

CfE

ADVANCED Higher BIOLOGY

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BrightRED Study Guide

CfE

ADVANCED Higher

BIOLOGY



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**NEW
EDITION**

INTRODUCTION

AN OVERVIEW

USING THIS BOOK FOR REVISION

In this book we have tried to present the course content in a concise form, so that you can follow the ideas and develop your own understanding. It is, however, only an **aid to your revision**. Effective revision has to be an **active process**, so your brain needs to be doing some serious work! This means that you have to:

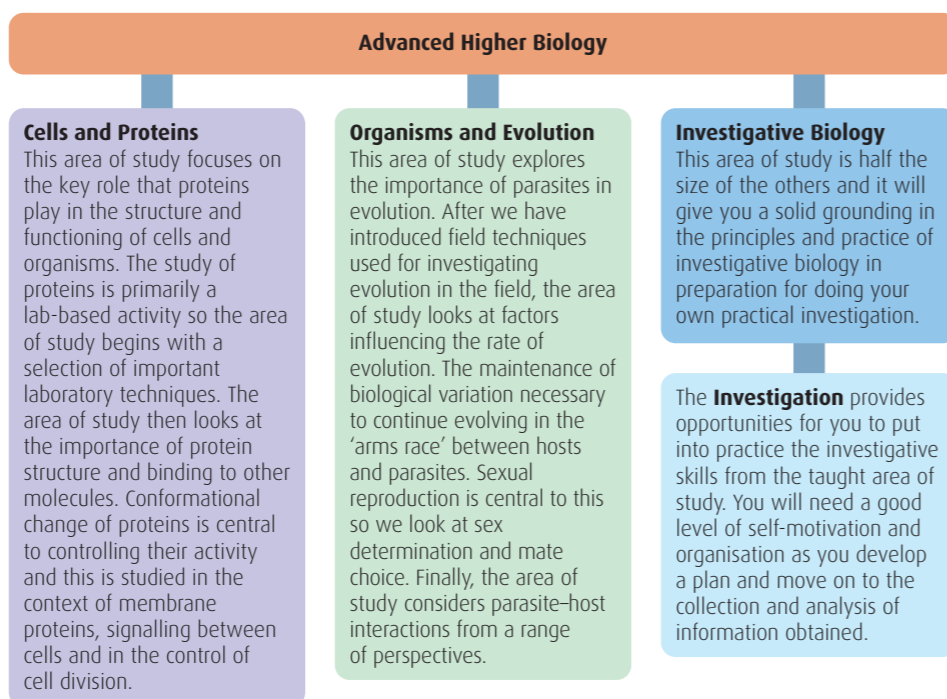
1. take in information and think about how you can **understand it or explain it** for yourself
2. create your own revision notes using **your own words or pictures**
3. keep **returning** to your revision notes to **reinforce your learning**.

This book has lots of features to help you in your active approach to improving your understanding and your learning:

- Some words or phrases are in **bold** to emphasise their importance. These are key terms and you should be able to explain them, or be able to use them to explain other ideas.
- **Don't forget** items point out key details that might get lost in the big picture.
- We have included **online** items and **video links** which we think will help to reinforce the ideas or explain them in a different way that will help you.
- There are short **online tests** available for each topic at www.brightredbooks.net.
- **Things to do and think about** are sections that take the content of a particular page further, to help you broaden your knowledge or understanding.

COURSE STRUCTURE

The AH Biology course has three taught areas of study and an individual practical investigation.



HOW THE COURSE IS GRADED

To gain a grade, you must pass the internal assessments for all three topics, sit the **written exam** and submit an **investigation report**. Your final grade is based on these marks and the grades are A, B, C or D. No grade is awarded if the marks are below those needed for a D grade.

The written exam

This lasts 3 hours and has a maximum possible 100 marks. These will be distributed approximately proportionately across the three taught units. The majority of the marks (about 70) will be awarded for **demonstration of knowledge and application of knowledge** while the other marks (about 30) will be awarded for applying **scientific inquiry and problem-solving skills**.

The exam has two sections:

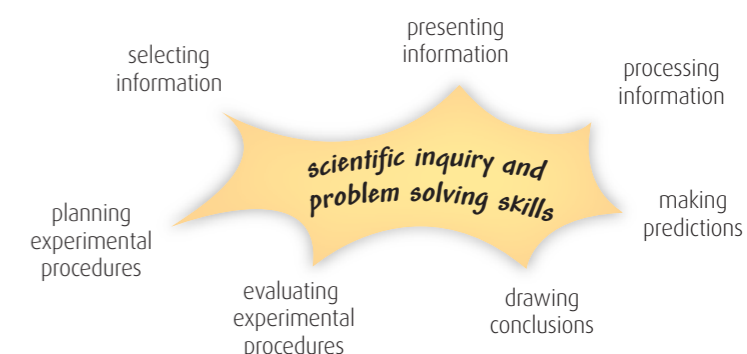
1. Section 1 has 20 multiple-choice questions, worth one mark each.
2. Section 2 has 80 marks. There will be one **short essay** (4 or 5 marks), one **long essay** (8–10 marks), a **data-handling** question (7–10 marks) and an **experimental design** question (5–9 marks). The remaining marks will be awarded to **short-answer** questions. The marks are scaled so that the exam is worth 75% of the total and the project report is worth 25%.

The project report

This must be a piece of individual work and your teacher/lecturer will help you to choose a suitable topic which interests you. You will research the underlying biology and carry out an open-ended investigation involving a significant amount of work that you will carry out without close supervision. For the most part, you will be working autonomously, though your teacher/lecturer will be available to provide support and advice.

The final report is written up in a formal style and will be sent to the SQA for marking. The mark allocation for each section of the report is shown in the table. There are also two marks for aspects of presentation. There is more data on 'Writing Your Report' in topic 3, later in the book.

Section	Marks
Abstract	1
Introduction	5
Procedures	9
Results	6
Discussion	7
Presentation	2



ONLINE

The Open University has useful tips on how to revise. Follow the link at www.brightredbooks.net

VIDEO LINK

Find out about the scientifically proven tips for effective studying by watching the clip at www.brightredbooks.net

DON'T FORGET

Keep returning to your revision notes and try to rewrite brief versions from memory to check your learning.

ONLINE

The 'syllabus' can be found at **Course Support Notes** on the SQA AH Biology website. The key areas and depth of knowledge required are listed here. Follow the link at www.brightredbooks.net

ONLINE

More information about the **scientific inquiry and problem-solving skills** can be found on page 6–9 of the **Course Support Notes** on the SQA AH Biology website, a direct link can be found at www.brightredbooks.net

DON'T FORGET

Instead of 'essay', the SQA use the term **'extended-response question'**!

ONLINE

Get to grips with the exam format by looking at recent exam papers at www.brightredbooks.net

THINGS TO DO AND THINK ABOUT

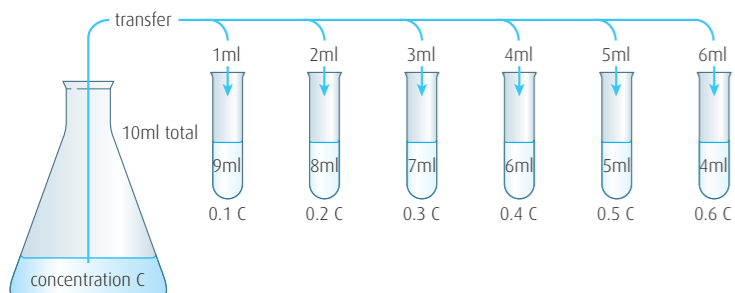
Broaden your interest in biology. Watch out for TV programmes on biological topics, and *NewScientist* regularly has interesting articles about cutting-edge biology. Follow biology-related Twitter accounts for up-to-the-minute news and stories.

CELLS AND PROTEINS

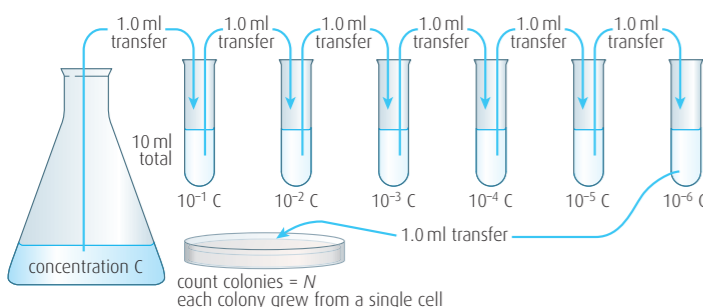
LABORATORY TECHNIQUES FOR BIOLOGISTS: LIQUIDS AND SOLUTIONS

DILUTION SERIES

The study of cells and proteins in the laboratory requires careful development of basic laboratory skills. Many substances are found in cells at extremely low concentrations. To recreate cellular conditions in the laboratory requires an understanding of **dilution** and **measurement uncertainty**. To ensure accuracy, it is important to use appropriate measuring methods whether using scales, measuring cylinders, pipettes or autopipettes.



A linear dilution series that would make six dilutions, each with a volume of 10 ml. To calculate the volume of stock solution required (V_1) to make a new concentration (C_2) the formula $V_1C_1 = V_2C_2$ can be used. Note that in this example V_2 is always 10 ml.



A log dilution series involving six 10-fold dilutions. Note that each dilution acts as the stock to make the next dilution in the series. Log dilution series are often used to allow the estimate of microbial cell density. In the case at the top of this page, the number of colonies is countable on the 10^{-4} and 10^{-5} plates which allows the undiluted concentration of viable cells (C) in the original culture to be calculated. $C =$ approximately 2.6×10^7 cells per ml.

Dilutions are used in many experimental procedures. They can be used to control potential confounding variables in an experimental system, to generate a suitable range in an independent variable or as a way of modifying the dependent variable, so that a measurable value can be obtained.

Linear dilution series

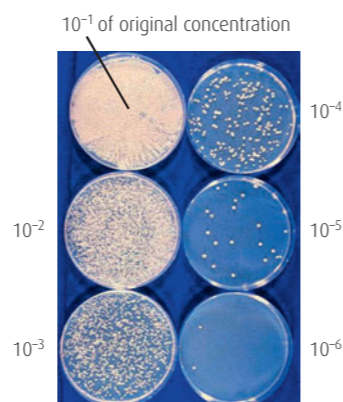
A linear dilution series consists of a range of dilutions that differ by an **equal interval**. For example, solutions of concentrations 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 ml would represent a linear dilution series.

To make a linear dilution series, it is normal practice to add different volumes of stock solution to different volumes of solvent. In this way, **each concentration is made individually** and any measurement errors affect only the one concentration.

Log dilution series

A log dilution series consists of a range of different dilutions that differ by a **constant proportion**. For example, solutions of concentrations 10^{-1} , 10^{-2} , 10^{-3} , 10^{-4} , 10^{-5} and 10^{-6} would represent a log dilution series.

To make a log dilution series, it is normal for each dilution solution to act as the stock for the subsequent dilution. In this way, each concentration depends on those made before and any earlier measurement **errors are compounded** in later dilutions.



DON'T FORGET

Any measurement errors made while making up any stock solution will be compounded if further dilutions are made.

COLORIMETER

A colorimeter is used to measure the **concentration of a pigment** in a solution, the **turbidity** of liquid or the **density of cells** in a culture. It does this by illuminating a small sample of the test substance, held in a small transparent cuvette and electronically recording how much of the light is **absorbed** by the sample. A suitable wavelength filter is used so that the concentration of a coloured solution can be determined. For turbidity, a denser sample will show a lower degree of **transmission**. For each experiment the

contd

machine is **calibrated** using a 'blank' cuvette containing solvent only, which acts as a **baseline** for the comparison.

Typical uses of a colorimeter in schools include measuring:

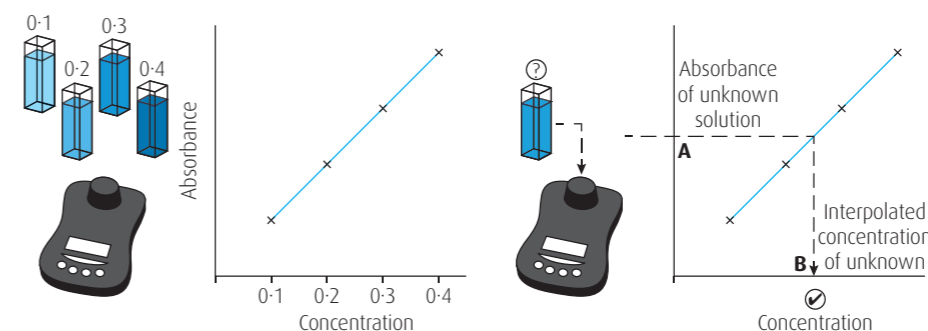
- the density of a cell culture growing in a liquid broth – careful aseptic technique is required for this
- the concentration of betanin leaking from beetroot cells whose membrane proteins have been denatured by heat
- the rate of reaction of enzymes such as dopa oxidase
- quantifying the result of an ELISA demonstration.



A colorimeter along with a series of cuvettes. Do not expect your colorimetry investigation to be as colourful as this!

STANDARD CURVE FOR DETERMINING AN UNKNOWN

A standard curve is made by plotting the absorbance readings for a series of **known concentrations** of a substance or culture. Once the line (the standard curve) has been produced, it can be used as a reference for any samples of unknown concentrations of the same substance or culture. Through **interpolation**, the concentration of the unknown can be estimated.



The absorbance of standard solutions of known concentration is measured in a colorimeter – in this case, 0.1, 0.2, 0.3 and 0.4 units. The standard curve is plotted using these data. The standard curve can now be used to determine the concentration of an unknown, once its absorbance has been measured. It is only possible to interpolate from a standard curve, so if the unknown appears to have a concentration outside the initial range of the standards, then a greater range of standards must be measured.

BUFFERS TO CONTROL PH

Buffers are aqueous solutions that show **very little variation in their pH** despite addition of acids or alkalis. As almost all biological processes are pH dependent, cells and their secretions tend to contain pH buffers. For example, in mammalian blood the presence of carbonic acid and bicarbonate anions buffers the blood pH and keeps it between the values of pH 7.35 and 7.45. Any variation beyond either pH 6.8 or 7.8 is likely to be lethal.

In laboratory experiments, buffers can be selected so that the pH of reaction mixture can be kept constant. In cell-culture media, buffers are used to prevent pH changes that could otherwise occur as a result of the build-up of waste products.

THINGS TO DO AND THINK ABOUT

Interpolate, don't extrapolate

Interpolation is the prediction of a data point between two values and is a scientific technique that can allow confident predictions to be made.

Extrapolation involves predicting a data point beyond the last known value, and this means you'll have less confidence in the prediction.

VIDEO LINK

Watch the video at www.brightredbooks.net to see a portable colorimeter in action.

VIDEO LINK

Head to www.brightredbooks.net and watch the clip for a demonstration of how to determine the molecular weight of an unknown protein after gel electrophoresis.

ONLINE

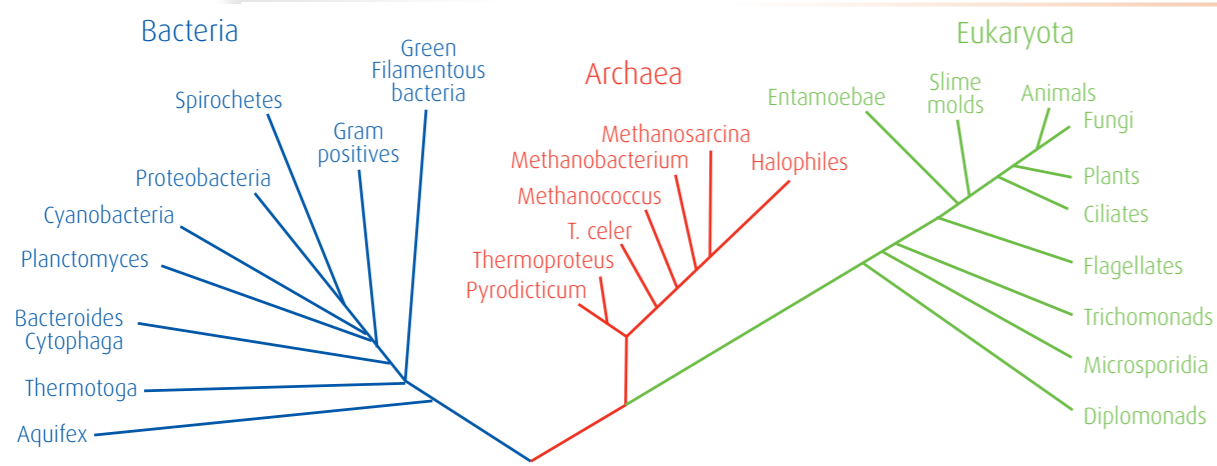
There is a useful overview of risk assessment at www.brightredbooks.net

ONLINE TEST

Head to www.brightredbooks.net to test yourself on this topic.

ORGANISMS AND EVOLUTION

FIELD TECHNIQUES FOR BIOLOGISTS: PHYLOGENETICS



Genome comparison studies have shown life to be divided into three main domains, the Bacteria, the Archaea and the Eukaryota. Note that the Archaea are more closely related to the Eukaryota than they are to the Bacteria.

UNDERSTANDING PATTERNS OF EVOLUTION

Phylogenetics is the study of the evolutionary history and relationships among individuals or groups of organisms. Phylogenetics is changing the traditional classification of many organisms. Phylogenetics uses heritable traits such as morphology, DNA sequences and protein structure to make inferences about an organism's evolutionary history and to create a phylogeny (phylogenetic tree) – a diagrammatic hypothesis of relationships. Thousands of phylogenetic studies have now been combined to reveal the overall pattern of evolutionary relationships of the whole tree of life.

Patterns of descent are not always obvious when observing phenotypic characters alone. Evolution can produce closely related species that look very different to one another, and distantly related species that look very similar. The comparison of genetic evidence reveals relatedness that is obscured by this divergent or convergent evolution.

Divergent evolution

Divergent evolution is the development of **differing life forms from a common origin** and it results in closely related forms of life with very different phenotypic characteristics. This occurs when different selection pressures are acting

on each lineage. As a result, the ancestral characteristics are lost and are replaced by differing adaptive characteristics in the different lineages. Within the platyhelminths, the body plan of the parasitic tapeworms is quite different from their non-parasitic relatives. In lineages that have few competitors (maybe as a result of a mass extinction event, or in lineages that have had the good fortune to accumulate the mutations necessary for a particularly successful adaptation), divergent evolution can result in a radiation of many forms.



This is a cactus isn't it? Actually, no – it is a Euphorbia from Africa. Cacti are from the Americas but these two families of flowering plants show a strong convergence as a result of exploiting similar niches.



The molluscs provide an example of divergent evolution – it is not immediately obvious that a snail and an octopus belong in the same phylum.

DON'T FORGET



Molecular sequencing reveals relatedness.

ONLINE



Explore the tree of life online at www.brightredbooks.net

Convergent evolution

Convergent evolution is the **separate evolution of similar phenotypic adaptations** in lineages whose ancestors did not share these adaptations. This occurs when very similar selection pressures are acting on these unrelated lineages. For example, the structure of the eye in ourselves and in the octopus evolved independently in the vertebrates and the cephalopods. Likewise, the parasitic barnacle mentioned on page 81 is a member of one of two lineages of barnacles that have independently converged on this parasitic way of life. Convergent evolution is common; it seems that selection is efficient at arriving at a set of adaptations, even when starting off from different places.

OUR FAMILY TREE

There is now consensus amongst biologists on the relative positions of many phyla in the tree of life. Of course, some areas require more study and taxonomists do not agree on the position of every branch. However, there is overwhelming evidence from molecular sequences, from studies of anatomy, physiology and behaviour, and from fossils, that all life is related and has evolved into the diversity that we see today over the course of billions of years. It is no longer a credible scientific position to doubt this.

Bacteria

There are about 300 000 known types of bacteria. These single-celled organisms are thought to contribute more biomass than all animals and plants put together. We are familiar with bacteria for their key role that they play in nutrient cycles, their importance in modern biotechnology and the various pathogenic types. Examples of the latter include bacteria that cause bubonic plague, leprosy, anthrax, cholera and tuberculosis.

Many bacteria have had their entire genomes sequenced.

Archaea

These are single celled and differ from other forms of life in their ribosomal RNA structure and in the molecular structure of their lipids. The archaea are relatively poorly known – some are extremophiles; others have unusual metabolic activities, such as methanogenesis. There are about 4000 types, many of which are only known from genomic sequences sampled from the environment. There are no known parasitic or pathogenic members of this domain.

Eukaryota

There are over 2 million known species of eukaryotes, which have the shared cellular features of a true nucleus and membrane-covered organelles. The multicellular forms of life are found in this domain, but there are also many single-celled eukaryotes. Within eukaryotes, there are the familiar kingdoms of plants, fungi and animals. Of those three, the plant kingdom is the least closely related. It has major divisions such as mosses, liverworts, ferns, conifers and flowering plants.

THINGS TO DO AND THINK ABOUT

The comparison of the human genome with other species reveals remarkable similarities. Many gene sequences, such as the *Hox* genes that control developmental segmentation in animals as different as humans and *Drosophila*, have been conserved over long periods of evolutionary change.

	
Plant division: Moss	Animal phylum: Chordata (sea squirts and vertebrates)
	
Plant division: Liverworts	Animal phylum: Arthropoda (joint-legged invertebrates: segmented body typically with paired appendages)
	
Plant division: Ferns	Animal phylum: Nematoda (round worms: very diverse, mainly parasitic)
	
Plant division: Conifers	Animal phylum: Platyhelminthes (flatworms: bilateral symmetry, internal organs but no body cavity, many parasitic)
	
Plant division: Flowering plants	Animal phylum: Mollusca (diverse, many with shells)

Taxonomic groups

ONLINE TEST

Head to www.brightredbooks.net to test yourself on the tree of life.

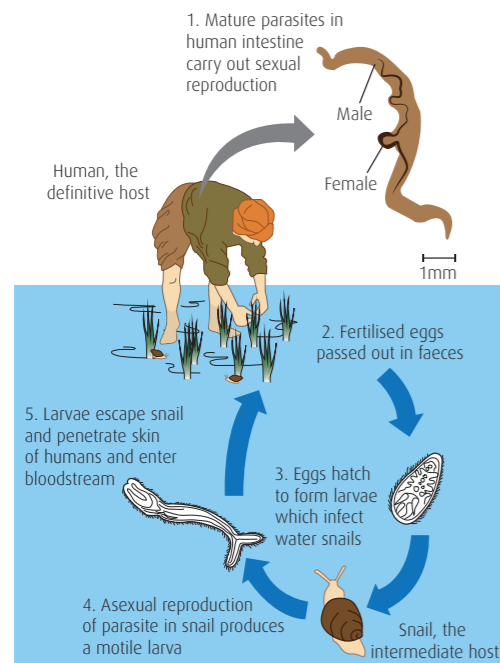
ORGANISMS AND EVOLUTION

PARASITIC LIFECYCLES

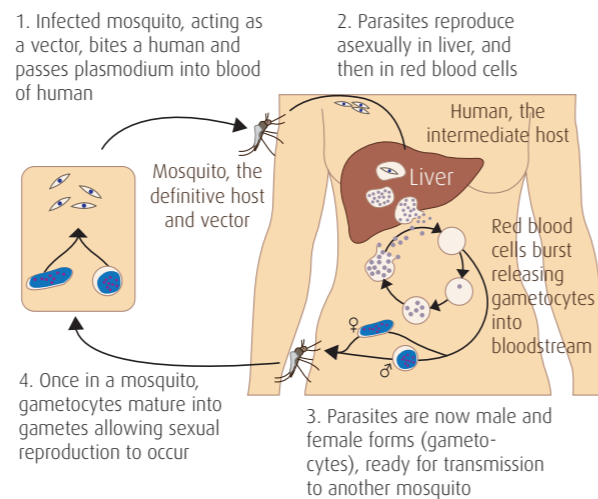
PLASMODIUM AND SCHISTOSOMA PARASITES

Two key examples of parasites that need intermediate hosts to complete the development of their lifecycle are noted below and in the diagrams:

- Schistosoma* are platyhelminths which cause the disease schistosomiasis in humans. This parasite needs to spend part of its lifecycle in a snail, so that it can develop into a larval form which can penetrate the skin of a human, its definitive host.
- Plasmodium* are protists which cause the malaria disease in humans. The parasites have to spend part of the lifecycle in humans so that they can develop into male and female forms ready to infect a mosquito, its definitive host.



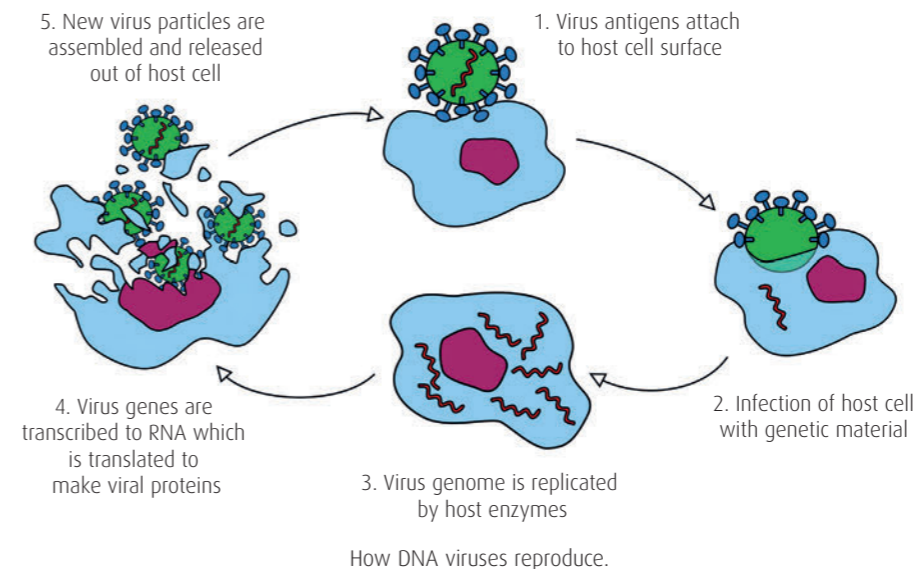
The lifecycle of *Schistosoma* parasites.



The lifecycle of *Plasmodium* parasites.

Virus reproduction

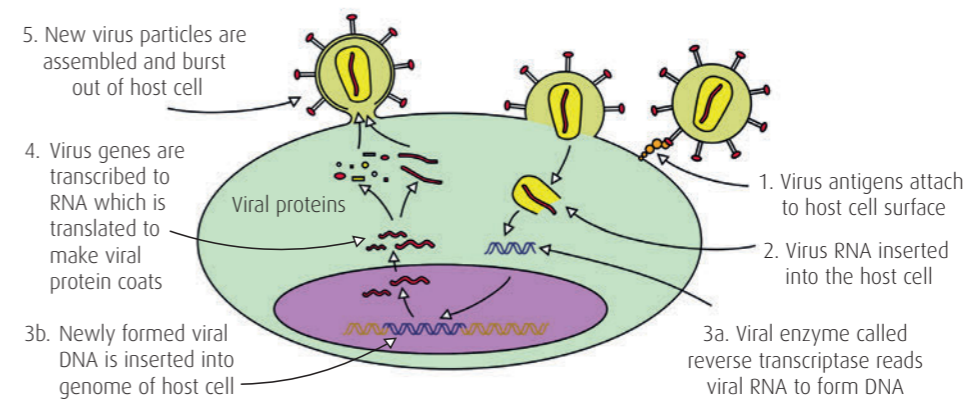
DNA viruses have their genetic material in the form of DNA and these include smallpox, herpes, and chickenpox viruses. These viruses reproduce using the steps shown in the diagram.



How DNA viruses reproduce.

RNA viruses (such as influenza, Ebola, hepatitis C, polio, rabies and measles) have an RNA genome. These viruses use the same process of reproduction as the DNA viruses except, at Step 3, the viral RNA genome is replicated directly using an enzyme from the virus. Viral DNA is never made.

RNA retroviruses, such as HIV, use a slightly more complex process for reproduction, though it is really just Step 3 that is different. These viruses use the enzyme **reverse transcriptase** to form a DNA copy of the virus genome. This DNA is then inserted into the genome of the host cell. The virus genome can then be replicated as part of the normal cell cycle, so the virus genome will always be in the host cells. Viral genes can then be expressed to form new viral particles.



THINGS TO DO AND THINK ABOUT

The treatment of HIV infection has become very effective at preventing the development of AIDS in the patient. The treatment uses a combination of three or more antiretroviral drugs to stop the virus replicating. The combination of drugs is needed because a single antiretroviral drug is a simple selection pressure, so the virus can quickly evolve and become resistant to that drug.

VIDEO LINK

Watch the lifecycle of one species of *Schistosoma* at www.brightredbooks.net

DON'T FORGET

Most RNA viruses simply replicate their RNA so they are not retroviruses.

DON'T FORGET

Reproduction of DNA viruses, RNA viruses and RNA retroviruses only differs fundamentally in the middle steps.

DON'T FORGET

The genetic material of viruses can be DNA or RNA.

VIDEO LINK

Watch the story of retroviral reproduction at www.brightredbooks.net

ONLINE TEST

Head to www.brightredbooks.net to test yourself on parasitic lifecycles.

ONLINE

How does malaria affect humans? Find out at www.brightredbooks.net

DON'T FORGET

The definitive host is the one in which the parasite reproduces sexually.

VIDEO LINK

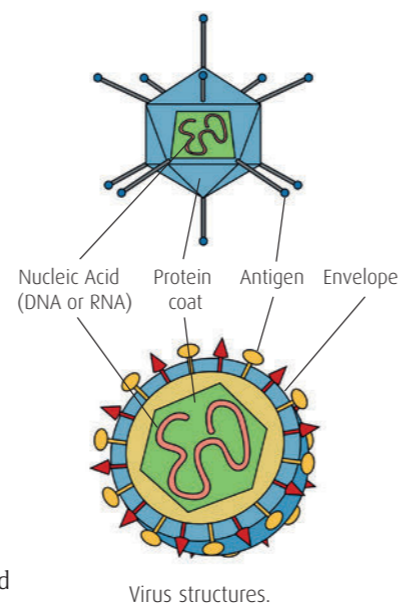
Watch the life of the malarial parasite at www.brightredbooks.net

THE 'LIFE' OF A VIRUS

Viruses are infectious parasitic agents that can only replicate inside a host cell. They don't quite meet most biologists' definition of 'living'. The viruses can't carry out any of the normal functions for life except for one – reproduction, and they can only do this in the cell of a living organism.

Virus structure

For reproduction to occur, viruses have to contain genetic information stored in a **nucleic acid** (DNA or RNA). This nucleic acid is packaged inside a **protective protein coat** (the capsid) and some viruses are also surrounded by a phospholipid membrane derived from host cell materials. The outer surface of a virus has proteins that are coded for by the viral genes. These proteins are called **antigens**, because a cell from the host organism may or may not be able to detect them as foreign and initiate an immune response.



Virus structures.

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CfE ADVANCED Higher

BIOLOGY

David Lloyd and Geoff Morgan

This BrightRED Study Guide is the ultimate companion to your CfE Advanced Higher Biology studies! Written by our trusted authors and experienced Biology teachers, David Lloyd and Geoff Morgan, this book is full-colour and packed with clear and accessible information, excellent examples, activities and advice. Inside, you will find:

- ▶ **All the essential course information, fully up-to-date with SQA course changes**, arranged in easily digestible double-page topic spreads.
- ▶ **Detailed full-colour diagrams, illustrations and data boxes** to make sure all that study sticks!
- ▶ **Don't forget** pointers offering advice on the key facts to remember, and on how to avoid common mistakes.
- ▶ **Things to do and think about** sections encouraging the regular review of key points covered.
- ▶ **Digital Zone activities and tests** to supercharge your learning efforts online!
- ▶ **An index of key terms** to help when revising.

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