

# CONTENTS



<b>Introduction</b> .....	<b>ix</b>
Biology syllabus.....	ix
Breakdown of the Leaving Certificate examination.....	xi
<b>UNIT 1: BIOLOGY: THE STUDY OF LIFE</b> .....	<b>1</b>
<b>1.1 The Scientific Method</b> .....	<b>2</b>
Limitations of scientific method.....	2
<b>1.2 The Characteristics of Life</b> .....	<b>5</b>
Characteristics of living things (organisms) .....	5
<b>1.3 Nutrition</b> .....	<b>6</b>
Food .....	6
Carbohydrates.....	7
Lipids .....	7
Protein .....	8
Vitamins.....	8
Minerals.....	8
Water.....	9
<b>Mandatory activity</b> – Food tests .....	9
<b>1.4 General Principles of Ecology</b> .....	<b>11</b>
Environmental factors in an ecosystem.....	12
Abiotic factors .....	12
Biotic factors .....	12
Energy flow in an ecosystem .....	12
Food web .....	12
Food chain .....	13
Pyramid of numbers .....	13
Limitations of a pyramid of numbers .....	14
Pyramid of biomass .....	14
Factors that affect population numbers in an ecosystem .....	15
Competition.....	15
Predation .....	16
Parasitism.....	17
Symbiosis .....	17

Nutrient recycling.....	18
The carbon cycle .....	18
The nitrogen cycle .....	19
Human population.....	20
Human impact on an ecosystem .....	21
Pollution.....	20
Conservation .....	22
Waste management.....	23
<b>1.5 Study of an Ecosystem Guidelines.....</b>	<b>25</b>
<b>UNIT 2: THE CELL .....</b>	<b>27</b>
<b>2.1 Cell Structure .....</b>	<b>28</b>
Microscopy .....	28
<b>Mandatory activity</b> – To make slides of animal and plant cells and observe under a microscope .....	29
Cell ultrastructure .....	31
Movement through cell membranes .....	33
Osmosis and diffusion .....	33
Turgor and plasmolysis .....	33
<b>Mandatory activity</b> – Conduct any activity to demonstrate osmosis .....	34
Eukaryotic and prokaryotic cells .....	35
<b>2.2 Cell Metabolism .....</b>	<b>37</b>
Enzymes .....	37
Factors affecting enzyme activity .....	38
Enzyme action (How an enzyme works).....	39
<b>Mandatory activity</b> – To investigate the effect of pH on the rate of enzyme activity .....	40
<b>Mandatory activity</b> – To investigate the effect of temperature on the rate of enzyme activity .....	41
<b>Mandatory activity</b> – To investigate the effect of heat denaturation on catalase activity .....	43
Enzyme immobilisation .....	44
<b>Mandatory activity</b> – To prepare an enzyme immobilisation and examine its application .....	45
Photosynthesis .....	48
Role of photosynthesis in nature .....	49
Adaptations of the leaf for photosynthesis .....	49
Energy in the cell.....	50
Biochemistry of photosynthesis.....	50
<b>Mandatory activity</b> – To investigate the effect of light intensity on the rate of photosynthesis.....	53
Greenhouse cultivation.....	54



Respiration.....	56
Biochemistry of cellular respiration .....	57
Difference between aerobic and anaerobic respiration.....	58
<b>Mandatory activity</b> – To prepare and show the production of alcohol by yeast .....	59
<b>2.3 Cell Continuity.....</b>	<b>61</b>
Cell division .....	61
Haploid and diploid cells .....	61
Mitosis.....	61
Significance of mitosis .....	62
Stages of mitosis .....	62
Cell cycle .....	63
Cancer .....	63
Meiosis .....	64
Significance of meiosis .....	64
<b>2.4 Cell Diversity – Tissues, Organs and Systems .....</b>	<b>65</b>
Organ systems .....	65
Tissue culture .....	66
<b>2.5 Genetics .....</b>	<b>67</b>
Gregor Mendel .....	68
Mendel's Laws .....	69
Linkage and the effects on Mendel's Second Law .....	71
Sex chromosomes .....	72
Sex linkage .....	73
Chromosome and DNA .....	76
DNA structure .....	76
DNA replication.....	78
DNA and protein synthesis .....	79
Differences between DNA and RNA.....	79
Non-nuclear inheritance of DNA.....	80
<b>Mandatory activity</b> – To isolate DNA from plant tissue .....	80
DNA profiling.....	81
Genetic screening and testing .....	82
Genetic engineering and applications.....	82
Evolution .....	85
Natural selection (Darwin and Wallace).....	85
Evidence for evolution .....	85
Comparative anatomy .....	85
Variation of species .....	86
Mutations .....	86

<b>UNIT 3: THE ORGANISM</b>	<b>89</b>
<b>3.1 Diversity of Organisms and Classification</b>	<b>90</b>
Bacteria (Monera)	91
Reproduction and growth curve of micro-organisms	91
Endospores	93
Nutrition in bacteria	93
Antibiotics	94
Fungi	96
<i>Rhizopus</i> (bread mould)	97
<i>Saccharomyces</i> (yeast)	98
Laboratory procedures when culturing micro-organisms	99
<b>Mandatory activity</b> – To investigate the growth of leaf yeast using agar plates and controls	101
Protista (amoeba)	104
<b>3.2 Organisational Complexity in Plants and Animals</b>	<b>105</b>
Monocots and dicots	105
Plant tissues	106
Plant growth	108
Monocot and dicot stems	108
Dicot roots	109
<b>Mandatory activity</b> – To examine microscopically the transverse section of a dicot stem	109
Organisational complexity of the human circulatory system	110
Constituents of blood	112
Blood cells	112
Blood groups	113
Blood vessels	113
The heart	114
<b>Mandatory activity</b> – To dissect, display and identify an ox or sheep heart	115
<b>Mandatory activity</b> – To investigate the effect of exercise on the pulse rate of a human	116
Blood pressure	117
Heart disease	117
Lymphatic system	117
<b>3.3 Transport and Nutrition</b>	<b>121</b>
Nutrition in the flowering plant	121
Nutrition in the human	125
The digestive system	125
Teeth and dentition	127
Small intestine and adaptations to its functions	127

Secretions and digestive enzymes in the alimentary canal .....	128
Large intestine and adaptations to its functions.....	129
The liver and bile.....	129
<b>3.4 Breathing System and Excretion.....</b>	<b>132</b>
Homeostasis .....	132
Breathing system in the human .....	133
Gaseous exchange in humans .....	133
Breathing disorders .....	136
Control of breathing .....	136
The excretory system in humans.....	136
Urinary system and the nephron .....	137
Osmoregulation .....	140
ADH .....	140
<b>3.5 Responses to Stimuli.....</b>	<b>142</b>
Responses in the flowering plant and tropisms.....	142
Growth regulators .....	143
Adaptations of plants to adverse environmental conditions .....	144
<b>Mandatory activity</b> – To investigate the effect of IAA growth regulator on plant tissue.....	144
Responses in humans.....	146
Nervous system .....	146
Central nervous system – brain and spinal cord.....	146
Reflex action (Arc) .....	148
Neurons – nerve cells.....	148
Synapse.....	150
Parkinson's disease .....	151
Sense organs .....	152
The eye .....	152
Accommodation .....	153
Eye defects .....	153
The ear.....	155
The skin .....	156
Endocrine system .....	157
Endocrine and exocrine glands and hormones .....	157
Insulin .....	158
Hormone supplements .....	159
Feedback mechanisms – negative feedback inhibition.....	159
Differences between endocrine and nervous systems.....	160
Musculoskeletal system.....	163
Human skeleton .....	163
Structure of bone .....	163

Cartilage .....	166
Joints .....	166
Antagonistic muscles .....	167
Musculoskeletal disorders .....	167
Defence and the immune system .....	168
Natural immunity .....	168
Induced (acquired) immunity .....	169
Viruses – viral diseases and treatment .....	171
<b>3.6 Reproduction and Growth.....</b>	<b>175</b>
Sexual reproduction in the flowering plant.....	175
Pollen development.....	176
Embryo sac development .....	177
Sexual reproduction .....	177
Pollination .....	177
Fertilisation.....	178
Fruits and seed dispersal.....	180
Germination.....	180
<b>Mandatory activity</b> – To investigate the effect of water, oxygen and temperature on germination.....	181
<b>Mandatory activity</b> – To show digestive activity during germination using starch agar or skimmed milk plates .....	182
Dormancy .....	183
Vegetative propagation .....	183
Comparison of vegetative propagation and sexual reproduction.....	184
Artificial propagation.....	185
Sexual reproduction in the human .....	187
Male reproductive system.....	187
Female reproductive system.....	189
Copulation .....	190
Birth control .....	190
Development after fertilisation .....	190
Implantation .....	191
Placenta .....	191
Development of the embryo to the thirteenth week .....	192
Birth (Parturition) .....	192
Lactation .....	193
Infertility .....	193
Menstrual disorder .....	194
In-vitro fertilisation .....	194
Hormonal control in the menstrual cycle .....	195
<b>Glossary .....</b>	<b>199</b>

## DNA replication

This is the means by which chromosomes (DNA) can form identical copies of themselves.

DNA replication begins when:

- The **hydrogen bonds** holding the base pairs together break.
- The strands of the parent DNA then separate.
- The DNA double helix unwinds.
- Each strand of the DNA now acts as a template.
- **Nucleotides**, with specific bases from the cytoplasm, match the free bases on each of the parent strands of DNA.

This process produces two DNA helices identical to the first. One half of each double helix contains the original parent strand (see fig. 2.33).



Two enzymes are involved in DNA replication:

1. **DNA polymerase** creates a new strand of DNA by joining DNA nucleotides together.
2. **DNA ligase** joins separate strands of DNA together.

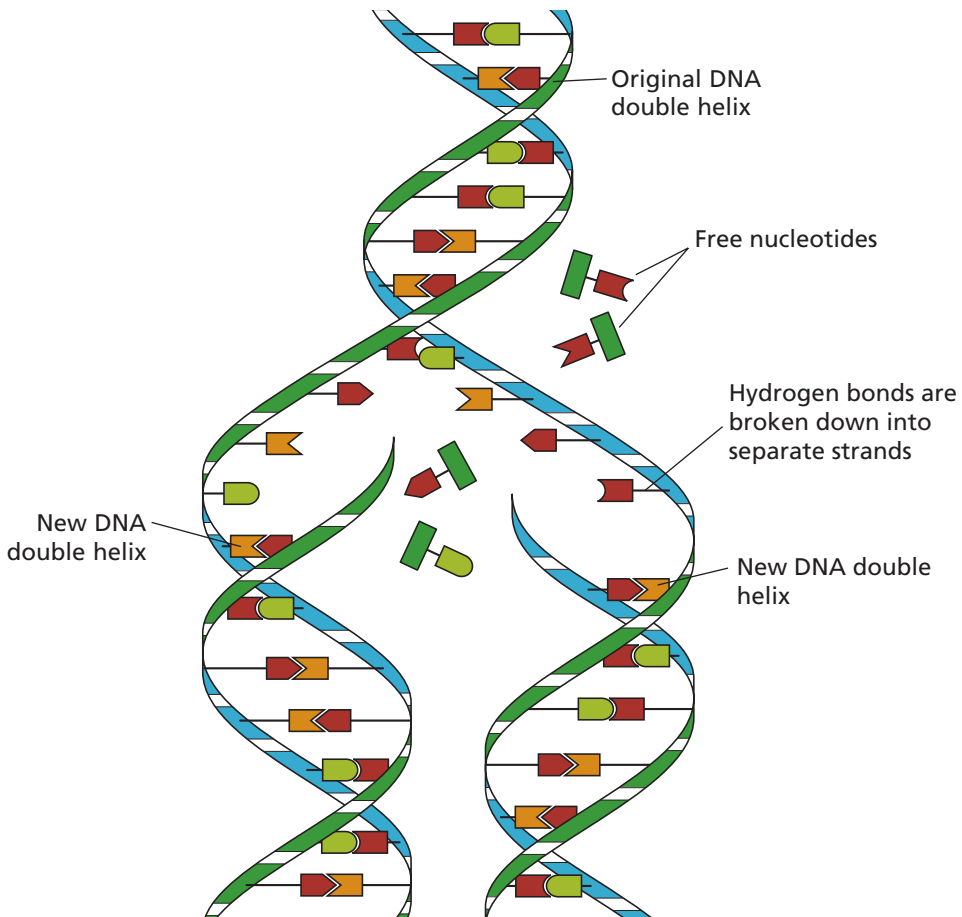


Figure 2.33 DNA replication

## DNA and protein synthesis

Specific enzymes control all chemical reactions in the body. Enzymes are proteins made up of a defined sequence of amino acids.

- DNA codes for amino acids, and their correct sequence, through a triplet code.
- The nitrogen-containing bases (A, T, G and C) in DNA are arranged in threes along the double helix.
- Each triplet codes for one specific amino acid.
- DNA sends its code for an enzyme to the ribosome by messenger RNA, or **mRNA**.
- **Ribosomes**, in the cytoplasm, make the proteins.

## Protein synthesis

The whole process of protein synthesis occurs in two stages: transcription and translation.

### 1. Transcription

- When a particular enzyme is needed by a cell, the portion of DNA in the nucleus that codes for it unwinds, exposing its bases.
- A strand of mRNA is produced from RNA nucleotides, mirroring the DNA code.
- When complete, the strand of mRNA separates from the DNA and moves to a ribosome (rRNA) in the cytoplasm.

key  
point

The nucleotides on mRNA are arranged in a triplet code forming codons. Each **codon** codes for a particular amino acid.

**tRNA** also has a triplet code of nucleotides that match the codons of mRNA. Each matching triplet is known as an **anticodon**.

### 2. Translation

- At the ribosome, the mRNA code is matched by nucleotides of transfer RNA (tRNA). Each tRNA molecule carries a specific amino acid.
- The tRNA carries the amino acids in the correct sequence to the ribosome.
- The amino acids are then linked together in strict order, producing the protein (enzyme), which then assumes its unique **folded shape**.

## Differences between DNA and RNA

	Structure	Function	Location
<b>DNA</b>	Deoxyribose is the sugar Double helix shape Base pairing Has the base thymine instead of uracil	Codes for genotype	Nucleus
<b>RNA</b>	Ribose is the sugar Single helix No base pairing Has the base uracil instead of thymine	<b>mRNA</b> carries code from nucleus to <b>rRNA</b> (ribosomes); <b>tRNA</b> transports amino acids	Cytoplasm



## HL Non-nuclear inheritance of DNA

Many scientists believe that **mitochondria** and **chloroplasts** evolved from forms of bacteria. Through evolution they became assimilated into larger-celled organisms. The two organisms then formed a mutualistic (symbiotic) relationship, giving rise to plant and animal cells. Mitochondria and chloroplasts are unique as organelles in that they:

- contain their own DNA
- can replicate themselves in the cell.

key  
point

**Non-nuclear DNA** in chloroplasts and mitochondria does not undergo meiosis or fertilisation during sexual reproduction.

## Mandatory activity

### To isolate DNA from plant tissue

**Note:** *The extra information in brackets below is not required when describing the procedure.*

1. Add 3 g of **salt** to 10 cm<sup>3</sup> of washing-up liquid in a beaker and bring up to 100 cm<sup>3</sup> with distilled water. (*Salt reduces the attraction between protein and DNA. Washing-up liquid breaks down phospholipid membranes in the cell.*)
2. **Chop** some onion into very small pieces and add to the beaker. (*Chopping breaks down the cell walls and allows cytoplasm to leak out.*)
3. Put the beaker in a water bath at **60 °C for exactly 15 minutes**. (*High temperature denatures enzymes harmful to DNA. Any longer than 15 minutes, the DNA itself would break down.*)
4. **Cool** the mixture by placing in a large beaker of ice water for five minutes. (*Slows the activity of any remaining enzymes harmful to DNA.*)
5. Place the mixture in a **blender for three seconds**. (*Blending further breaks down cell walls and membranes. Any longer than three seconds shreds the DNA.*)
6. **Filter** the mixture into a second beaker. (*Removes cellular debris.*)
7. Place 10 cm<sup>3</sup> of the filtrate into a test tube.
8. Add 3 drops of **protease solution** and mix gently. (*Breaks down proteins associated with DNA.*)
9. Trickle 10 cm<sup>3</sup> of **ethanol from the freezer** down the side of the test tube.
10. Leave for a few minutes to settle. (*Cold ethanol draws water from DNA, condensing it.*)
11. Gently stir with a glass rod.

### Expected result

White mucus-like DNA forms at the interface of the ethanol and the filtrate.

## DNA profiling

Humans have 23 pairs of chromosomes in the nucleus of every cell in the body (with the exception of gametes). A single chromosome can have up to 4,000 genes, which code for different traits. It is known that 90 per cent of DNA does not code for any gene or protein in the body.

**Coding DNA** refers to sections of DNA that make up genes. They code for an enzyme or protein.

**Non-coding DNA** describes sections of DNA, between genes, that do not code for an enzyme or protein. They are often referred to as 'junk DNA'.

The sections of non-coding DNA often have repeating nucleotide sequences in sections called hypervariable regions. The number and length of these nucleotide sequences vary between individuals, but are similar in related individuals.

Forensic scientists use DNA profiling to compare DNA from hair, saliva, blood or semen found at the scene of a crime.

The procedure for DNA profiling is outlined in fig. 2.34.

**DNA profiling or DNA fingerprinting** uses the repeating nucleotide sequences of non-coding DNA to produce a pattern of bands for comparison of individuals.

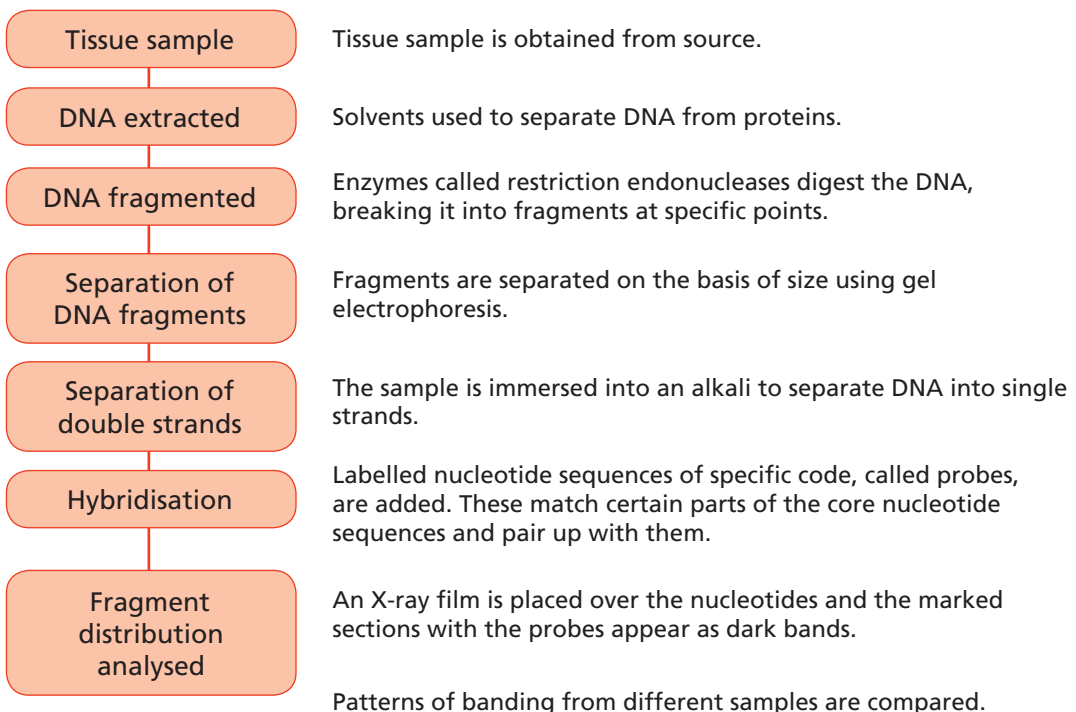


Figure 2.34 DNA profiling

## Applications of DNA profiling

DNA profiling can be used to:

- prove the parentage of a child
- detect criminals guilty of violent crimes
- confirm pedigree in animals.

## Genetic screening and testing

**Genetic screening** is the use of laboratory procedures to test a large number of individuals to identify those who may have or may pass on a genetic disorder.

**Example:** Amniocentesis is the testing of the cells in the amniotic fluid around the foetus for genetic disorders such as **Down's syndrome**.

**Genetic testing** describes the laboratory procedures used to investigate an individual suspected of having a high risk of a genetic disorder, based on family history or a positive screening test.

**Example:** The testing for the genetic disorder responsible for **cystic fibrosis**.

## Genetic engineering and applications

**Genetic engineering** is a process where genes from one organism are introduced into the genome (DNA) of an unrelated organism, usually micro-organisms. The micro-organisms with the new genes are replicated and used to create large quantities of useful chemicals.

**Note:** The process is often referred to as **recombinant DNA technology**.

Genetic engineering involves the following steps.

- Locating a specific gene in a donor cell.
- Isolation of the gene.
- Insertion of the gene into the DNA that has been removed from a micro-organism.
- Transferring the DNA and new gene back into the micro-organism.
- Replicating the micro-organism and harvesting the chemicals produced due to the new gene.

The process is summarised in fig. 2.35.

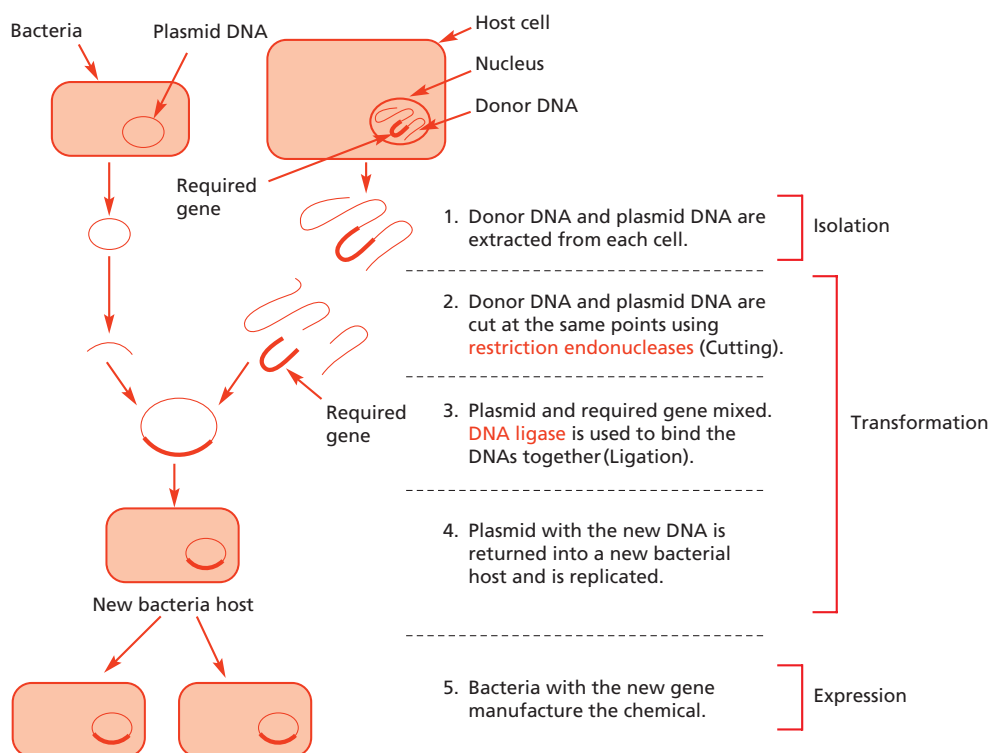


Figure 2.35 Genetic engineering

## Applications of genetic engineering

- There is enormous demand for the hormone insulin to treat **insulin-dependent diabetes**. This disease used to be treated by using insulin obtained from the pancreas of cattle and pigs. Subtle differences in the forms of insulin stimulated antibody responses in some humans. Genetic engineering is now used to isolate the human gene for insulin production. The gene is inserted into a host bacterium to produce large quantities of human insulin.
- Genetically modified **plants** have an advantageous gene inserted into their DNA which is passed on to future generations. Characteristics such as disease and insect resistance have been introduced into food crops. The improved plant has greater yields.
- In **animals**, genetic engineering has been used to increase meat and milk yields in cattle.
- In **microorganisms**, bacteriophage can be genetically engineered to kill antibiotic-resistant bacteria.

exam  
Q

HL

**2014 Q7 (a)/(b) HIGHER LEVEL**

7. (a) (i) What is the chemical composition of a chromosome?  
 (ii) What is meant by the term junk DNA?
- (b) (i) In relation to the isolation of DNA from a plant tissue, explain why you used each of the following:
1. Washing-up or similar liquid.
  2. Sodium chloride.
  3. Protease.
  4. Freezer-cold ethanol.

**LEAVING CERT MARKING SCHEME**

7. (a) 5 + 1
- (a) (i) DNA and protein  
 (ii) Non-coding (DNA)
- (b) 8 + 8 + 1 + 1
- (b) (i) 1. To breakdown the (cell) membrane(s)  
 2. To cause the DNA to clump  
 3. To breakdown (or remove or digest) the protein in the chromosomes  
 4. To bring the DNA out of solution or to make the DNA visible or to separate the DNA

HL

**2015 Q10 (b) HIGHER LEVEL**

10. (b) Write notes on each of the following topics in relation to nucleic acids. In each case your notes should contain three points. Do not give diagrams in your answers.
- (i) Complementary base pairs.
- (ii) Codons.
- (iii) Transcription. (27)

**LEAVING CERT MARKING SCHEME**

10. (b) (i) (Two bases joined by) hydrogen bonds / purine with pyrimidine / Cytosine with Guanine / Adenine with Thymine in DNA / Adenine with Uracil in RNA or Thymine replaced by Uracil in RNA (3[3])
- (ii) Sequence(c) of three bases / on DNA / on mRNA or on tRNA / (each codon) codes for one amino acid / that codes for a start (or stop) (3[3])
- (iii) mRNA is formed / using a (single) strand of DNA / (DNA acts) as a template (or described) / in nucleus / (catalysed by) RNA polymerase (3[3])