = Know this.

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Introduction

Each book in the 'Surfing' series contains a summary, with occasional more detailed sections, of all the mandatory sections of the syllabus, along with questions and answers.

It is envisaged this book will be useful in class for both initial understanding and revision, while the more traditional textbook can remain at home for more detailed analysis.

All types of questions – short response, structured response and free response – are provided. Questions are written in exam style and use the verbs specified by the Board of Studies so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

The topic test at the end of the book is in the style of the HSC options questions. These are useful for revision and exam practice. Marking guidelines are supplied where appropriate.

Verbs To Watch

When you are answering questions in this book, your textbook or any examinations, make sure you answer what the question is asking. To do this you will have to know what each of the terms below means – they dictate what sort of an answer is required. It is essential that you learn their meanings as required by the Board of Studies. Your exam answers will be marked according to what these terms indicate your answer should be saying.

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Identify components and the relationships among them, draw out and relate implications.

apply Use, utilise, employ in a particular situation.

appreciate Make a judgement about the value of something.

assess Make a judgement of value, quality, outcomes, results or size.

calculate Determine from given facts, figures or information.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

compare Show how things are similar or different.

construct Make, build, put together items or arguments.

contrast Show how things are different or opposite.

critically (analyse/evaluate) Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to an analysis or evaluation.

deduce Draw conclusions.

define State the meaning of and identify essential qualities.

demonstrate Show by example.

describe Provide characteristics and features.

discuss Identify issues and provide points for and against.

distinguish Recognise or note/indicate as being distinct or different from, note difference between things.

evaluate Make a judgement based on criteria.

examine Inquire into.

explain Relate cause and effect, make the relationship between things evident, provide why and/or how.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

outline Sketch in general terms; indicate the main features.

predict Suggest what may happen based on available information.

propose Put forward (a point of view, idea, argument or suggestion) for consideration or action.

recall Present remembered ideas, facts or experiences.

recommend Provide reasons in favour.

recount Retell a series of events.

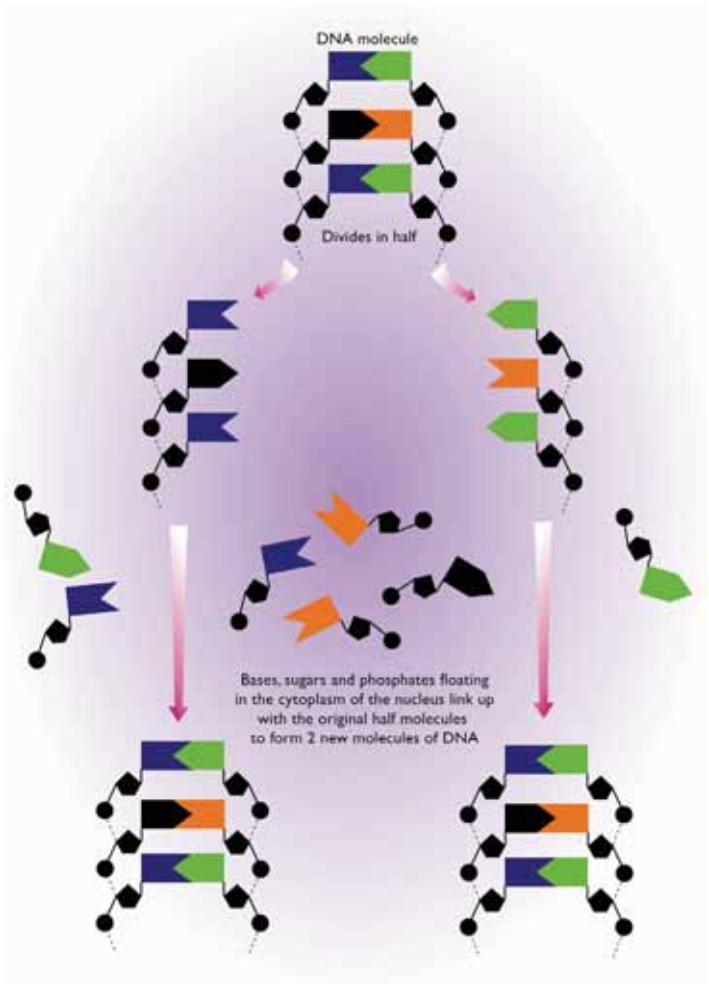
summarise Express concisely the relevant details.

synthesise Put together various elements to make a whole.

1 Assumed Knowledge

1. What does DNA stand for?
2. Name the basic unit of DNA.
3. Where is DNA located in cells?
4. Outline the structure of the DNA molecule.
5. Discuss one benefit of the twisting and packaging of the DNA into a tight coil.
6. Identify the main people involved in working out the structure of DNA.
7. Define polypeptide.
8. Outline the nitrogenous base pairing that occurs in the DNA molecule.
9. The diagram shows DNA replicating.

Figure 1.1 DNA replicating



Describe what happens during DNA replication.

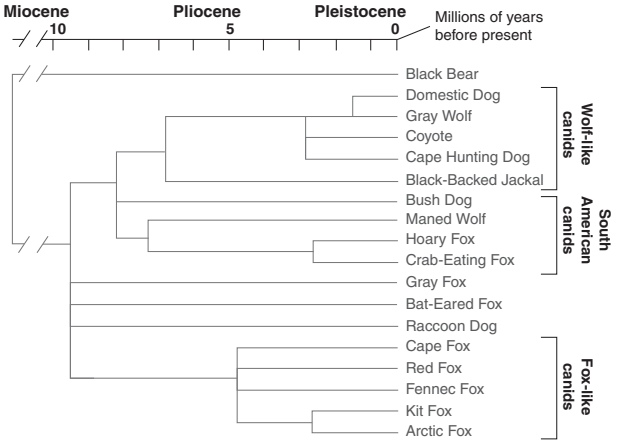
10. Outline the relationship between DNA and genes.
11. State the one-gene-one-polypeptide theory.
12. Define allele.
13. What is meant by 'multiple alleles'?
14. In humans there are three alleles for blood group. Identify these three alleles.
15. Gregor Mendel has often been called the 'Father of Genetics'.
    The following picture shows Gregor Mendel.

Figure 1.2 Gregor Mendel

Describe Mendel's contribution to the study of genetics.

16. Outline what is involved during crossing over in meiosis.
17. What is the Human Genome Project?
18. Define mutation.
19. Identify some causes of mutation.
20 Distinguish between a procaryote and a eucaryote.
21. Define hybrid.
22. What is a zygote.
23. The following diagram shows a possible evolutionary tree for the dog family (Family Canidae).

Figure 1.3 Evolution of the dog family



Outline areas of evidence that are used to construct evolutionary trees.

24. What is a clone?
25. Explain cloning as a current reproductive technology that may alter the genetic composition of a population.
26. What is biotechnology? Give an example.
27. Outline one process used to produce transgenic species. Use an example.

2 Constructing a Model of DNA

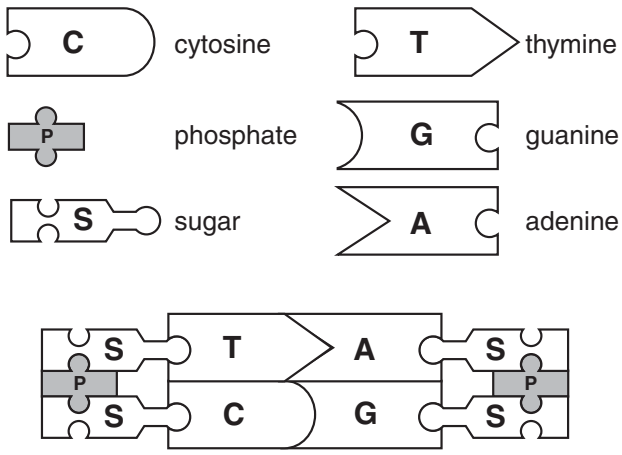
There are many ways you can construct a model to show the structure of DNA. You can use molecular model kits with sticks and balls and make a model similar to the one built by James Watson and Francis Crick. This model has the benefit that it gives a three-dimensional vision of DNA to show the double helix structure.

Figure 2.1 Watson and Crick – James Watson and Francis Crick and their model of the DNA molecule

Another way of showing this three-dimensional structure is to make an 'edible' DNA, e.g. using different coloured jellybeans to represent the nitrogenous bases, the phosphate and the sugar. The jellybeans can be joined with toothpicks to represent the bonds holding the nucleotides together.

Many models of DNA use jigsaw cut-outs of coloured paper or cardboard and align the pieces to give a two-dimensional view of the ladder and rung structure of DNA.

Figure 2.2 DNA Jigsaw



A codon, or triplet, is the basic instruction of the genetic code. A codon is three bases next to each other in a molecule of DNA or mRNA and specifies a particular amino acid. Reading the sequence of codons in DNA means that you are reading the sequence of amino acids which will be joined together to form a polypeptide. Thus a model of a section of DNA shows the genetic coding to manufacture a particular protein. Since proteins determine the different appearance and type of cells found in the body and also determine the reactions that occur in cells (enzymes are proteins), a section of DNA (gene) determines your appearance and phenotype.

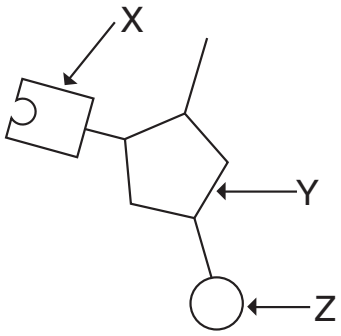
For You To Do

1. Draw a simple, fully labelled diagram of a part of a DNA molecule showing eight base pairs.
2. The table shows the percentage of adenine, guanine, cytosine and thymine in a series of DNA samples.

DNA source	Adenine	Guanine	Cytosine	Thymine
Yeast	33.2	16.1	16.9	33.8
Bacteria	26.9	22.7	23.0	27.4
Invertebrate	31.5	18.5	18.6	31.4

   Discuss how this data shows an important feature of the DNA molecule.
3. The diagram represents one nucleotide.

Figure 2.3 One nucleotide



   (a) Identify the components X, Y and Z.
   (b) Draw a diagram to show how two more nucleotides would connect with this nucleotide.
4. Describe a model you could construct to show the structure of the DNA molecule and assess the uses and limitations of this model.
5. What is a codon?
6. Explain why the coding of the base pairs in a section of DNA is important.

3 DNA Produces a Polypeptide

To produce a polypeptide the coded information on the DNA in the nucleus needs to be carried out of the nucleus to the cytoplasm. In the process called **transcription**, messenger RNA (mRNA) copies the information from DNA and travels from the nucleus to a ribosome in the cytoplasm.

Figure 3.1 Transcription

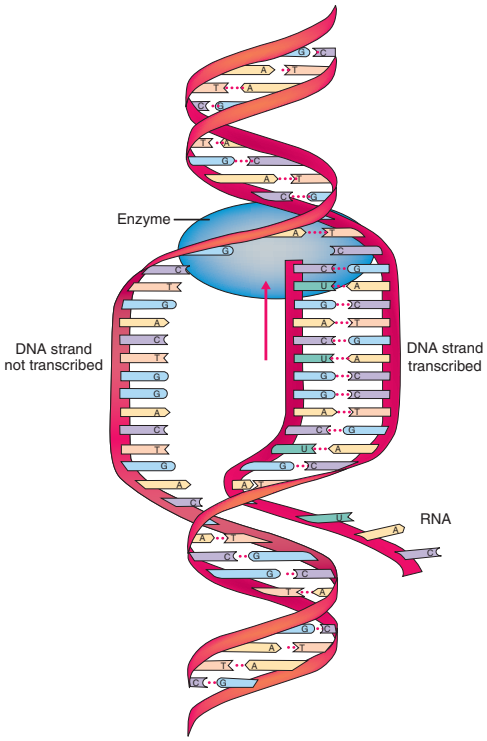
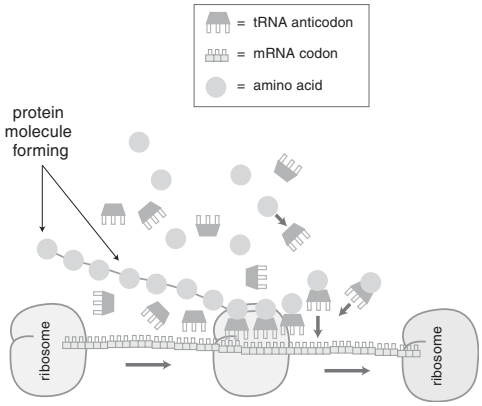


Figure 3.2 Translation



During transcription the DNA unzips and the enzyme RNA polymerase binds to one of the DNA strands. The enzyme makes a long chain of RNA nucleotides that are complementary to the DNA nucleotides. This forms the mRNA which is released from the enzyme. In eucaryote cells the mRNA moves out of the nucleus into the cytoplasm.

During translation the coding on the mRNA is used to make proteins. Translation occurs on ribosomes in the cytoplasm. The ribosome provides the structural site for the mRNA and a tRNA brings an amino acid to this site. The tRNA has a triplet code which is complementary to the code on the mRNA. The ribosome moves to the next triplet code and the amino acids are added to the growing peptide chain.

Sometimes there are clusters of ribosomes on a mRNA and since each one make a polypeptide strand the final result is a more complex protein.

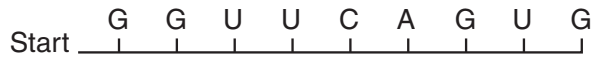
Table 3.1 mRNA and amino acid codes

UUU	phenylalanine	UCU		UAU	trypsin	UGU	cystine
UUC		UCC		UAC		UGC	
UUA	leucine	UCA	serine	UAA	stop	UGA	stop
UUG		UCG		UAG	stop	UGG	trypsin
CUU		CCU		CAU	histidine	CGU	
CUC	leucine	CCC	proline	CAC		CGC	arginine
CUA		CCA		CAA	glutamine	CGA	
CUG		CCG		CAG		CGU	
AUU		ACU		AAU	asparagine	AGU	
AUC	isoleucine	ACC	threonine	AAC		AGC	serine
AUA		ACA		AAA		AGA	
AUG	start/methionine	ACG		AAG	lysine	AGG	arginine
GUU		GCU		GAU	aspartic acid	GGU	glycine
GUC	valine	GCC	alanine	GAC		GGC	
GUA		GCA		GAA		GGG	
GUG		GCG		GAG	glutamine	GGA	

For You To Do

1. Define transcription.
2. Describe the steps that occur during transcription.
3. Distinguish between the location of transcription and translation.
4. Identify what happens during translation.
5. The diagram shows a part of a mRNA molecule formed from a given length of DNA in the nucleus in a cell.

Figure 3.3 Part of mRNA

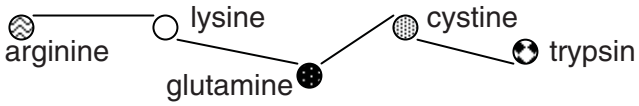


   (a) Identify the sequence of amino acids coded for by this length of mRNA.
   (b) If the DNA which formed this mRNA had the third base from the right replaced by the base thymine, what amino acid sequence would be coded on the mRNA and what amino acid would this form?
6. Distinguish between a codon and an anticodon.
7. Discuss how the bases that make up RNA differ from the bases that make up DNA.
8. Compare mRNA and tRNA.
9. The following code is part of a single strand of DNA.

   AAATAGTGGCCAAGC

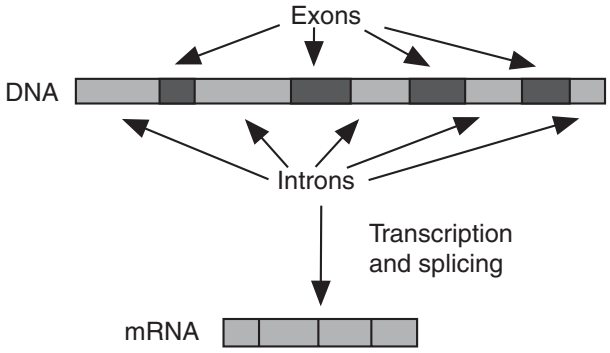
   Construct a table to show how this code would be found after transcription on the mRNA and translation on the anticodon of the tRNA with the corresponding amino acid that will be formed. (You will need to use the information in Table 3.1, mRNA and amino acid codes, to identify each amino acid.)
10. What happens at the beginning of transcription?
11. The following diagram shows a section of a polypeptide.

Figure 3.4 Part of a polypeptide

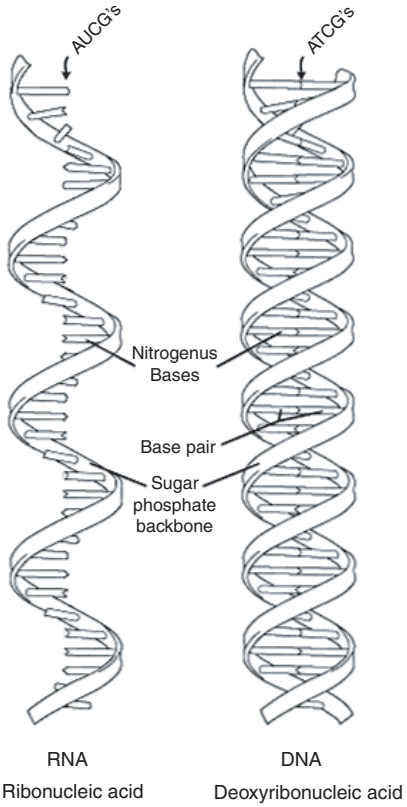


   Write down TWO DNA codes that could form this section of the polypeptide.
12. An exon is a sequence of DNA that codes information for protein synthesis and is transcribed to messenger RNA. Introns are part of the DNA code that do not code for proteins and are found between exons.

Figure 3.5 Introns and exons



   From the diagram, when are introns removed from the code?
13. Insulin is a small simple protein consisting of 51 amino acids in two chains. What would be the minimum number of bases needed to code this protein? Why is it most likely that the number of bases in the gene is greater than this?
14. The following diagram shows RNA and its corresponding DNA.



   Colour in a section of each of these using the colour code red=A, blue=C, green=G, black=U and yellow=T, to show RNA with a code for the three amino acids alanine, valine and glycine in a sequence.