

Learner Guide

Cambridge
International
AS & A Level

Cambridge International AS & A Level
Biology

9700

Cambridge Advanced



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How to use this guide

The guide describes what you need to know about your Cambridge International AS and A Level Biology examination.

It can be used to help you to plan your revision programme for the theory examinations and will explain what we are looking for in the answers you write. It can also be used to help you revise by using the table in Section 4, 'What you need to know', to check what you know and which topic areas of biology you have covered.

The guide contains the following sections:

Section 1: How will you be tested?

This section will give you information about the different types of theory and practical examination papers that are available.

Section 2: Examination advice

This section gives you advice to help you do as well as you can. Some of the ideas are general advice and some are based on the common mistakes that learners make in exams.

Section 3: What will be tested?

This section describes the areas of knowledge, understanding and skills that you will be tested on.

Section 4: What you need to know

This shows the syllabus content in a simple way so that you can check:

- the topics you need to know about
- the contents of each part of the syllabus
- details about each topic in the syllabus
- how much of the syllabus you have covered

Section 5: Useful websites

Section 6: Appendices

This section covers the other things you need to know, including:

- information about the mathematical skills you need
- information about terminology, units and symbols, and the presentation of data
- the importance of the command words used in the examination papers

Section 1: How will you be tested?

About the examinations

There are three ways you can gain a Cambridge International Advanced Level qualification.

- take the Advanced Subsidiary (AS) qualification only
- follow a **staged** assessment route to the Advanced (A) Level by taking the AS Level papers and the A Level papers in different examination sessions. Usually this means taking the AS Level papers at the end of one year of study and the A Level papers at the end of a second year of study.
- take all the examination papers in the same examination session leading to the full A Level

AS Level

You will be entered for **three** examination papers, **two** theory papers and **one** practical paper.

You will take Paper 1 Multiple Choice (theory), Paper 2 (theory) and Paper 3 (Advanced Practical Skills).

A Level

You will be entered for **two** further examination papers, Paper 4 A Level Structured Questions (theory) and Paper 5 Planning, Analysis and Evaluation.

About the papers

The table gives you information about the examination papers.

| Paper number | How long and how many marks? | What's in the paper? | Weighting % | |
|--------------|------------------------------|--|-------------|----|
| | | | AS | A |
| 1 | 1 hour (40 marks) | 40 multiple-choice questions. You choose one answer you consider correct from a choice of four possible answers. | 31 | 15 |
| 2 | 1 hour 15 minutes (60 marks) | Structured questions. You should write your answers in the spaces provided. The paper tests the AS syllabus only. | 46 | 23 |
| 3 | 2 hours (40 marks) | A practical test set and marked by Cambridge. It will include experiments and investigations based on the AS syllabus. | 23 | 12 |
| 4 | 2 hours (100 marks) | Structured questions, totalling 85 marks plus one free response question that carries a further 15 marks. Based on the A Level syllabus, but a knowledge of the AS syllabus is required. | – | 38 |
| 5 | 1 hour 15 minutes (30 marks) | A written paper that tests the practical skills of planning, analysis and evaluation. It will include information about experiments and investigations from both AS and A Level. | – | 12 |

About the practical papers

Twenty-three percent of the marks for Cambridge International AS Biology are for practical work.

In Paper 3, you will have to handle familiar and unfamiliar biological material and will be expected to show evidence of the following skills:

- manipulation, measurement and observations
- presentation of data and observations
- analysis, conclusions and evaluation.

When unfamiliar materials or techniques are involved, you will be given full instructions. One question will require the use of a light microscope.

No dissection will be set in Paper 3.

If you continue to a full A Level, after AS, the mark you obtained in Paper 3 will contribute twelve percent of your overall mark and Paper 5 will contribute a further twelve percent.

In Paper 5, there will be questions in which you will be expected to design an investigation and write out a plan that you will not carry out, as well as analysing and evaluating experimental data. To do this confidently you need plenty of experience of practical work in the laboratory.

Questions involving an understanding of the use of the t-test and the chi-squared test may be set. You will be provided with the formulae for these tests.

Section 2: Examination advice

Much of this advice is given in response to the types of answers that learners have written in the past. It is presented under various subheadings to help you to prepare for your examinations. Some examples of questions and answers are included to illustrate some of the advice.

- Make sure that you read all the general advice. These can be important in any of the papers that you take.
- Have a copy of the syllabus to look at as you read through this section. Note that in Section 4 the first part is the AS Level syllabus and the second part is A Level.
- Make sure that you know the examination papers that you are taking before you look at the advice for the different papers.
- At AS Level, you will take
 - Paper 1, which is a multiple-choice paper.
 - Paper 2, which consists of short-answer questions.
 - Paper 3 which is the practical paper.

There are different versions of each paper; for example, Papers 11, 12 and 13 are all multiple-choice papers.

- At A Level, you will take
 - Paper 4, which has a short-answer section for 85 marks and an essay for 15 marks.
 - Paper 5, which tests your skills of planning, analysis and evaluation. It is not a practical paper like Paper 3, but does require a lot of experience of practical work.

General advice

- Use your syllabus all the time while you are revising and preparing for the examination papers. You must know which topics you will be tested on.
- Make sure you have all the equipment you will need for the exam in a clear, plastic container. You need two pens, pencils (preferably HB or B), a clean eraser, a ruler (which measures in mm), a pencil sharpener and a calculator.

Answering questions

- The questions are designed to test your knowledge and understanding and your ability to apply the skills you have gained during the course. When you are writing your answers remember that another person has to be able to read them.
- Do not waste time by writing out the question before you start to answer.
- Keep your handwriting clear and legible.
- Keep your answers on the lines on the question paper. Do not write in the left hand or right-hand margins of the paper.
- If you wish to change an answer, cross out your first answer and rewrite. Do not write over what you have already written.

- If you have to cross out something, put a line through it; do not scribble over it. If you run out of space, use white space on another part of the exam paper for a continuation answer; do not try to squeeze in your answer by using very small writing.
- If you have to use a different space for a rewritten answer or to continue an answer, put a note to tell the Examiner where it is, e.g. “see page 5” or “see back page”.
- Always try to write accurately using the correct biological terms. This often helps you to give a better answer.
- If you want to use the word “it” or “they” – think “what is it?” or “what are they?” and then phrase your answer more precisely.
- If you want to use the word “affect” or “effect” – remember to write “how they affect” or “what effect do they have?”

Example 1

Question

Chronic obstructive pulmonary disease (COPD) is a progressive disease that develops in many smokers. COPD refers to two conditions:

- chronic bronchitis
- emphysema.

(i) State two ways in which the lung tissue of someone with emphysema differs from the lung tissue of someone with healthy lungs [2]

Correct answer for two marks

- 1 There are fewer alveoli than in a healthy lung.
- 2 The surface area for gas exchange is much smaller.

From the wording of the question it is clear that the answers refer to the lung tissue of emphysema.

Ambiguous answers for no marks

- 1 There are many air spaces.
- 2 There is less diffusion of oxygen and carbon dioxide.
- 3 There are fewer capillaries.

Both types of lung tissue have many air spaces. The technical term *alveoli* should be used as in the correct answers. Even though the third answer is correct, it will not be marked as the question asks for two ways.

- Do not write the first answer that comes into your head. You are unlikely to think of exactly the correct phraseology or have all the necessary detail to answer the question. Plan what you intend to write before you start writing.
- Remember to read the question carefully, plan an answer, write the answer clearly, re-read the question, re-read your answer and then make any additions or corrections clearly. Always re-read your answers to check them against the question.
- During your course you will probably have seen many mark schemes from past papers. Do not learn them. If you write out a mark scheme that you have learnt, it is unlikely to gain you many marks and

often none at all, as it is very unlikely to be relevant to the exact question you were supposed to be answering

- Be prepared for questions on aspects of practical biology; they can appear on all the papers, not just Papers 3 and 5.

Terms

These are the technical words used in biology. Many of them are given in the syllabus. These terms will be used in questions. You will give a better answer if you can use them correctly in your examination. Ask your teacher if you are unsure of the meanings of the biological terms used in the syllabus and in any textbook you are using. You will notice that many terms you need to know are stated in the syllabus, so that is a good place to start when making your own dictionary. It would be a good idea to write concise definitions for yourself and use them to start your own biological dictionary using your class notes, websites and the glossaries from the back of textbooks.

- Try to use the correct spelling. If you cannot remember how to spell a word, write it down as best you can. The examiners will probably recognise what word you mean; if the spelling is too far out or ambiguous, then they cannot allow you a mark.
- Some biological terms have very similar spelling. Make sure you write clearly and always try to spell as accurately as you can.
- Do not try to mix the spellings of two words when you are not sure which of them is the correct answer. For example, you might write “meitosis” when you are not sure whether the answer is mitosis or meiosis. This answer will not get a mark.

Writing in your own words

You often have to write two or more sentences to answer a question.

- Use short sentences. If you write long sentences you can become confused and your meaning is lost. You might also write something contradictory. It is hard for the examiner to find correct statements in a muddled answer.
- You are often asked to write down something you have learned. Make sure you have learnt the meanings of the common terms used in biology, e.g. active transport, osmosis, photosynthesis and respiration.
- During your course take every opportunity to read and write as much as you can to improve the way you express yourself.

Advice about the questions

The marks

- Always look to see how many marks are available for each question.
 - In Paper 1 there is one mark for each question.
 - The number of marks is printed on the examination papers for Papers 2, 3, 4 and 5. The mark available for each part question ((a), (b), (c)(i), etc.) is printed in square brackets, e.g. [2]. The number of marks helps you decide how much to write. The total number of marks for each question is printed at the end of the last part question, e.g. [Total: 12].
 - The number of marks is a guide to how long to spend on each part of a question.

- Do not waste time and write a long answer for a question which has one or two marks. You will not get any extra marks even if your answer is full of many correct and relevant statements.
- If there are two or more marks do not write the same thing in two different ways, e.g. "The leaf is very large. The leaf has a large surface area". Notice that the second sentence is more accurate and is preferable to the first one.

The instructions

These are called command words and tell you what to do.

- You can find all the command words in the *Glossary of command words* used in science papers in the syllabus.
- If a question asks you to 'name' or 'state' **two** things only the first two will be marked. Use the numbered lines for your answers if they are given on the question paper. If you write more than two and the first is correct, the second one is wrong, and the third one correct, you will only get one mark (see Example 1).
- Some questions have two commands in the question, for example 'predict and explain'. This means that you have to say what you think will happen **AND** then say why you think it will happen. Usually the word **and** is printed in bold type to help you. See the section below for advice about answering questions that have two command terms and require an extended answer.
- Make sure you know what you should do in response to each command word.

Example 2

Question

A learner investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase. The results are shown in Fig. 4.1.

The graph in Fig. 4.1 shows that as the substrate concentration increases the rate of activity of sucrase increases to a constant level.

Describe **and** explain the results shown in Fig. 4.1.

It is quite easy to forget that there are two parts to this question. Before writing your answer it is a good idea to write *description* at the beginning of the first of the answer lines and then *explanation* about half way down. You could write these in pencil and rub them out when you have finished your answer. Alternatively, you may choose to write a description of the first part of the graph (activity increases) and then explain it followed by a description and explanation of the plateau on the graph. That is also a perfectly acceptable way to answer the question.

The questions

- Make sure you know which part of the syllabus is being tested.
- Read the whole of a question carefully including all the stimulus material and parts (a), (b), (c) (i) and (c) (ii), etc. before you begin to answer. Some of the parts may have similar answers so you need to work out the differences between them. If you write exactly the same thing in different parts of the same question, the answer cannot be correct for both parts.
- There is often stimulus material for each question. This might be a photograph, diagram, drawing, flow chart, table of data, graph or just some text. Read all of this information carefully and study any pictures, tables or graphs that are included. All of it is relevant to the questions.

- The stimulus material is often about something you have not studied. Do not panic. There will be enough information in the question for you to work out an answer. You are being tested on your ability to **apply** your knowledge to new information.
- All the different parts of a question may be about the same topic, e.g. cells structure from Section 1 or blood from Section 8, but you should be prepared for questions that test different topics, e.g. the structure and function of white blood cells (phagocytes and lymphocytes) involving sections of 1, 8 and 11.
- Look for clues in the wording of the questions.
- If you are only given a Latin name or a name you do not recognise, e.g. impala, look to see if you are told anything about it. If in a question on Section 18 you are told that impala are herbivores, then you know they eat plants.
- Answer each question as far as you can. Do not spend a long time staring at a question.
- If you do not know the answer or how to work it out, then leave it and come back to it later. It is best to put a mark by the side of the question so you can find it easily. An asterisk (*) is a good idea or a large question mark against the letter of the part question. Not all part questions have answer lines. You may not realise that you have left out a part question when you check through your answers towards the end of the examination.
- Try not to leave blanks. Always check through your answers towards the end of the examination. When you come back to a question you may remember what to write as an answer to a question that you left out earlier in the exam.
- Do not waste time by writing about things unrelated to the question.

Command words and phrases

Examiners use command words to help you to understand what they are looking for in your answer. This table explains what each of these words or phrases means and will help you to understand the kind of answer you should write. The list of command words is in alphabetical order. You should remember that the meaning of a term may vary slightly according to how the question is worded.

- You can find out more about command terms in the *Glossary of command words* in the syllabus. These notes should help you respond to each of the command words.

| Command words | What you should do in response to each command word |
|---|---|
| Define | Give a definition – these should be concise definitions |
| What do you understand by the term? | Give a definition or a fairly brief explanation of what the term means. You can use an example to illustrate if this seems appropriate |
| State | Give a brief answer – maybe one word or a phrase |
| List | A number of brief answers should be given; usually you are asked for a specific number of points. You do not gain extra marks by writing more than the number stated |
| Describe | You may have to describe the steps in a process or describe the appearance of a biological structure. You may also have to describe some data given in a table or a graph. Make sure you have the correct vocabulary for such a description. For example, use the words increase, decrease, constant, peak, maximum, minimum, etc. |

| Command words | What you should do in response to each command word |
|---------------|---|
| Explain | This is not the same as describe. You should give an answer that has some reasons. You may have to explain why something happens or how it happens |
| Discuss | You may be asked to discuss advantages and disadvantages – so make sure you give some of both. Much depends on the type of question, but 'discuss' usually means you should give different sides of an argument |
| Outline | This is not the same as describe. You should give the main important points without any detail |
| Predict | This means you should state what you think will happen. You may be asked to justify your prediction or explain it; explanation is not required if all the question says is "predict..." |
| Suggest | This is often used when there is no single correct answer; you should look through the information you have been given for some clues as to what to 'suggest' in response to the question. Many problem-solving questions use this command word |
| Calculate | This is obvious; make sure you know how to calculate means, percentages, percentage changes, rates and ratios (e.g. for genetics). At A Level, you should also know how to use the formulae for standard deviation, standard error, the chi-squared test and the <i>t</i> -test. Always give your working even if not asked. Always make sure you use the correct units |
| Measure | You should use a suitable measuring instrument to take a reading. Often this involves using a ruler to measure to the nearest mm. Make sure you write down the unit after the numerical answer |
| Determine | This is not the same as 'measure'. Often this means that you should explain how an experiment could be set up to take measurements and how you calculate the answer from the results. |
| Estimate | You do not have to give an accurate answer – but your answer (which is usually numerical) should be approximate |
| Sketch | This is usually used about graphs. You should put a line (straight or curved) on a pair of axes. This may be a graph that has a line on it already or it may be a pair of axes printed on the exam paper without a line or curve |
| Deduce | This is used in a similar way to <i>predict</i> , except you will need to support your answer with a statement e.g. referring to a principle, or theory, or including reasoning with your prediction. |

| Command words | What you should do in response to each command word |
|---|--|
| Find | This is a general term which can mean several similar things, such as calculate, measure, determine, etc. |
| Give a reason/reasons | See 'Explain'. |
| Meant (what is meant by the term...) | See 'Understand'. |
| Understand (what do you understand by the term...) | You should (i) define something and (ii) make a more detailed comment about it. The amount of detail depends on the number of marks awarded; <i>e.g. explain what you understand by the term transcription.</i> |

The style of questions

We use a great variety of different styles of questions. If you answer plenty of past papers during your course you will gain lots of practice at these. Here are some:

- Putting ticks and crosses in a table to make comparisons. For example, comparing the properties of different biological molecules.
- Completing tables of information by writing in single words, numbers or short phrases, e.g. what happens to the four valves in the heart during different phases of the cardiac cycle.
- Completing a passage of text with the missing terms.
- Writing definitions – make these as concise as you can; there is no need to use any examples unless asked.
- Making a list – answers should also be concise; detail is not required.
- Matching pairs from two lists, e.g. matching the names for the stages of mitosis with descriptions of what happens inside a cell during this type of nuclear division.
- Putting stages of a process into the correct sequence, e.g. the stages of protein synthesis.
- Labelling a diagram – label lines may already be on the diagram or you may have to add them yourself.
- Completing a genetic diagram (Paper 4).
- Describing and/or explaining data from a table or a graph.
- Explaining aspects of an investigation, e.g. a learner investigation that you might have carried out or a piece of research that has been adapted from a scientific paper.
- Adding information to a flow chart.
- Writing a flow chart from information that you are given, e.g. drawing a food web from written descriptions of the feeding relationships in a community.

The information in the question

- Questions may ask you to “Use examples from...” or “Use **only** the information in” or “With reference to Fig. 6.2”. If you read instructions like these, find out what you are expected to use as examples or take information from. You will not get any marks if you use examples from somewhere else. The information can be given to you in different ways:
 - a diagram, such as a food web, a set of apparatus or a biological structure;

Section 2: Examination advice

- a graph, which could be a line graph, a bar chart or a histogram – always check the headings and units carefully;
- a table – always read the headings of the columns and/or rows carefully and look for any units.

Tables and graphs

The stimulus material may be in the form of a table, line graph, bar chart or histogram.

- Always read the introductory text very carefully before you study the table or graph. Underline key points in the information that you are given. In Papers 4 and 5, there may be quite a bit of introductory text explaining how the information was collected.

Tables

- Look at the column and row headings in a table and make sure you understand them. If you have read the introduction carefully, then you will.
- Find the units that have been used. Make sure that you use the units if you give any figures in your answer.
- Use a ruler to help read the table. Align the ruler with the first column. This should be the independent variable and should increase in steps. Now put the ruler to the right of the next column and look at the figures in this second column that should be the dependent variable. Look for a pattern or trend in the figures. Identify the pattern or trend first before thinking of an explanation. Move the ruler across to the right of the third column if there is one and continue in the same way. It may help to sketch a little graph on the exam paper to help you identify any pattern or trend.

Line graphs

- Look carefully at the x-axis which is the independent variable and make sure you understand what has been changed. Look carefully at the y-axis which is the dependent variable. Both variables should be described in the introduction to the question.
- Put your ruler against the y-axis and move it gradually across the graph from left to right. Follow the pattern or trend of the line (or each line if there is more than one). Mark on the graph where something significant happens. For example, the line might show that the dependent variable becomes constant (gives a horizontal line).
- Use your ruler when taking figures from the graph. If the graph is plotted on a grid, then the examiners may allow \pm one small square or half a small square in taking your readings. If you use a ruler and rule lines on the graph, you should take exact readings.

Bar charts and histograms

- Look carefully at the x-axis and the y-axis to see what has been plotted. Again, it is a good idea to move a ruler across the bar graph or histogram from left to right to help you concentrate on one aspect at a time. You can identify the highest and lowest figures and see if there is any pattern.
- You should make yourself some notes about the table, graph or histogram before answering the questions.

Calculations

If you are asked to do a calculation you may have to find the figures from a table or graph.

- Write out all the working for your calculation. If you make a mistake and give the wrong answer, you may well be awarded marks for showing how to do the calculation.
- Make sure that you show the units in the calculation.

- Make sure you include the units if they are not given on the answer line.
- Always express your answer in the same way as other figures provided, e.g. in a table. If the other figures are 5.6 and 4.6, then your answer should be given to one decimal place, e.g. 2.0 and 7.0, not 2 and 7.
- Round up or down the result on your calculator – do not copy all the figures after the decimal point.

Making comparisons

- If you are asked to compare two things make sure you make it clear which thing you are writing about.
- The question may ask you to compare two structures or two processes that you have learnt about. Sometimes you may be expected to do this on answer lines in which case you must make clear the items that you are comparing (see Example 4).
- You may be given a table to complete. This may be blank and you have to fill it in, or it may already have some entries and you complete it.
- If you are given lines to make the comparison, it is perfectly acceptable to draw a table for your answer.

Example 3

Question

State **two** ways in which arteries differ from veins.

[2]

Correct answer:

- 1 Arteries have thicker walls than veins.
- 2 Veins have semi-lunar valves, but arteries do not.

Ambiguous answer:

- 1 They have thick walls.
- 2 They don't have valves.

No marks would be given to the last two answers as the comparisons have not been made.

Question

Complete the table to compare the structure of arteries with the structure of veins.

[2]

Correct answer

| arteries | veins |
|-------------------------|-----------------------------|
| have thick walls | have thin walls |
| have thick muscle layer | have very thin muscle layer |

Incorrect answers as the comparisons are not made between the same features

| arteries | veins |
|------------|------------------------|
| thick wall | thin elastic tissue |
| no valves | small amount of muscle |

In cases like this, it is much better to have an extra column that gives the features to be compared:

| feature | arteries | veins |
|-------------------|----------|---------|
| thickness of wall | thicker | thinner |
| valves | absent | present |

This extra column makes sure that you make direct comparisons in each row of the table. You can always add a first column if it is not included in the question.

Extended writing

- You are required to write longer answers to questions that have four or more marks. There are more of these questions in Paper 4 than in the other papers. You do not have to write your whole answer in prose. You can use labelled and annotated diagrams, flow charts, lists and bullet points. However you present your material, you should write enough to make your meaning clear.

Example 4

Question from Paper 2

Explain, in terms of **water potential**, how water moves from the xylem in a leaf to the air outside a stoma. [4]

This question requires a sequence, i.e. from xylem to cell walls of mesophyll cells; from walls to air spaces inside the leaf; from air spaces through the stoma to the air outside the leaf. The movement of water in each stage needs to be explained in terms of cohesion-tension, evaporation and diffusion. Writing out the pathway on its own does not get any marks.

Question from Paper 4

(a) Explain how changes in the nucleotide sequence of DNA may affect the amino acid sequence in a protein. [7]

(b) Explain how natural selection may bring about evolution. [8]

[Total: 15]

In **(a)**, you may find it easier to use some examples to show how changes in nucleotide sequences lead to changes in amino acid sequences. You do not need to know the genetic code, but you can use changes in DNA triplets to show what will happen, e.g. AAA changes to TAA. In **(b)**, you should have learnt several key points about natural selection that you can write down in a logical sequence.

Question from Paper 4

(a) Describe the part played by the proximal convoluted tubules in the functioning of the kidneys. [8]

(b) Explain how the collecting ducts in the kidneys may reduce the loss of water from the body. [7]

[Total: 15]

A diagram of a cell from the proximal convoluted tubule might help your answer to **(a)**. You can label and annotate your diagram to illustrate your answer. A feedback loop (a type of flow chart) would be a good way to illustrate part **(b)**.

- When you answer these questions always use full sentences if you can. If you find it helps to write bullet points, then make sure that each bullet point is a full sentence. If you abbreviate your answer too much by writing notes, then you may not convey enough information to gain the marks.
- If you are giving a sequence of events (as in Example 5), then you should make sure they are in a logical order. If you are explaining a biological principle or making comparisons, then give the main points first.
- If you are describing something that moves from one place to another as in the Paper 2 question from Example 5, then make sure you include the direction of movement. For example, 'water moves by osmosis' is unlikely to gain a mark unless you include the direction; 'water enters the mesophyll cell down the water potential gradient' is a much better answer.

Advice about the papers

Paper 1 Multiple Choice

- You have about one minute to read and answer each question. Each question may test one topic or several topics from different parts of the AS syllabus.
- Some questions test what you know and understand.
- Some questions test if you can apply what you have learnt to understand new data. These questions will often have a diagram, graph or table to use.
- Some of the choices can be very similar; read carefully and underline words that make each choice distinct from the other three.
- Try to decide what the question is testing as you are reading it. The sequence of questions usually follows the sequence of topics in the syllabus. Therefore you can expect the early questions to ask about cells and biological molecules and those at the end to be on infectious disease and immunity.
- Do not try to find a pattern in the order of your answers (e.g. A, B, C, D, A, B....)
 - The same letter could be the correct answer for several questions in a row.
 - Letter A might be the correct answer for more questions than B, C or D. Or there could be fewer correct answers shown by letter D than any of the others.
 - Do not let what you have chosen for the previous questions influence which letter you choose.
- Some questions may ask about aspects of practical work, for example about different variables: independent, dependent and controlled.
- It is important to understand how to use terminology, e.g. how to apply water potential terminology to problems on cells and osmosis.

Paper 2 AS Level Structured Questions

- This paper has a mix of short-answer questions and those requiring slightly longer answers. There is no essay.
- Longer answers will need four or five sentences with two or three different ideas. Always look at the number of marks for each part question to help you decide how much to write.
- Look at the number of command words: ask yourself 'do you have to do one or two things?'. See Example 2.
- Use the lines given. Stick to the point and do not write too much.
- Only give the number of answers that are asked. Use the numbered lines and give one answer per line.
- There will only be a few parts of questions that need extended writing. These will have four [4] or five [5] marks. These questions will often be related to some information you are given. You will need to write four or five sentences in a sequence that makes sense. You can think of it as "telling a story with a beginning, a middle and an end". Remember to refer to any information you are given.

Paper 3 Advanced Practical Skills

General advice

Success at Paper 3 requires you to do plenty of practical work during your course and have several attempts at past paper questions to find out how to complete everything in the time available. During the practical exam you will have to make some decisions; if you practise plenty of past questions you will find out what

sort of decisions to expect. As you revise, make sure you know exactly how to carry out the practical procedures described in the AS syllabus. You will be assessed on your skills at:

- manipulating apparatus to collect results and make observations
- data presentation
- analysis of results and observations
- evaluation of procedures and data.

You should make decisions, such as:

- identifying variables
- standardising the control variables
- how to change the independent variable
- choosing the number of measurements to take
- deciding the intervals between the values of the independent variable
- choosing a control experiment
- identifying any risks and stating appropriate precautions.

During the examination

- Read through the questions carefully, looking to see how many marks are given for each question.
- Read the instructions to the end; do not start a practical procedure without reading carefully all the steps involved.
- As you read, check that you have the apparatus and materials described. If not alert the supervisor.
- Think about the apparatus that you will use for each step and imagine using it in your mind.
- Make sure that you have a **sharp pencil** to use for making drawings and for drawing graphs and charts. Do **not** draw in ink because you cannot make changes as you can when using a pencil.
- Make sure you have a good, clean eraser for rubbing out your pencil lines if necessary. Do not press too hard when using a pencil for making drawings, graphs or charts. Sometimes it is hard for an examiner to tell which is your final line.

Following the instructions

- Follow the instructions for practical methods exactly. If you make a change in the method it may alter the results.
- Do not take short cuts.
- Always label test-tubes and other containers to help you remember which is which.
- If you are told to “Wash the apparatus thoroughly after each use” make sure you do. If there is anything left in the apparatus the next stage may not work.
- It is a good idea to put a tick by the side of each instruction when you have completed it. This helps you to find the right place in the instructions, so that you do not leave out a step or repeat a step when it is not required.
- Keep your exam paper on a part of the bench which you can keep dry. Do not pour liquids or use syringes or pipettes over your exam paper. If you keep your exam paper away from the ‘wet’ part of your bench you are unlikely to spill anything on it.

Recording your measurements and observations

You are expected to make observations and record them.

- You can record your observations:
 - as statements in writing
 - in tables
 - by using drawings
 - by constructing tally charts.

You will take readings from different apparatus. You must make the measurements as accurately and reliably as you can. Numerical readings will normally be collected and presented in a table.

- Follow the instructions below about drawing tables.
- Make clear descriptions of colours and colour changes; refer to 'blue', 'orange' and 'purple' when describing reagents used in biochemical tests. You may want to refer to slight differences, so use words like 'pale' and 'dark'.
- Make your measurements as accurate and reliable as possible.
- Accurate results are close to the actual or 'true' values; reliable results are those that are repeatable.
- If you can take repeat readings, then do so. There is not always enough time to do this.
- You can process your observations by:
 - carrying out calculations, e.g. percentages and percentage changes
 - plotting graphs – line graphs, bar charts and histograms.
- Use all the space available on the paper for your observations.
- Do not write an explanation until the question asks for one.
- Use a sharp HB or B pencil. It can be rubbed out easily if you need to correct a mistake. Use a good eraser so that is clear to the examiner which is your final line.
- Do not forget to include headings for the columns and the rows in tables.

Drawings

These will be from microscope slides or photographs.

- Read the question carefully, the drawing may have to be an accurate size e.g. twice the original.
- Make each drawing as big as the space allows without writing over the text of the question and making sure that you leave enough space for labels and annotations, if asked for.
- Use a ruler for labelling lines.
- Draw and label in pencil.
- Use one clear continuous outline not an artistic drawing. Do not shade.
- Observe details carefully, such as the relative number of chloroplasts in different cells and the thickness of cell walls in different cells in a vascular bundle. Show these accurately on your drawing.

A **plan diagram** shows the distribution of tissues in a section. It also shows the proportions of the different tissues. Although called a *low power* plan diagram you may use high power to identify the different tissues

and to be sure you are putting the boundaries of those tissues in the right place. You should **not** draw any cells in a lower power plan diagram.

When you make a plan diagram, follow these simple rules:

- make the drawing fill most of the space provided; leave space around the drawing for labels and annotations (if required by the question)
- use a sharp HB or B pencil (never use a pen)
- use thin, single, unbroken lines (often called 'clear and continuous lines')
- show the outlines of the tissues
- make the proportions of tissues in the diagram the same as in the section
- do not include drawings of cells
- do not use any shading or colouring.

Add labels and annotations (notes) to your drawing *only* if you are asked for these in the question. Use a pencil and a ruler to draw straight lines from the drawing to your labels and notes. Write labels and notes in pencil in case you make a mistake and need to change them. You may leave your labels and notes in pencil – do not write over them in ink.

High power drawings should show a small number of cells and they should be drawn a reasonable size so you can show any detail inside them. When you make a high power drawing, follow these simple rules:

- make the drawing fill most of the space provided; leave space around the drawing for labels and annotations (if required by the question)
- use a sharp HB or B pencil (never use a pen)
- use clear, continuous lines (see above)
- draw **only** what is asked in the question, e.g. three cell types or one named cell and all cells adjoining it
- show the outlines of the cells
- the proportions of the cells in the drawing must be the same as in the section you are drawing
- plant cell walls should be shown as double lines with a middle lamella between the cells; the proportions of cell walls should be drawn carefully.
- show any details of the contents of cells – draw what you see, not what you know should be present; for example, in plant cells you may see nuclei, chloroplasts and vacuoles
- do not use any shading or colouring.

Taking measurements of specimens and photographs

Using an eyepiece graticule

An eyepiece graticule is a scale that fits inside the eyepiece on your microscope. It allows you to take measurements of the specimens you view with the microscope. You can measure simply in graticule units, but you may be asked to make an actual measurement which involves calibrating the graticule using a stage micrometer. This is done by lining up the graticule with the divisions on the micrometer.

- Make your measurements as accurate as you can. You will probably be able to measure to the nearest division on the graticule.
- You may be asked to take several measurements and then calculate a mean.

Taking measurements from photographs

You may have to measure an object on a photograph and calculate the actual size of a structure or the magnification of an image.

- Always measure photographs in millimetres, not centimetres.
- If you have to use your measurements in a calculation, write neatly and show your working. The person marking your paper might be able to give you marks for knowing what to do even if you make a mistake or do not finish the calculation.

Presenting data and observations

Tables

Before you start to draw a table, decide what you wish to record. Decide on how many columns and how many rows you will need. Make sure you have read all the instructions before you draw the table outline. Follow these rules:

- use the space provided, do not make the table too small
- leave some space to the right of the table in case you decide you need to add one or more columns
- make the table ready to take observations or readings so that you can write them directly into the table rather than on another page and then copy them into the table (tables need to show all the raw data you collect)
- draw the table outlines in pencil
- rule lines between the columns and rows
- rule lines around the whole table
- write brief, but informative headings for each column
- columns headed with physical quantities should have appropriate SI units
- when two or more columns are used to present data, the first column should be the independent variable; the second and subsequent columns should contain the dependent variables
- entries in the body of the table should be brief – they should be single words, short descriptive phrases or numbers
- data should be recorded in the table **in the order in which it is collected** – this is because the table is prepared **before** the data collection. For example, if the instructions state that results from the highest temperature or highest pH is to be recorded first then these go at the top of their respective columns. It is more usual to arrange the values of the independent variable in ascending order (e.g. from 0 to 100) so that patterns are easier to follow and that is how data in tables for Papers 1, 2, 4 and 5 is usually presented
- numbers written into the body of the table do not have units (units only appear in the column headings).

You may have to process your results by calculating rates of reaction, changes in length, percentage changes or means of repeat readings. These processed results can appear in the same table with the raw data that you have collected or can be in a separate table with the independent variable.

The solidus or slash (/) meaning 'per' should **not** be used in units. For example, if you have to include concentrations as in a table you do **not** write g per 100 cm³ as g/100 cm³. It should always be written out in full using 'per' or, better, as g 100 cm⁻³. The negative exponent, cm⁻³, means 'per'.

Note that the solidus is used to separate what is measured from the unit in which it is measured. You may notice that text books and examination papers use brackets around the units in tables. This is also an accepted convention, but the solidus is the convention used in Cambridge International AS and A Level Biology.

Correct and incorrect ways of showing units in tables and graphs

| Correct | Incorrect |
|---|-------------------------------------|
| <i>either:</i> rate / mm cm ⁻³ <i>or:</i> rate (mm cm ⁻³) | rate mm/cm ³ |
| <i>either:</i> concentration / g 100 cm ⁻³ <i>or:</i> concentration (g 100 cm ⁻³) | concentration g/100 cm ³ |

A note on the uses of ticks and crosses in tables:

Do **not** use ticks and crosses in tables of results which should show observations, such as the colours obtained in biochemical tests.

Ticks and crosses may be used in tables of comparison if there is a key to explain what they mean,

e.g. ✓ = present; ✗ = absent.

You may want to show anomalous results in tables. If so circle them and put a note underneath the table to explain that they are anomalous results.

You may be asked to compare specimens viewed in the microscope and/or in photographs. These comparisons must be organised into a table. Draw your table so that it has a first column for the features that you have observed. You can then present both similarities and differences:

| Feature | Specimen A | Specimen B |
|---------|--------------|------------|
| | | |
| | | |
| | Similarities | |
| | | |
| | | |

Charts and graphs

Bar charts have separate columns that do not touch – there are gaps in between; histograms have columns that do touch each other. Bar charts are used to show data on discontinuous variables, for example blood groups, eye colour, etc.; histograms are used to show data on continuous variables, e.g. length, mass, speed, volume, etc.

Bar charts

Bar charts should be used if the independent variable is qualitative. If you are investigating the rate of respiration of yeast when given different substrates, the independent variable is the type of substrate, e.g. glucose, maltose, sucrose, etc. In this case there is no continuous scale for the independent variable and a bar chart is the appropriate way to present the results. The dependent variable is continuous as it is the rate of respiration and would be measured in units such as 'rate of carbon dioxide production/cm³ s⁻¹'.

Rules for drawing bar charts:

- use most of the grid provided, do not make the chart too small
- draw the chart in pencil
- bar charts can be made of lines, or more usually, blocks of equal width. There must be space between the lines or bars. They do not touch
- the intervals between the blocks on the x-axis should be equidistant
- the y-axis should be properly scaled with equidistant intervals; the scale should usually start at 0 and this should be written at the base of the axis. If all the numbers are large a displaced origin may be used but the start number should be clear at the base of the y-axis
- the y-axis should be labelled with the headings and units taken from the table of results
- the lines or blocks should be arranged in the same order as in the table of results
- each block should be identified; there is no need to shade the blocks or colour code them.

Histograms

Do not confuse bar charts with histograms. A histogram is drawn for continuous data that is subdivided into classes. A good example is collecting data on continuous variables, such as linear measurements or mass. Sometimes the intervals can be whole numbers, for example the numbers of seeds in fruits. If you are analysing data then you may wish to draw a frequency histogram to see if the data shows a normal distribution.

Histograms are used when the independent variable is numerical and the data are continuous. They are sometimes referred to as frequency diagrams.

First the raw data needs to be organised into classes.

- The number of classes needs to be established. This will largely depend on the type and nature of the data.
- The rule for determining the number of classes is $5 \times \log_{10}$ total number of readings.
- The range within each class needs to be determined; this is usually the total range divided by one less than the number of classes.
- There should be no overlap in the classes, e.g.
4.01 to 5.20 or $4.01 < 5.21$
5.21 to 6.40 or $5.21 < 6.41$ ($<$ = less than)

The data should be organised using a tally chart and drawing 'five bar gates' as in $### = 5$

Follow these rules when drawing a histogram:

- use most of the grid provided, do not make the histogram too small
- draw the histogram in pencil
- the x -axis represents the independent variable and is continuous. It should be labelled clearly with an appropriate scale
- the blocks should be drawn touching
- the *area* of each block is proportional to the size of the class. It is usual to have similar sized classes so the widths of the blocks are all the same
- the blocks should be labelled, e.g. '3.0 to 3.9' which means that 3.0 is included in this class, but 4.0 is not. 4.0 will be included in the next class: 4.0 to 4.9
- the y -axis represents the number or frequency and should be properly scaled with equidistant intervals. It should be labelled with appropriate units.

Line graphs

Line graphs are used to show relationships in data which are not immediately apparent from tables. The term *graph* applies to the whole representation. The term *curve* should be used to describe both curves and straight lines which are used to show trends.

Follow these guidelines:

- use at least half the grid provided, do not make the graph too small
- draw the graph in pencil
- the independent variable should be plotted on the x -axis
- the dependent variable should be plotted on the y -axis
- each axis should be marked with an appropriate scale. The origin should be indicated with a 0. The data should be examined critically to establish whether it is necessary to start the scale(s) at zero. If not, you may have a displaced origin for one or both axes, but this must be made obvious by labelling the displaced origin very clearly
- each axis should be scaled using multiples of 1, 2, 5 or 10 for each 20mm square on the grid. This makes it easy for you to plot and extract data. Never use multiples of 3
- each axis should be labelled clearly with the quantity and SI unit(s) or derived (calculated) units as appropriate, e.g. time/s and concentration/g dm⁻³; the axes labels and units must be the same as those in the table
- plotted points must be clearly marked and easily distinguishable from the grid lines on the graph. Dots in circles (⊙) or small, neatly drawn crosses (x) should be used; dots on their own should not. If you need to plot three lines, vertical crosses (+) can also be used
- label each line carefully or use a key. Use a pencil for both lines; do **not** use a blue or black pen or different colours
- in Paper 3 there are usually five or six results to plot.

After plotting the points you need to decide if any of them are anomalous. Ask yourself the question 'do they fit the trend?'. But what is the trend? You should know something about the theory behind the investigation so you should be aware of the likely trend. If you think one or more of the results are anomalous, then it is a good idea to ring them. Put a circle on the graph away from the line and put a key to state that the circled point(s) represent anomalous result(s). The next thing to decide is how to present the curve.

- It may be obvious that the points lie on a straight line; for example, the effect of enzyme concentration on the rate of an enzyme-catalysed reaction. If you have a result for the origin (0, 0) then that must be included and you can place a clear plastic ruler on the grid and draw a straight line from the origin making sure that there is an even number of points on either side of the line. If you do not have a result for the origin, then start the line at the first plotted point. Do **not** continue the line past the last plotted point.
- You should only draw a smooth curve if you know that the intermediate values fall on the curve. You may be expecting the relationship to be a smooth curve and if the points seem to fit on a curve then draw one. Again decide whether the origin is a point and, if not, start at the first plotted point. The curve should go through as many points as possible, but try to make sure there is an even number of points on either side of the line. Do not continue past the last plotted point.
- In the practical examination you may only have five or six results. These are likely to be single results rather than means of replicate results. Therefore you cannot be sure of the relationship and should not draw a straight line or a curve as described above. You should **draw straight lines between the points**. This indicates uncertainty about the results for values of the independent variable between those plotted.
- If a graph shows more than one line or curve, then each should be labelled to show what it represents.

Bar charts, histograms and line graphs should normally have informative titles. There is no need to give titles in the exam as it is obvious what they are. In all other circumstances give informative titles.

If you have times in minutes and seconds, never use minutes as the unit on a graph. It is very difficult to use a scale with each small square representing 3 or 6 seconds. Always plot results in seconds unless the unit for time is whole minutes.

Analysis, conclusions and evaluation

As part of analysis you should be able to:

- identify anomalous results. Anomalous results are those that do not fit the trend
- process your results to calculate means, percentages, changes in mass or length, calculate percentage changes and rates of reactions
- find unknown quantities by using axis intercepts or estimating from colour standards using known concentrations
- describe the pattern or trend in data
- make conclusions to consider whether experimental data supports hypotheses or not.

Processing results

You should be prepared to calculate:

- means
- percentages
- percentage changes
- rates of reaction by calculating $1/t$ or $1000/t$; the unit used is s^{-1} .

You should know how to use line graphs to:

- find an intercept – where a line you have drawn crosses a key value on the x-axis; for example, finding the water potential of a tissue using percentage change in length of plant tissues
- find the rate of a reaction by calculating the gradient of a line you have drawn.

As part of evaluation you should be able to:

- identify systematic and random errors
- systematic errors are those that affect all the results in the same way
- random errors do not affect all the results in the same way
- identify the **significant** errors in your investigation
- estimate the uncertainty in measurements. The actual error is half the smallest division on the apparatus you are using
- assess how effective you have been at standardising variables
- suggest improvements to the procedure you have followed
- suggest ways in which the investigation might be extended to answer a new question.

Estimating uncertainty in your results

You may have to estimate the uncertainty or error in your results. For particular apparatus, the error is half the smallest graduation on the apparatus, e.g. if the smallest division is 1.0 cm^3 then the uncertainty would be $\pm 0.5\text{ cm}^3$. So if you start your measuring at 0 the uncertainty applies where you take your measurement – say at 6.3 cm^3 . So the result is expressed as $6.3 \pm 0.5\text{ cm}^3$. BUT if you have to start at a measurement other than 0 (for example when taking readings from a burette) the uncertainty applies at both ends, so it is multiplied by two as there is an error at each end, e.g. $7.5 \pm 1.0\text{ cm}^3$. Similarly, if using a ruler then there would be an error at each end unless you start at 0. The same applies to measuring a quantity in a syringe by sucking up from empty. The error would be half the minimum measurement. But when you take two readings from the syringe (say delivering 2.0 cm^3 by moving the plunger from 6.5 cm^3 to 4.5 cm^3) the uncertainty is multiplied by two.

Percentage error is calculated as the error expressed as a percentage of the actual reading. For example if the reading is $7.5 \pm 1.0\text{ cm}^3$, then the percentage error is $1.0/7.5 \times 100 = 13.3\%$.

Conclusions

- Conclusions are brief statements supported with explanations using your knowledge from the AS syllabus.
- Use your own results for your conclusions.
- Before planning what to write for a conclusion, turn back to the beginning of the question and read the introduction. You may have forgotten what you were told about the investigation you have just carried out. Think about the theory and apply it to the results you have obtained.
- Sometimes you are expected to make conclusions about some other data, not the data you have collected.
- Do not write the conclusion you have learned from a class experiment or from theory.
- You should also consider the confidence that you have in your conclusions. For this it is a good idea to consider whether:
 - the standardised variables have been kept constant

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- there were any other variables that were not standardised
 - there were any anomalous results
 - any replicate results were similar or not.
- If you are unsure about any aspect of the practical you have carried out, then you can say that you do not have confidence in your conclusions and give a reason or reasons.

Suggesting improvements

You may be asked to suggest modifications or improvements that will increase the accuracy and reliability of the results. As you carry out the practical procedure you should think critically about it and make some notes. If asked to suggest improvements, then look back to these notes for ideas. You can suggest:

- ways to improve the standardisation of variables, for example by using a thermostatically-controlled water bath
- taking repeat readings (replicates) to assess the reliability of the data
- calculating mean results
- using a different way to measure the dependent variable so the results are more accurate
- using a different piece of apparatus to measure the dependent variable and reduce the percentage error (see above)

You may also have to justify your suggested improvements. When you do this, make sure you explain how they will improve the confidence you have in the data and therefore in the conclusion.

Paper 4 A Level Structured Questions

There are 85 marks for Section A and 15 for Section B.

- Section A consists of structured questions that have a variable number of marks.
- Questions on genetics may have genetic diagrams to complete and chi-squared tests to carry out.
- Section B has two essays from which you must choose one. If you write answers to both essays then the higher mark will be the one that you are given. It is unlikely that you will gain a better mark by writing two essays in a hurry, rather than one which you have planned and written more carefully.

Paper 5 Planning, Analysis and Evaluation

Remember that this is not a practical paper like Paper 3, but does require a lot of experience of practical work. The paper tests your skills of planning, analysis and evaluation. Each question is based on a practical investigation. You can expect that these investigations will be unfamiliar to you. The advice is the same as for other papers: read the information carefully, underline key words and phrases, annotate any diagrams, graphs and tables that you are given.

Paper 5 differs significantly from Paper 3 in its approach to data presentation. As Paper 5 is a written paper rather than a practical paper you are not required to construct tables and complete them with observations or numerical results. You will be given data and be expected to carry out an analysis, interpretation and evaluation. This means that it is assumed that you understand how data is presented.

In Paper 5 you will be asked to do such tasks as:

- identify anomalous results

- process raw data, for example by calculating means, standard deviations, standard errors, ratios and correlations
- identify and describe patterns and trends
- explain raw or processed data.

In most cases the data is more complex than in Paper 3 and often involves making comparisons. Complex tables, where variables are being compared may have a different layout to the one given in Paper 3 and you should look carefully for the dependent variable. In some cases, the table layout means that the dependent variable is a table heading across several columns and the independent variable is given in a row underneath.

You may be asked to plot a graph using figures provided although this is less likely than on Paper 3. In addition to the rules given for Paper 3, you should know how to add error bars to line graphs or bar charts using standard deviation or standard error. You should certainly understand why error bars are added to graphs.

In other cases, a graph plotted from the results of an investigation may be given and labels for the axes required. In this case units would be expected which may be in table headings or may have to be deduced from information in the question. In some cases, arbitrary units are acceptable, although you are expected to be familiar with units used to measure common variables, such as light, temperature, time and volume.

Paper 5 may also use scatter graphs or correlation curves to show the effect of one variable on another. You should know how to interpret these forms of presentation.

You should know how to make a sketch graph to predict the results of an investigation. As always, the axes should be orientated with the independent variable as the x-axis and the dependent variable as the y-axis. Axis labels are expected. Units are not required in sketch graphs unless they are specified in the question.

Planning investigations

One of the questions involves writing a plan for an investigation. You will be given some information about the investigation and this will be enough material for you to write your plan.

The skills that you are being tested on are:

1. Identifying key variables.
2. Describing a workable practical procedure.
3. Selecting appropriate methods for measuring the independent variable.
4. Selecting appropriate methods for varying and measuring the dependent variable.
5. Selecting appropriate methods for controlling other variables.
6. Suggesting a suitable control experiment.
7. Suggesting a quantitative, testable, prediction.
8. Selecting equipment of a level of precision appropriate to ensure accuracy.
9. Planning to collect sufficient results to ensure reliability.
10. Describing how results will be recorded.
11. Suggesting how results will be analysed.
12. Risk assessing the practical procedure.

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- When you read through the information provided on the paper, try to work out three main things:
 1. what should be changed – this is the independent variable
 2. what is going to be measured – this is the dependent variable
 3. what should be kept the same – these are the control variables
- You should organise your plan under several headings and then write as concisely as possible. Suitable headings are:
 - hypothesis and/or prediction
 - variables
 - risk assessment
 - method
 - collecting results
 - analysis of results.
- Some investigations need to have two parts.
 - The experimental – which measures the process being studied and contains the living organism, part of an organism (e.g. a leaf) or enzyme being tested.
 - The control – which will be exactly the same as the experimental except that the living organism will be missing or replaced by something non-living. The control shows that the results are due to the activity of the living organism and is not due to the apparatus or an environmental factor.
- Make sure you explain carefully how to standardise the control variables; for example, 'put test-tubes in to a thermostatically-controlled water bath' is better than 'keep the test-tubes at the same temperature'.
- All investigations should be repeated to increase the reliability of the results. If the same results are achieved (or the results are very similar) then they are reliable. You can also include the calculation of means and standard deviation in your plan under the heading of *analysis of results*.
- Always give quantities in appropriate terms – avoid the use of the word 'amount' as this does not convey precise meaning to any specific quantity. 'Amount' could mean volume, mass or concentration. For example, you can give the volume in cm^3 , mass in grams and concentration in an appropriate unit, such as $\text{grams } 100 \text{ cm}^{-3}$.
- Suggest appropriate volumes and concentrations in your plan. Include instructions on making up dilutions either by serial dilution or proportional dilution. You should have learnt how to do this when preparing for Paper 3.
- Choose apparatus that will give precise results. For example, if you are measuring using a syringe or measuring cylinder it may be difficult to measure to the nearest cm^3 . You should think about ways in which the precision can be improved before writing your answer.
- Write out your method as a list of numbered steps as if you are writing a set of instructions for someone else to follow. Think of your method as a recipe.
- Carry out a risk assessment on your plan and include a section headed risk assessment or safety precautions.

Analysing data, making conclusions and evaluation

In preparation for Paper 3, you will have learnt how to analyse data, draw graphs, evaluate data and experimental methods, and make conclusions. You will be tested on these skills in Paper 5. In addition, you should know about some statistical methods and apply them to the data provided.

There is always a question that asks you to analyse the data from an investigation. You should know about the following aspects of statistics:

- calculating standard deviation and standard error (formulae will be provided)

- using statistical tests – the chi-squared test, the *t*-test, and the Pearson and Spearman tests for correlation (formulae for these tests will be provided)
- making a null hypothesis.

You should know when and how to use these methods. There are several different styles of questions that test your understanding of these statistical methods. The best preparation is to look at the way data is presented in past paper questions and see what sort of questions are asked.

Section 3: What will be tested?

The assessment objectives (AOs) describe the knowledge, skills and abilities that you will be expected to demonstrate at the end of your course.

There are three main objectives:

AO1 Knowledge with understanding – what you remember and how you make use of what you know in both familiar and unfamiliar situations.

AO2 Handling information and solving problems – how you handle information provided in the question and how well you solve the problems posed.

AO3 Experimental skills and investigations

The theory papers test AO1 and AO2. The purpose of the practical papers is to test AO3. Your teacher will be able to give you more information about how each of these is used in the examination papers.

The following tables show you the range of skills you will need to develop:

| Skill area | You will need to demonstrate this skill in relation to: |
|----------------------------------|---|
| AO1 Knowledge with understanding | biological phenomena, facts, laws, definitions, concepts and theories |
| | biological vocabulary, terminology, conventions (including symbols, quantities and units) |
| | scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety |
| | scientific quantities and their determination |
| | biological and technological applications with their social, economic and environmental implications |

Questions testing the skills in the table above will usually begin with one of the following words: *define, state, name, describe, explain or outline*. See Section 6 for an explanation of these words.

| Skill area | You will need to use written, symbolic, graphical and numerical forms of presentation to: |
|---|---|
| AO2 Handling information and solving problems | locate, select, organise and present information from a variety of sources |
| | translate information from one form to another |
| | manipulate numerical and other data |
| | use information to identify patterns, report trends and draw conclusions |
| | present reasoned explanation for phenomena, patterns and relationships |
| | make predictions and propose hypotheses |
| | apply knowledge, including principles, to novel situations |
| | demonstrate awareness of the limitations of biological theories and models |
| | solve problems |

Questions testing the skills in the table above will usually begin with one of the following words: *discuss*, *predict*, *suggest*, *calculate* or *determine*. See Section 6 for an explanation of these words.

Look carefully at the skills you need to develop during your course in preparation for Papers 3 and 5.

| Skill area | You will need to be able to: |
|--|--|
| AO3 Experimental skills and investigations | plan experiments and investigations |
| | collect, record and present observations, measurements and estimates |
| | analyse and interpret quality of data to reach conclusions |
| | evaluate methods and quality of data and suggest possible improvements |

The following table will give you a general idea of the allocation of marks to assessment objectives in the different examination papers – though the balance in each paper may vary slightly.

| Assessment objective | Weighting (%) | Examination papers |
|---|---------------|--------------------|
| AO1 Knowledge with understanding | 40 | Papers 1, 2 and 4 |
| AO2 Handling information and solving problems | 37 | Papers 1, 2 and 4 |
| AO3 Experimental skills and investigations | 23 | Papers 3 and 5 |

In addition, 15% of the total marks will be awarded for an awareness of the social, economic, environmental and technological implications and applications of biology. These marks will be awarded within the AO1 and AO2 categories.

Section 4: What you need to know

This is in the form of a table, which describes what you may be tested on in the examination. It is divided into the syllabuses for AS and A Level.

How to use the table

The table is divided into a number of columns.

Topic – this is a main subject area within each syllabus. There are a varying number of topics within each syllabus;

Sub-topic – this column subdivides the main topic into a number of different topics.

You should be able to – this column gives you all the detail that you will be expected to know and understand in relation to each topic. It is arranged in bullet points. Each bullet point is a **learning outcome** taken from the syllabus. You should read these learning outcomes very carefully as examiners set questions on these. If you know the learning outcomes you will be well prepared for the examinations as you will know what topics you are being tested on.

Examiners can set questions on unfamiliar situations and expect you to apply your knowledge to understanding and analysing them. Do not panic if you have a question on an organism you have not been taught about or something else that is new to you. There will be clues in the question to help you identify the topic that is being tested in the question.

You can use the table throughout your course to check the topic areas you have covered.

You can also use it as a revision aid. When you think you have a good knowledge of a topic, you can place a tick in the checklist column.

The column headed **Comments** can be used:

- to add further information about the details for each bullet point
- to add learning aids
- to highlight areas of difficulty/things about which you need to ask your teacher.

| AS Level material | | | | |
|-------------------|---|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 1 Cell structure | 1.1 The microscope in cell studies An understanding of the principles of microscopy shows why light and electron microscopes have been essential in improving our knowledge of cells. | a) compare the structure of typical animal and plant cells by making temporary preparations of live material and using photomicrographs b) calculate the linear magnifications of drawings, photomicrographs and electron micrographs c) use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre, nanometre) used in cell studies d) explain and distinguish between resolution and magnification, with reference to light microscopy and electron microscopy e) calculate actual sizes of specimens from drawings, photomicrographs and electron micrographs | | |

| AS Level material | | | | |
|-------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 1 Cell structure | <p>1.2 Cells as the basic units of living organisms</p> <p>The cell is the basic unit of all living organisms. The interrelationships between these cell structures show how cells function to transfer energy, produce biological molecules including proteins and exchange substances with their surroundings.</p> <p>Prokaryotic cells and eukaryotic cells share some features, but the differences between them illustrate the divide between these two cell types.</p> | <p>a) describe and interpret electron micrographs and drawings of typical animal and plant cells as seen with the electron microscope</p> <p>b) recognise the following cell structures and outline their functions:</p> <ul style="list-style-type: none"> • cell surface membrane • nucleus, nuclear envelope and nucleolus • rough endoplasmic reticulum • smooth endoplasmic reticulum • Golgi body (Golgi apparatus or Golgi complex) • mitochondria (including small circular DNA) • ribosomes (80S in the cytoplasm and 70S in chloroplasts and mitochondria) • lysosomes • centrioles and microtubules • chloroplasts (including small circular DNA) • cell wall • plasmodesmata • large permanent vacuole and tonoplast of plant cells <p>c) state that ATP is produced in mitochondria and chloroplasts and outline the role of ATP in cells</p> <p>d) outline key structural features of typical prokaryotic cells as seen in a typical bacterium (including: unicellular, 1-5µm diameter, peptidoglycan cell walls, lack of organelles surrounded by double membranes, naked circular DNA, 70S ribosomes)</p> <p>e) compare and contrast the structure of typical prokaryotic cells with typical eukaryotic cells (reference to mesosomes should not be included)</p> <p>f) outline the key features of viruses as non-cellular structures (limited to protein coat and DNA/RNA)</p> | | |

| AS Level material | | | | |
|------------------------|---|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 2 Biological molecules | <p>2.1 Testing for biological molecules</p> <p>Tests for biological molecules can be used in a variety of contexts, such as identifying the contents of mixtures of molecules and following the activity of digestive enzymes.</p> | <p>a) carry out tests for reducing sugars and non-reducing sugars, the iodine in potassium iodide solution test for starch, the emulsion test for lipids and the biuret test for proteins to identify the contents of solutions</p> <p>b) carry out a semi-quantitative Benedict's test on a reducing sugar using dilution, standardising the test and using the results (colour standards or time to first colour change) to estimate the concentration</p> | | |

| AS Level material | | | | |
|------------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 2 Biological molecules | 2.2 Carbohydrates and lipids Carbohydrates and lipids have important roles in the provision and storage of energy and for a variety of other functions such as providing barriers around cells: the phospholipid bilayer of all cell membranes and the cellulose cell walls of plant cells. | a) describe the ring forms of α -glucose and β -glucose b) define the terms monomer, polymer, macromolecule, monosaccharide, disaccharide and polysaccharide c) describe the formation of a glycosidic bond by condensation, with reference both to polysaccharides and to disaccharides, including sucrose d) describe the breakage of glycosidic bonds in polysaccharides and disaccharides by hydrolysis, with reference to the non-reducing sugar test e) describe the molecular structure of polysaccharides including starch (amylose and amylopectin), glycogen and cellulose and relate these structures to their functions in living organisms f) describe the molecular structure of a triglyceride with reference to the formation of ester bonds and relate the structure of triglycerides to their functions in living organisms g) describe the structure of a phospholipid and relate the structure of phospholipids to their functions in living organisms | | |

AS Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|------------------------|---|---|-----------|----------|
| 2 Biological molecules | <p>2.3 Proteins and water</p> <p>An understanding of protein structure and how it is related to function is central to many aspects of biology, such as enzymes, antibodies and muscle contraction.</p> <p>Globular and fibrous proteins play important roles in biological processes such as the transport of gases and providing support for tissues.</p> <p>Water is a special molecule with extraordinary properties that make life possible on this planet 150 million kilometres from the Sun.</p> | <p>a) describe the structure of an amino acid and the formation and breakage of a peptide bond</p> <p>b) explain the meaning of the terms primary structure, secondary structure, tertiary structure and quaternary structure of proteins and describe the types of bonding (hydrogen, ionic, disulfide and hydrophobic interactions) that hold these molecules in shape</p> <p>c) describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions (The importance of iron in the haemoglobin molecule should be emphasised. A haemoglobin molecule is composed of two alpha (α) chains and two beta (β) chains, although when describing the chains the terms α-globin and β-globin may be used. There should be a distinction between collagen molecules and collagen fibres)</p> <p>d) explain how hydrogen bonding occurs between water molecules and relate the properties of water to its roles in living organisms (limited to solvent action, specific heat capacity and latent heat of vapourisation)</p> | | |

| AS Level material | | | | |
|-------------------|--|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 3 Enzymes | <p>3.1 Mode of action of enzymes</p> <p>There are many different enzymes, each one specific to a particular reaction. This specificity is the key to understanding the efficient functioning of cells and living organisms.</p> | <p>a) explain that enzymes are globular proteins that catalyse metabolic reactions</p> <p>b) state that enzymes function inside cells (intracellular enzymes) and outside cells (extracellular enzymes)</p> <p>c) explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity (the lock and key hypothesis and the induced fit hypothesis should be included)</p> <p>d) investigate the progress of an enzyme-catalysed reaction by measuring rates of formation of products (for example, using catalase) or rates of disappearance of substrate (for example, using amylase)</p> | | |
| 3 Enzymes | <p>3.2 Factors that affect enzyme action</p> <p>Investigating the effects of factors on enzyme activity gives opportunities for planning and carrying out experiments under controlled conditions.</p> | <p>a) investigate and explain the effects of the following factors on the rate of enzyme-catalysed reactions:</p> <ul style="list-style-type: none"> • temperature • pH (using buffer solutions) • enzyme concentration • substrate concentration • inhibitor concentration <p>b) explain that the maximum rate of reaction (V_{max}) is used to derive the Michaelis-Menten constant (K_m) which is used to compare the affinity of different enzymes for their substrates</p> <p>c) explain the effects of reversible inhibitors, both competitive and non-competitive, on the rate of enzyme activity</p> <p>d) investigate and explain the effect of immobilising an enzyme in alginate on its activity as compared with its activity when free in solution</p> | | |

| AS Level material | | | | |
|--------------------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 4 Cell membranes and transport | 4.1 Fluid mosaic membranes The structure of cell surface membranes allows movement of substances between cells and their surroundings and allows cells to communicate with each other by cell signalling. | a) describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins b) outline the roles of cell surface membranes including references to carrier proteins, channel proteins, cell surface receptors and cell surface antigens c) outline the process of cell signalling involving the release of chemicals that combine with cell surface receptors on target cells, leading to specific responses | | |

| AS Level material | | | | |
|--------------------------------|---|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 4 Cell membranes and transport | <p>4.2 Movement of substances into and out of cells</p> <p>The fluid mosaic model allows an understanding of how substances enter and exit cells by a variety of different mechanisms.</p> <p>Investigating the effect of increasing the size of model cells allows an understanding of the constraints of obtaining resources across the cell surface and moving substances out of cells.</p> | <p>a) describe and explain the processes of diffusion, facilitated diffusion, osmosis, active transport, endocytosis and exocytosis (no calculations involving water potential will be set)</p> <p>b) investigate simple diffusion using plant tissue and non-living materials, such as glucose solutions, Visking tubing and agar</p> <p>c) calculate surface areas and volumes of simple shapes (e.g. cubes) to illustrate the principle that surface area to volume ratios decrease with increasing size</p> <p>d) investigate the effect of changing surface area to volume ratio on diffusion using agar blocks of different sizes</p> <p>e) investigate the effects of immersing plant tissues in solutions of different water potential, using the results to estimate the water potential of the tissues</p> <p>f) explain the movement of water between cells and solutions with different water potentials and explain the different effects on plant and animal cells</p> | | |

AS Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|--------------------------|--|---|-----------|----------|
| 5 The mitotic cell cycle | <p>5.1 Replication and division of nuclei and cells</p> <p>During the mitotic cell cycle, DNA is replicated and passed to daughter cells.</p> <p>Stem cells in bone marrow and the skin continually divide by mitosis to provide a continuous supply of cells that differentiate into blood and skin cells.</p> | <p>a) describe the structure of a chromosome, limited to DNA, histone proteins, chromatids, centromere and telomeres</p> <p>b) explain the importance of mitosis in the production of genetically identical cells, growth, cell replacement, repair of tissues and asexual reproduction</p> <p>c) outline the cell cycle, including interphase (growth and DNA replication), mitosis and cytokinesis</p> <p>d) outline the significance of telomeres in permitting continued replication and preventing the loss of genes</p> <p>e) outline the significance of mitosis in cell replacement and tissue repair by stem cells and state that uncontrolled cell division can result in the formation of a tumour</p> | | |
| 5 The mitotic cell cycle | <p>5.2 Chromosome behaviour in mitosis</p> <p>The events that occur during mitosis can be followed by using a light microscope.</p> | <p>a) describe, with the aid of photomicrographs and diagrams, the behaviour of chromosomes in plant and animal cells during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell surface membrane and the spindle (names of the main stages of mitosis are expected)</p> <p>b) observe and draw the mitotic stages visible in temporary root tip squash preparations and in prepared slides of root tips of species such as those of <i>Vicia faba</i> and <i>Allium cepa</i></p> | | |

| AS Level material | | | | |
|---------------------------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 6 Nucleic acids and protein synthesis | 6.1 Structure and replication of DNA Understanding the structure of nucleic acids allows an understanding of their role in the storage of genetic information and how that information is used in the synthesis of proteins. | a) describe the structure of nucleotides, including the phosphorylated nucleotide ATP (structural formulae are not required) b) describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases (include reference to adenine and guanine as purines and to cytosine, thymine and uracil as pyrimidines. Structural formulae for bases are not required but the recognition that purines have a double ring structure and pyrimidines have a single ring structure should be included) c) describe the semi-conservative replication of DNA during interphase | | |
| 6 Nucleic acids and protein synthesis | 6.2 Protein synthesis The genetic code specifies the amino acids that are assembled to make polypeptides. The way that DNA codes for polypeptides is central to our understanding of how cells and organisms function. | a) state that a polypeptide is coded for by a gene and that a gene is a sequence of nucleotides that forms part of a DNA molecule b) state that a gene mutation is a change in the sequence of nucleotides that may result in an altered polypeptide c) describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide with reference to the nucleotide sequence for Hb^A (normal) and Hb^S (sickle cell) alleles of the gene for the β -globin polypeptide d) describe how the information in DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes | | |

| AS Level material | | | | |
|-----------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 7 Transport in plants | 7.1 Structure of transport tissues Plants have two transport tissues: xylem and phloem. | a) draw and label from prepared slides plan diagrams of transverse sections of stems, roots and leaves of herbaceous dicotyledonous plants using an eyepiece graticule to show tissues in correct proportions (see 1.1c) b) draw and label from prepared slides the cells in the different tissues in roots, stems and leaves of herbaceous dicotyledonous plants using transverse and longitudinal sections c) draw and label from prepared slides the structure of xylem vessel elements, phloem sieve tube elements and companion cells and be able to recognise these using the light microscope d) relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions | | |

| AS Level material | | | | |
|-----------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 7 Transport in plants | <p>7.2 Transport mechanisms</p> <p>Movement of xylem sap and phloem sap is by mass flow. Movement in the xylem is passive as it is driven by evaporation from the leaves; plants use energy to move substances in the phloem.</p> <p>Xylem sap moves in one direction from the roots to the rest of the plant. The phloem sap in a phloem sieve tube moves in one direction from the location where it is made to the location where it is used or stored. At any one time phloem sap can be moving in different directions in different sieve tubes.</p> | <p>a) explain the movement of water between plant cells, and between them and their environment, in terms of water potential (see 4.2. No calculations involving water potential will be set)</p> <p>b) explain how hydrogen bonding of water molecules is involved with movement in the xylem by cohesion-tension in transpiration pull and adhesion to cellulose cell walls</p> <p>c) describe the pathways and explain the mechanisms by which water and mineral ions are transported from soil to xylem and from roots to leaves (include reference to the symplastic pathway and apoplastic pathway and Casparian strip)</p> <p>d) define the term transpiration and explain that it is an inevitable consequence of gas exchange in plants</p> <p>e) investigate experimentally and explain the factors that affect transpiration rate using simple potometers, leaf impressions, epidermal peels, and grids for determining surface area</p> <p>f) make annotated drawings, using prepared slides of cross-sections, to show how leaves of xerophytic plants are adapted to reduce water loss by transpiration</p> <p>g) state that assimilates, such as sucrose and amino acids, move between sources (e.g. leaves and storage organs) and sinks (e.g. buds, flowers, fruits, roots and storage organs) in phloem sieve tubes</p> <p>h) explain how sucrose is loaded into phloem sieve tubes by companion cells using proton pumping and the co-transporter mechanism in their cell surface membranes</p> <p>i) explain mass flow in phloem sap down a hydrostatic pressure gradient from source to sink</p> | | |

AS Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|------------------------|--|--|-----------|----------|
| 8 Transport in mammals | <p>8.1 The circulatory system</p> <p>The mammalian circulatory system consists of a pump, many blood vessels and blood, which is a suspension of red blood cells and white blood cells in plasma.</p> | <ul style="list-style-type: none"> a) state that the mammalian circulatory system is a closed double circulation consisting of a heart, blood vessels and blood b) observe and make plan diagrams of the structure of arteries, veins and capillaries using prepared slides and be able to recognise these vessels using the light microscope c) explain the relationship between the structure and function of arteries, veins and capillaries d) observe and draw the structure of red blood cells, monocytes, neutrophils and lymphocytes using prepared slides and photomicrographs e) state and explain the differences between blood, tissue fluid and lymph f) describe the role of haemoglobin in carrying oxygen and carbon dioxide with reference to the role of carbonic anhydrase, the formation of haemoglobinic acid and carbaminohaemoglobin (details of the chloride shift are not required) g) describe and explain the significance of the oxygen dissociation curves of adult oxyhaemoglobin at different carbon dioxide concentrations (the Bohr effect) h) describe and explain the significance of the increase in the red blood cell count of humans at high altitude | | |

| AS Level material | | | | |
|----------------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 8 Transport in mammals | 8.2 The heart The mammalian heart is a double pump: the right side pumps blood at low pressure to the lungs and the left side pumps blood at high pressure to the rest of the body. | a) describe the external and internal structure of the mammalian heart b) explain the differences in the thickness of the walls of the different chambers in terms of their functions with reference to resistance to flow c) describe the cardiac cycle (including blood pressure changes during systole and diastole) d) explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue, but not to nervous and hormonal control) | | |
| 9 Gas exchange and smoking | 9.1 The gas exchange system The gas exchange surface in the lungs is extensive, very thin, well supplied with blood and well ventilated. The trachea and bronchi provide little resistance to the movement of air to and from the alveoli. | a) describe the gross structure of the human gas exchange system b) observe and draw plan diagrams of the structure of the walls of the trachea, bronchi, bronchioles and alveoli indicating the distribution of cartilage, ciliated epithelium, goblet cells, smooth muscle, squamous epithelium and blood vessels c) describe the functions of cartilage, cilia, goblet cells, mucous glands, smooth muscle and elastic fibres and recognise these cells and tissues in prepared slides, photomicrographs and electron micrographs of the gas exchange system d) describe the process of gas exchange between air in the alveoli and the blood | | |

| AS Level material | | | | |
|----------------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 9 Gas exchange and smoking | 9.2 Smoking Smoking is one of the major avoidable risk factors of chronic, life-threatening diseases of the gas exchange and circulatory systems. | a) describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system with reference to lung cancer and chronic obstructive pulmonary disease (COPD) b) describe the short-term effects of nicotine and carbon monoxide on the cardiovascular system | | |
| 10 Infectious disease | 10.1 Infectious diseases While many infectious diseases have been successfully controlled in some parts of the world, many people worldwide are still at risk of these diseases. | a) define the term disease and explain the difference between an infectious disease and a non-infectious disease (limited to sickle cell anaemia and lung cancer) b) state the name and type of causative organism (pathogen) of each of the following diseases: cholera, malaria, tuberculosis (TB), HIV/AIDS, smallpox and measles (detailed knowledge of structure is not required. For smallpox (<i>Variola</i>) and measles (<i>Morbillivirus</i>) only the name of genus is needed) c) explain how cholera, measles, malaria, TB and HIV/AIDS are transmitted d) discuss the biological, social and economic factors that need to be considered in the prevention and control of cholera, measles, malaria, TB and HIV/AIDS (a detailed study of the life cycle of the malarial parasite is not required) e) discuss the factors that influence the global patterns of distribution of malaria, TB and HIV/AIDS and assess the importance of these diseases worldwide | | |

| AS Level material | | | | |
|-----------------------|--|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 10 Infectious disease | 10.2 Antibiotics The 'age of antibiotics' began in the 1940s with the availability of penicillin. With an increase in antibiotic resistance is this age about to come to an end? | a) outline how penicillin acts on bacteria and why antibiotics do not affect viruses b) explain in outline how bacteria become resistant to antibiotics with reference to mutation and selection c) discuss the consequences of antibiotic resistance and the steps that can be taken to reduce its impact | | |
| 11 Immunity | 11.1 The immune system The immune system has non-specific and specific responses to pathogens. Auto-immune diseases are the result of failures in the system to distinguish between self and non-self. | a) state that phagocytes (macrophages and neutrophils) have their origin in bone marrow and describe their mode of action b) describe the modes of action of B-lymphocytes and T-lymphocytes c) describe and explain the significance of the increase in white blood cell count in humans with infectious diseases and leukaemias d) explain the meaning of the term immune response, making reference to the terms antigen, self and non-self e) explain the role of memory cells in long-term immunity f) explain, with reference to myasthenia gravis, that the immune system sometimes fails to distinguish between self and non-self | | |

| AS Level material | | | | |
|-------------------|--|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 11 Immunity | <p>11.2 Antibodies and vaccination</p> <p>Active and passive immunisations are effective ways to treat and prevent infectious diseases. Smallpox has been eradicated; other diseases may soon follow, but vaccine development has proved more difficult for diseases such as malaria.</p> | <p>a) relate the molecular structure of antibodies to their functions (see 2.3b)</p> <p>b) outline the hybridoma method for the production of monoclonal antibodies</p> <p>c) outline the use of monoclonal antibodies in the diagnosis of disease and in the treatment of disease</p> <p>d) distinguish between active and passive, natural and artificial immunity and explain how vaccination can control disease</p> <p>e) discuss the reasons why vaccination programmes have eradicated smallpox, but not measles, tuberculosis (TB), malaria or cholera</p> | | |

| A Level material | | | | |
|---------------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 12 Energy and respiration | 12.1 Energy ATP is the universal energy currency as it provides the immediate source of energy for cellular processes. | a) outline the need for energy in living organisms, as illustrated by anabolic reactions, such as DNA replication and protein synthesis, active transport, movement and the maintenance of body temperature b) describe the features of ATP that make it suitable as the universal energy currency c) explain that ATP is synthesised in substrate-linked reactions in glycolysis and in the Krebs cycle d) outline the roles of the coenzymes NAD, FAD and coenzyme A in respiration e) explain that the synthesis of ATP is associated with the electron transport chain on the membranes of mitochondria and chloroplasts (see 12.2g) f) explain the relative energy values of carbohydrate, lipid and protein as respiratory substrates and explain why lipids are particularly energy-rich g) define the term respiratory quotient (RQ) and determine RQs from equations for respiration h) carry out investigations, using simple respirometers, to determine the RQ of germinating seeds or small invertebrates (e.g. blowfly larvae) | | |
| 12 Energy and respiration | 12.2 Respiration Respiration is the process whereby energy from complex organic molecules is transferred to ATP. | a) list the four stages in aerobic respiration (glycolysis, link reaction, Krebs cycle and oxidative phosphorylation) and state where each occurs in eukaryotic cells b) outline glycolysis as phosphorylation of glucose and the subsequent splitting of fructose 1,6-bisphosphate (6C) into two triose phosphate molecules, which are then further oxidised to pyruvate with a small yield of ATP and reduced NAD c) explain that, when oxygen is available, pyruvate is converted into acetyl (2C) coenzyme A in the link reaction | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|---------------------------|--|---|-----------|----------|
| 12 Energy and respiration | This process of ATP synthesis using the energy in proton gradients is common to both respiration and photosynthesis. | <p>d) outline the Krebs cycle, explaining that oxaloacetate (a 4C compound) acts as an acceptor of the 2C fragment from acetyl coenzyme A to form citrate (a 6C compound), which is reconverted to oxaloacetate in a series of small steps</p> <p>e) explain that reactions in the Krebs cycle involve decarboxylation and dehydrogenation and the reduction of NAD and FAD</p> <p>f) outline the process of oxidative phosphorylation including the role of oxygen as the final electron acceptor (no details of the carriers are required)</p> <p>g) explain that during oxidative phosphorylation:</p> <ul style="list-style-type: none"> • energetic electrons release energy as they pass through the electron transport system • the released energy is used to transfer protons across the inner mitochondrial membrane • protons return to the mitochondrial matrix by facilitated diffusion through ATP synthase providing energy for ATP synthesis (details of ATP synthase are not required) <p>h) carry out investigations to determine the effect of factors such as temperature and substrate concentration on the rate of respiration of yeast using a redox indicator (e.g. DCPIP or methylene blue)</p> <p>i) describe the relationship between structure and function of the mitochondrion using diagrams and electron micrographs</p> | | |

| A Level material | | | | |
|---------------------------|---|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 12 Energy and respiration | Some organisms and some tissues are able to respire in both aerobic and anaerobic conditions. When yeast and plants respire under anaerobic conditions, they produce ethanol and carbon dioxide as end-products; mammalian muscle tissue produces lactate when oxygen is in short supply. | <ul style="list-style-type: none"> j) distinguish between respiration in aerobic and anaerobic conditions in mammalian tissue and in yeast cells, contrasting the relative energy released by each (a detailed account of the total yield of ATP from the aerobic respiration of glucose is not required) k) explain the production of a small yield of ATP from respiration in anaerobic conditions in yeast and in mammalian muscle tissue, including the concept of oxygen debt l) explain how rice is adapted to grow with its roots submerged in water in terms of tolerance to ethanol from respiration in anaerobic conditions and the presence of aerenchyma m) carry out investigations, using simple respirometers, to measure the effect of temperature on the respiration rate of germinating seeds or small invertebrates | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|-------------------|---|---|-----------|----------|
| 13 Photosynthesis | <p>13.1 Photosynthesis as an energy transfer process</p> <p>Light energy absorbed by chloroplast pigments in the light dependent stage of photosynthesis is used to drive reactions of the light independent stage that produce complex organic compounds.</p> <p>Chromatography is used to identify chloroplast pigments and was also used to identify the intermediates in the Calvin cycle.</p> | <p>a) explain that energy transferred as ATP and reduced NADP from the light dependent stage is used during the light independent stage (Calvin cycle) of photosynthesis to produce complex organic molecules</p> <p>b) state the sites of the light dependent and the light independent stages in the chloroplast</p> <p>c) describe the role of chloroplast pigments (chlorophyll a, chlorophyll b, carotene and xanthophyll) in light absorption in the grana</p> <p>d) interpret absorption and action spectra of chloroplast pigments</p> <p>e) use chromatography to separate and identify chloroplast pigments and carry out an investigation to compare the chloroplast pigments in different plants (reference should be made to R_f values in identification)</p> <p>f) describe the light dependent stage as the photoactivation of chlorophyll resulting in the photolysis of water and the transfer of energy to ATP and reduced NADP (cyclic and non-cyclic photophosphorylation should be described in outline only)</p> <p>g) outline the three main stages of the Calvin cycle:</p> <ul style="list-style-type: none"> • fixation of carbon dioxide by combination with ribulose biphosphate (RuBP), a 5C compound, to yield two molecules of GP (PGA), a 3C compound • the reduction of GP to triose phosphate (TP) involving ATP and reduced NADP • the regeneration of ribulose biphosphate (RuBP) using ATP <p>h) describe, in outline, the conversion of Calvin cycle intermediates to carbohydrates, lipids and amino acids and their uses in the plant cell</p> | | |

| A Level material | | | | |
|-------------------|--|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 13 Photosynthesis | <p>13.2 Investigation of limiting factors</p> <p>Environmental factors influence the rate of photosynthesis. Investigating these shows how they can be managed in protected environments used in crop production.</p> | <p>a) explain the term limiting factor in relation to photosynthesis</p> <p>b) explain the effects of changes in light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis</p> <p>c) explain how an understanding of limiting factors is used to increase crop yields in protected environments, such as glasshouses</p> <p>d) carry out an investigation to determine the effect of light intensity or light wavelength on the rate of photosynthesis using a redox indicator (e.g. DCPIP) and a suspension of chloroplasts (the Hill reaction)</p> <p>e) carry out investigations on the effects of light intensity, carbon dioxide and temperature on the rate of photosynthesis using whole plants, e.g. aquatic plants such as <i>Elodea</i> and <i>Cabomba</i></p> | | |
| 13 Photosynthesis | <p>13.3 Adaptations for photosynthesis</p> <p>All the stages of photosynthesis occur in the chloroplast. Some tropical crops have C4 metabolism and adaptations to maximise carbon dioxide fixation.</p> | <p>a) describe the relationship between structure and function in the chloroplast using diagrams and electron micrographs</p> <p>b) explain how the anatomy and physiology of the leaves of C4 plants, such as maize or sorghum, are adapted for high rates of carbon fixation at high temperatures in terms of:</p> <ul style="list-style-type: none"> the spatial separation of initial carbon fixation from the light dependent stage (biochemical details of the C4 pathway are required in outline only) the high optimum temperatures of the enzymes involved | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|----------------|---|--|-----------|----------|
| 14 Homeostasis | <p>14.1 Homeostasis in mammals</p> <p>Homeostasis in mammals requires complex systems to maintain internal conditions near constant.</p> <p>The kidneys remove wastes from the blood and are the effectors for controlling the water potential of the blood.</p> | <ul style="list-style-type: none"> a) discuss the importance of homeostasis in mammals and explain the principles of homeostasis in terms of internal and external stimuli, receptors, central control, co-ordination systems, effectors (muscles and glands) b) define the term negative feedback and explain how it is involved in homeostatic mechanisms c) outline the roles of the nervous system and endocrine system in co-ordinating homeostatic mechanisms, including thermoregulation, osmoregulation and the control of blood glucose concentration d) describe the deamination of amino acids and outline the formation of urea in the urea cycle (biochemical detail of the urea cycle is not required) e) describe the gross structure of the kidney and the detailed structure of the nephron with its associated blood vessels using photomicrographs and electron micrographs f) describe how the processes of ultrafiltration and selective reabsorption are involved with the formation of urine in the nephron g) describe the roles of the hypothalamus, posterior pituitary, ADH and collecting ducts in osmoregulation h) explain how the blood glucose concentration is regulated by negative feedback control mechanisms, with reference to insulin and glucagon i) outline the role of cyclic AMP as a second messenger with reference to the stimulation of liver cells by adrenaline and glucagon | | |

| A Level material | | | | |
|------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 14 Homeostasis | | <p>j) describe the three main stages of cell signalling in the control of blood glucose by adrenaline as follows:</p> <ul style="list-style-type: none"> hormone-receptor interaction at the cell surface (see 4.1c) formation of cyclic AMP which binds to kinase proteins an enzyme cascade involving activation of enzymes by phosphorylation to amplify the signal <p>k) explain the principles of operation of dip sticks containing glucose oxidase and peroxidase enzymes, and biosensors that can be used for quantitative measurements of glucose in blood and urine</p> <p>l) explain how urine analysis is used in diagnosis with reference to glucose, protein and ketones</p> | | |
| 14 Homeostasis | <p>14.2 Homeostasis in plants Stomatal aperture is regulated in response to the requirements for uptake of carbon dioxide for photosynthesis and conserving water.</p> | <p>a) explain that stomata have daily rhythms of opening and closing and also respond to changes in environmental conditions to allow diffusion of carbon dioxide and regulate water loss by transpiration</p> <p>b) describe the structure and function of guard cells and explain the mechanism by which they open and close stomata</p> <p>c) describe the role of abscisic acid in the closure of stomata during times of water stress (the role of calcium ions as a second messenger should be emphasised)</p> | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|------------------------------|--|--|-----------|----------|
| 15 Control and co-ordination | <p>15.1 Control and co-ordination in mammals</p> <p>The nervous system provides fast communication between receptors and effectors.</p> <p>Transmission between neurones takes place at synapses.</p> | <ul style="list-style-type: none"> a) compare the nervous and endocrine systems as communication systems that co-ordinate responses to changes in the internal and external environment (see 14.1a and 14.1b) b) describe the structure of a sensory neurone and a motor neurone c) outline the roles of sensory receptor cells in detecting stimuli and stimulating the transmission of nerve impulses in sensory neurones (a suitable example is the chemoreceptor cell found in human taste buds) d) describe the functions of sensory, relay and motor neurones in a reflex arc e) describe and explain the transmission of an action potential in a myelinated neurone and its initiation from a resting potential (the importance of sodium and potassium ions in impulse transmission should be emphasised) f) explain the importance of the myelin sheath (saltatory conduction) in determining the speed of nerve impulses and the refractory period in determining their frequency g) describe the structure of a cholinergic synapse and explain how it functions, including the role of calcium ions h) outline the roles of synapses in the nervous system in allowing transmission in one direction and in allowing connections between one neurone and many others (summation, facilitation and inhibitory synapses are not required) i) describe the roles of neuromuscular junctions, transverse system tubules and sarcoplasmic reticulum in stimulating contraction in striated muscle | | |

| A Level material | | | | |
|------------------------------|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 15 Control and co-ordination | The endocrine system is a slower system that controls long-term changes. Fertility may be controlled by use of hormones. | <ul style="list-style-type: none"> j) describe the ultrastructure of striated muscle with particular reference to sarcomere structure k) explain the sliding filament model of muscular contraction including the roles of troponin, tropomyosin, calcium ions and ATP l) explain the roles of the hormones FSH, LH, oestrogen and progesterone in controlling changes in the ovary and uterus during the human menstrual cycle m) outline the biological basis of contraceptive pills containing oestrogen and/or progesterone | | |
| 15 Control and co-ordination | <p>15.2 Control and co-ordination in plants</p> <p>Plant co-ordination systems involve rapid responses as in the case of the Venus fly trap, but also complex interactions between plant growth regulators, such as auxin and gibberellin. Plants respond quite differently to different concentrations of plant growth regulators.</p> | <ul style="list-style-type: none"> a) describe the rapid response of the Venus fly trap to stimulation of hairs on the lobes of modified leaves and explain how the closure of the trap is achieved b) explain the role of auxin in elongation growth by stimulating proton pumping to acidify cell walls c) describe the role of gibberellin in the germination of wheat or barley d) explain the role of gibberellin in stem elongation including the role of the dominant allele, <i>Le</i>, that codes for a functioning enzyme in the gibberellin synthesis pathway, and the recessive allele, <i>le</i>, that codes for a non-functional enzyme | | |

| A Level material | | | | |
|---------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 16 Inherited change | <p>16.1 Passage of information from parent to offspring</p> <p>Diploid organisms contain pairs of homologous chromosomes. The behaviour of maternal and paternal chromosomes during meiosis generates much variation amongst individuals of the next generation.</p> | <p>a) explain what is meant by homologous pairs of chromosomes</p> <p>b) explain the meanings of the terms haploid and diploid and the need for a reduction division (meiosis) prior to fertilisation in sexual reproduction</p> <p>c) outline the role of meiosis in gametogenesis in humans and in the formation of pollen grains and embryo sacs in flowering plants</p> <p>d) describe, with the aid of photomicrographs and diagrams, the behaviour of chromosomes in plant and animal cells during meiosis, and the associated behaviour of the nuclear envelope, cell surface membrane and the spindle (names of the main stages are expected, but not the sub-divisions of prophase)</p> <p>e) explain how crossing over and random assortment of homologous chromosomes during meiosis and random fusion of gametes at fertilisation lead to genetic variation including the expression of rare, recessive alleles</p> | | |

| A Level material | | | | |
|---------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 16 Inherited change | <p>16.2 The roles of genes in determining the phenotype</p> <p>Patterns of inheritance are explained by using genetic diagrams. The results of genetic crosses are analysed statistically using the chi-squared test.</p> <p>Studies of human genetic conditions have revealed the links between genes, enzymes and the phenotype.</p> | <p>a) explain the terms gene, locus, allele, dominant, recessive, codominant, linkage, test cross, F1 and F2, phenotype, genotype, homozygous and heterozygous</p> <p>b) use genetic diagrams to solve problems involving monohybrid and dihybrid crosses, including those involving autosomal linkage, sex linkage, codominance, multiple alleles and gene interactions (the term epistasis does not need to be used; knowledge of the expected ratio for various types of epistasis is not required. The focus is on problem solving)</p> <p>c) use genetic diagrams to solve problems involving test crosses</p> <p>d) use the chi-squared test to test the significance of differences between observed and expected results (the formula for the chi-squared test will be provided) (see Mathematical requirements)</p> <p>e) explain that gene mutation occurs by substitution, deletion and insertion of base pairs in DNA and outline how such mutations may affect the phenotype</p> <p>f) outline the effects of mutant alleles on the phenotype in the following human conditions: albinism, sickle cell anaemia, haemophilia and Huntington's disease</p> <p>g) explain the relationship between genes, enzymes and phenotype with respect to the gene for tyrosinase that is involved with the production of melanin</p> | | |

| A Level material | | | | |
|----------------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 16 Inherited change | <p>16.3 Gene control</p> <p>Some genes are transcribed all the time to produce constitutive proteins; others are only 'switched on' when their protein products are required.</p> | <p>a) distinguish between structural and regulatory genes and between repressible and inducible enzymes</p> <p>b) explain genetic control of protein production in a prokaryote using the <i>lac</i> operon</p> <p>c) explain the function of transcription factors in gene expression in eukaryotes</p> <p>d) explain how gibberellin activates genes by causing the breakdown of DELLA protein repressors, which normally inhibit factors that promote transcription</p> | | |
| 17 Selection and evolution | <p>17.1 Variation</p> <p>The variation that exists within a species is categorised as continuous and discontinuous. The environment has considerable influence on the expression of features that show continuous (or quantitative) variation.</p> | <p>a) describe the differences between continuous and discontinuous variation and explain the genetic basis of continuous (many, additive genes control a characteristic) and discontinuous variation (one or few genes control a characteristic) (examples from 16.2f may be used to illustrate discontinuous variation; height and mass may be used as examples of continuous variation)</p> <p>b) explain, with examples, how the environment may affect the phenotype of plants and animals</p> <p>c) use the <i>t</i>-test to compare the variation of two different populations (see Mathematical requirements)</p> <p>d) explain why genetic variation is important in selection</p> | | |

| A Level material | | | | |
|----------------------------|--|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 17 Selection and evolution | <p>17.2 Natural and artificial selection</p> <p>Populations of organisms have the potential to produce large numbers of offspring, yet their numbers remain fairly constant year after year.</p> <p>Humans use selective breeding (artificial selection) to improve features in ornamental plants, crop plants, domesticated animals and livestock.</p> | <p>a) explain that natural selection occurs as populations have the capacity to produce many offspring that compete for resources; in the 'struggle for existence' only the individuals that are best adapted survive to breed and pass on their alleles to the next generation</p> <p>b) explain, with examples, how environmental factors can act as stabilising, disruptive and directional forces of natural selection</p> <p>c) explain how selection, the founder effect and genetic drift may affect allele frequencies in populations</p> <p>d) use the Hardy–Weinberg principle to calculate allele, genotype and phenotype frequencies in populations and explain situations when this principle does not apply</p> <p>e) describe how selective breeding (artificial selection) has been used to improve the milk yield of dairy cattle</p> <p>f) outline the following examples of crop improvement by selective breeding:</p> <ul style="list-style-type: none"> the introduction of disease resistance to varieties of wheat and rice the incorporation of mutant alleles for gibberellin synthesis into dwarf varieties so increasing yield by having a greater proportion of energy put into grain inbreeding and hybridisation to produce vigorous, uniform varieties of maize | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|----------------------------|---|--|-----------|----------|
| 17 Selection and evolution | <p>17.3 Evolution</p> <p>Isolating mechanisms can lead to the accumulation of different genetic information in populations, potentially leading to new species.</p> <p>Over prolonged periods of time, some species have remained virtually unchanged, others have changed significantly and many have become extinct.</p> | <p>a) state the general theory of evolution that organisms have changed over time</p> <p>b) discuss the molecular evidence that reveals similarities between closely related organisms with reference to mitochondrial DNA and protein sequence data</p> <p>c) explain how speciation may occur as a result of geographical separation (allopatric speciation), and ecological and behavioural separation (sympatric speciation)</p> <p>d) explain the role of pre-zygotic and post-zygotic isolating mechanisms in the evolution of new species</p> <p>e) explain why organisms become extinct, with reference to climate change, competition, habitat loss and killing by humans</p> | | |

| A Level material | | | | |
|--|--|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 18 Biodiversity, classification and conservation | 18.1 Biodiversity Biodiversity is much more than a list of all the species in a particular area. | a) define the terms species, ecosystem and niche b) explain that biodiversity is considered at three different levels: <ul style="list-style-type: none"> variation in ecosystems or habitats the number of species and their relative abundance genetic variation within each species c) explain the importance of random sampling in determining the biodiversity of an area d) use suitable methods, such as frame quadrats, line transects, belt transects and mark-release-recapture, to assess the distribution and abundance of organisms in a local area e) use Spearman's rank correlation and Pearson's linear correlation to analyse the relationships between the distribution and abundance of species and abiotic or biotic factors f) use Simpson's Index of Diversity (D) to calculate the biodiversity of a habitat, using the formula $D = 1 - \left(\sum \left(\frac{n}{N}\right)^2\right)$ and state the significance of different values of D | | |

| A Level material | | | | |
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| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 18 Biodiversity, classification and conservation | 18.2 Classification Organisms studied locally may be used to show how hierarchical classification systems are organised. | a) describe the classification of species into the taxonomic hierarchy of domain, kingdom, phylum, class, order, family, genus and species b) outline the characteristic features of the three domains Archaea, Bacteria and Eukarya c) outline the characteristic features of the kingdoms Protocista, Fungi, Plantae and Animalia d) explain why viruses are not included in the three domain classification and outline how they are classified, limited to type of nucleic acid (RNA or DNA) and whether these are single stranded or double stranded | | |

| A Level material | | | | |
|--|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 18 Biodiversity, classification and conservation | <p>18.3 Conservation</p> <p>Maintaining biodiversity is important for many reasons.</p> <p>Actions to maintain biodiversity must be taken at local, national and global levels.</p> <p>It is important to conserve ecosystems as well as individual species.</p> | <p>a) discuss the threats to the biodiversity of aquatic and terrestrial ecosystems (see 18.1b)</p> <p>b) discuss the reasons for the need to maintain biodiversity</p> <p>c) discuss methods of protecting endangered species, including the roles of zoos, botanic gardens, conserved areas (national parks and marine parks), ‘frozen zoos’ and seed banks</p> <p>d) discuss methods of assisted reproduction, including IVF, embryo transfer and surrogacy, used in the conservation of endangered mammals</p> <p>e) discuss the use of culling and contraceptive methods to prevent overpopulation of protected and non-protected species</p> <p>f) use examples to explain the reasons for controlling alien species</p> <p>g) discuss the roles of non-governmental organisations, such as the World Wide Fund for Nature (WWF) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), in local and global conservation</p> <p>h) outline how degraded habitats may be restored with reference to local or regional examples</p> | | |

A Level material

| Topic | Sub-topic | You should be able to: | Checklist | Comments |
|-----------------------|---|--|-----------|----------|
| 19 Genetic technology | <p>19.1 Principles of genetic technology</p> <p>Genetic engineering involves the manipulation of naturally occurring processes and enzymes.</p> <p>Genome sequencing gives information about the location of genes and provides evidence for the evolutionary links between organisms.</p> | <p>a) define the term recombinant DNA</p> <p>b) explain that genetic engineering involves the extraction of genes from one organism, or the synthesis of genes, in order to place them in another organism (of the same or another species) such that the receiving organism expresses the gene product</p> <p>c) describe the principles of the polymerase chain reaction (PCR) to clone and amplify DNA (the role of <i>Taq</i> polymerase should be emphasised)</p> <p>d) describe and explain how gel electrophoresis is used to analyse proteins and nucleic acids, and to distinguish between the alleles of a gene (limited to the separation of polypeptides and the separation of DNA fragments cut with restriction endonucleases)</p> <p>e) describe the properties of plasmids that allow them to be used in gene cloning</p> <p>f) explain why promoters and other control sequences may have to be transferred as well as the desired gene</p> <p>g) explain the use of genes for fluorescent or easily stained substances as markers in gene technology</p> <p>h) explain the roles of restriction endonucleases, reverse transcriptase and ligases in genetic engineering</p> <p>i) explain, in outline, how microarrays are used in the analysis of genomes and in detecting mRNA in studies of gene expression</p> | | |

| A Level material | | | | |
|-----------------------|---|--|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 19 Genetic technology | 19.2 Genetic technology applied to medicine | <ul style="list-style-type: none"> a) define the term bioinformatics b) outline the role of bioinformatics following the sequencing of genomes, such as those of humans and parasites, e.g. <i>Plasmodium</i> (details of methods of DNA sequencing are not required) c) explain the advantages of producing human proteins by recombinant DNA techniques (reference should be made to some suitable examples, such as insulin, factor VIII for the treatment of haemophilia and adenosine deaminase for treating severe combined immunodeficiency (SCID)) d) outline the advantages of screening for genetic conditions (reference may be made to tests for specific genes such as those for breast cancer, <i>BRCA1</i> and <i>BRCA2</i>, and genes for haemophilia, sickle cell anaemia, Huntington's disease and cystic fibrosis) e) outline how genetic diseases can be treated with gene therapy and discuss the challenges in choosing appropriate vectors, such as viruses, liposomes and naked DNA (reference may be made to SCID, inherited eye diseases and cystic fibrosis) f) discuss the social and ethical considerations of using gene testing and gene therapy in medicine (reference should be made to genetic conditions for which treatments exist and where none exist, also to IVF, embryo biopsy and preselection and to therapeutic abortions) g) outline the use of PCR and DNA testing in forensic medicine and criminal investigations | | |

| A Level material | | | | |
|-----------------------|---|---|-----------|----------|
| Topic | Sub-topic | You should be able to: | Checklist | Comments |
| 19 Genetic technology | <p>19.3 Genetically modified organisms in agriculture</p> <p>The ability to manipulate genes has many potential benefits in agriculture, but the implications of releasing genetically modified organisms (GMOs) into the environment are subject to much public debate in some countries.</p> | <p>a) explain the significance of genetic engineering in improving the quality and yield of crop plants and livestock in solving the demand for food in the world, e.g. Bt maize, vitamin A enhanced rice (Golden rice™) and GM salmon</p> <p>b) outline the way in which the production of crops such as maize, cotton, tobacco and oil seed rape may be increased by using varieties that are genetically modified for herbicide resistance and insect resistance</p> <p>c) discuss the ethical and social implications of using genetically modified organisms (GMOs) in food production</p> | | |

Section 5: Useful websites

These web pages can be used as useful resources to help you study for your Cambridge International AS and A Level Biology.

www.biozone.co.uk

This is an excellent gateway to many other websites with useful material to support topics in both AS and A Level. Click on Biolinks Database on the home page.

www.s-cool.co.uk

Many web pages of structured notes to help you with most of the topics at AS and A Level. There is plenty of useful advice on revision.

users.rcn.com/jkimball.ma.ultranet/BiologyPages/

Kimball's Biology Pages: an American online textbook. This is very well organised so that you can find information easily.

www.biotopics.co.uk/

A private web site run by a teacher in the UK. It has many useful resources and links.

www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html

This is the table of contents for Mike Farabee's online textbook of biology. Many topics from the AS and A Level syllabus are covered.

www.bozemanscience.com/science-videos/

You will find many videos on biological topics on YouTube; this site has video lessons that support Advanced Placement (AP), but are just as suitable for A Level.

www.cellsalive.com

An interactive website with lots of good images and animations to help you with cell biology, microscopy, microbiology and the immunity section in AS Level.

www.biology.arizona.edu/default.html

The Biology Project from the University of Arizona. This has many excellent animations, tutorials and online tests.

www.dnafb.org/dnafb/

DNA from the beginning: online tutorials on the structure of DNA, genetics, and genetic organisation and control. There are 41 different topics including easy-to-follow explanations of key experiments in the history of genetics from Mendel onwards.

www-medlib.med.utah.edu/kw/pharm/hyper_heart1.html

An excellent site that shows you what happens during the cardiac cycle. You need Adobe Shockwave to run the animation.

www.who.ch

This is the website of the World Health Organization. Use this website to find up-to-date information on infectious and non-infectious diseases.

www.cdc.gov/

This is the website of the Centers for Disease Control in the USA. You can also use this website for up-to-date information about diseases.

www.mbgnet.net/bioplants/main.html

The biology of plants – the website of the Missouri Botanic Gardens. A simple introduction to plant science.

images.botany.org/

This site has many useful images of plant biology to complement the website above.

www.bu.edu/histology/m/index.htm

The Histology Learning System has many electron micrographs of animal cells (see the section called Ultrastructure of the Cell) and photomicrographs of tissues.

www.uni-mainz.de/FB/Medizin/Anatomie/workshop/EM/EMAtlas.html

This site has many excellent transmission electron micrographs – all in black and white, not false colour as in many textbooks. Electron micrographs in examination papers are always printed in black and white and you should get used to interpreting them.

www.chemguideforcie.co.uk/index.html

This is a site that supports Cambridge International AS and A Level Chemistry. You may find this useful for Section 2 on biological molecules if you are unsure about some basic chemistry.

www.rsc.org/Education/Teachers/Resources/cfb/

Chemistry for Biologists from the Royal Society of Chemistry which will also help you with Section B on biological molecules. You can visualise molecules on this website with Jmol the open access molecular visualisation application.

www.johnkyrk.com/

This site has animations for a variety of topics in your course, such as DNA replication, transcription, translation, mitosis, meiosis, respiration and photosynthesis.

highered.mcgraw-hill.com/sites/dl/free/0072437316/120060/ravenanimation.html

The animations that support the American textbook: Biology by Raven and Johnson are highly recommended.

www.sumanasinc.com/webcontent/animation.html

This site has animations for a wide variety of topics in the syllabus.

learn.genetics.utah.edu/

This is the website of Learn Genetics™, the Genetic Science Learning Center of the University of Utah. This will help you with the ethics of modern genetics as well as much else.

www.yourgenome.org/

This is the educational website of the Wellcome Trust's Sanger Institute in Cambridge, UK. This will bring you up-to-date on many aspects of your course.

www.wellcome.ac.uk/Education-resources/Teaching-and-education/Big-Picture/index.htm

Online resources for post-16 biology courses from the Wellcome Trust in the UK.

www.beep.ac.uk/

The Bioethics Education Project based at Bristol in the UK. Many useful resources for the ethical issues discussed in the A Level course.

Section 5: Useful websites

library.med.utah.edu/WebPath/

This site has many useful images of human anatomy and histology.

evolution.berkeley.edu/

Many resources on evolution from the University of California Museum of Palaeontology.

www.nobelprize.org/

The Nobel Prize website has many useful educational resources as well as information about past Nobel Prize winners, such as Francis Watson, James Crick, Melvin Calvin and Hans Krebs, and their discoveries.

www.wellcometreeoflife.org/

The Interactive Tree of Life from the Wellcome Trust. this will help you with biodiversity in the A Level course.

www.iucn.org/

The website of the International Union for Conservation of Nature (IUCN). This holds lots of information about biodiversity and conservation. The IUCN has a database of many endangered species showing their conservation status at www.iucnredlist.org/

www.kew.org/science-conservation/index.htm

These are the Science and Conservation pages of the website of the Royal Botanic Gardens at Kew, London.

www.zsl.org/conservation/

The conservation pages of the website of ZSL – the Zoological Society of London.

textbookofbacteriology.net/themicrobialworld/homepage.html

The New Microbial World. Although designed for university students, you will find useful background material on the microorganisms you study in sections on prokaryote structure, disease, classification and biotechnology.

Section 6: Appendices

Mathematical skills

This is a checklist of the mathematical skills you need for your biology examination. You should tick each box in the checklist when you know that you have learned the skill.

Ask your teacher to explain any skill you are unsure about. The 'Comments' column is for extra notes and examples.

You can use a calculator for all the examination papers. If your calculator is one that can be programmed, you should make sure that any information in it is removed before the examination.

| You should be able to: | Checklist | Comments |
|--|-----------|----------|
| At AS Level and A Level | | |
| <ul style="list-style-type: none"> recognise and use expressions in decimal and standard form | | |
| <ul style="list-style-type: none"> use a calculator for addition, subtraction, multiplication and division, finding the arithmetical mean and to find and use x, x^2, $\frac{1}{x}$, $\log_{10}x$ and \sqrt{x} | | |
| <ul style="list-style-type: none"> understand and use the symbols $<$, $>$, Δ, \approx, $/$, ∞, Σ | | |
| <ul style="list-style-type: none"> understand and use the prefixes: giga (G), mega (M), kilo (k), milli (m), micro (μ), and nano (n) | | |
| <ul style="list-style-type: none"> calculate magnifications and actual sizes | | |
| <ul style="list-style-type: none"> take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified | | |
| <ul style="list-style-type: none"> make estimations of the results of calculations (without using a calculator) | | |
| <ul style="list-style-type: none"> use a spreadsheet program for collating, analysing and presenting data | | |
| <ul style="list-style-type: none"> recognise and use ratios | | |
| <ul style="list-style-type: none"> calculate percentages and percentage changes | | |
| <ul style="list-style-type: none"> express errors in experimental work as percentage errors | | |
| <ul style="list-style-type: none"> calculate areas of right-angled and isosceles triangles, circumferences and areas of circles, areas and volumes of cylinders, rectangles and rectangular blocks | | |
| <ul style="list-style-type: none"> translate information between graphical, numerical, and algebraic forms | | |
| <ul style="list-style-type: none"> construct and interpret frequency distributions and diagrams, such as pie charts, bar charts and histograms | | |
| <ul style="list-style-type: none"> understand when information should be presented in the form of a bar chart, histogram or line graph | | |

| You should be able to: | Checklist | Comments |
|--|-----------|----------|
| <ul style="list-style-type: none"> select appropriate variables and scales for graph plotting using standard 2 mm square graph paper | | |
| <ul style="list-style-type: none"> recognise when it is appropriate to join the points on a graph with straight ruled lines and when it is appropriate to use a line (straight or curved) of best fit | | |
| <ul style="list-style-type: none"> calculate the rate of change from a line on a graph | | |
| <ul style="list-style-type: none"> draw and use the slope of a tangent to a curve as a means to obtain the rate of change. | | |
| At A Level only | | |
| <ul style="list-style-type: none"> have sufficient understanding of probability to understand genetic ratios | | |
| <ul style="list-style-type: none"> understand the principles of sampling as applied to biological situations and data | | |
| <ul style="list-style-type: none"> understand the importance of chance when interpreting data | | |
| <ul style="list-style-type: none"> use the Petersen or Lincoln index to calculate an estimate of population size using mark-release-recapture data and the formula: $N = \frac{n_1 \times n_2}{m_2}$ N = population estimate n_1 = number of marked individuals released n_2 = number of individuals (both marked and unmarked) captured m_2 = number of marked individuals recaptured | | |
| <ul style="list-style-type: none"> calculate Simpson's Index of Diversity (D) using the formula: $D = 1 - \sum \frac{n}{N} \frac{n}{N}$ n = number of individuals of each type present in the sample (types may be species and/or higher taxa such as genera, families, etc.) N = the total number of all individuals of all types | | |
| <ul style="list-style-type: none"> calculate standard deviation and standard error | | |
| <ul style="list-style-type: none"> understand the benefits of using standard error and 95% confidence intervals (95% CI) to make statements about data and to use as error bars on graphs | | |
| <ul style="list-style-type: none"> understand the difference between correlation and causation; use Spearman's rank correlation and Pearson's linear correlation to test for correlation | | |
| <ul style="list-style-type: none"> use the χ^2 test and the t-test | | |
| <ul style="list-style-type: none"> use a spreadsheet program for analysing and presenting data, making calculations and carrying out statistical tests. | | |

More information about the examination

The command words used in biology examination papers are given in the sections that follow. It is very important that you know and understand all of them before you take your examination. You should ask your teacher to explain anything that you are unsure about.

Numbers

The decimal point will be placed on the line, e.g. 52.35.

Numbers from 1000 to 9999 will be printed without commas or spaces.

Numbers greater than or equal to 10000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

Units

The International System of units or, where appropriate, units approved by the BIPM for use with the SI (e.g. minute) will be used. Units will be indicated in the singular not in the plural, e.g. 28 kg.

(a) SI units commonly used in biology

N.B. Care should be taken in the use of *mass* and *weight*. In most biological contexts, the term mass is correct, e.g. dry mass, biomass.

| <i>Quantity</i> | <i>Name of unit</i> | <i>Symbol for unit</i> |
|---------------------|---------------------|------------------------|
| length | kilometre | km |
| | metre | m |
| | centimetre | cm |
| | millimetre | mm |
| | micrometer | µm |
| mass | tonne (1000 kg) | (no symbol) |
| | kilogram | kg |
| | gram | g |
| | milligram | mg |
| | microgram | µg |
| time | year | y |
| | day | d |
| | hour | h |
| | minute | min |
| | second | s |
| amount of substance | mole | mol |

(b) Derived SI units

| | | |
|--------|---------------------------|----|
| energy | kilojoule | kJ |
| | joule | J |
| | (the calorie is obsolete) | |

(c) Recommended units for area, volume and density are listed below.

| | | | |
|---------|--------------------------------------|-----------|---------------------------------|
| area | hectare = 10^4 m^2 | | ha |
| | square metre | | m^2 |
| | square decimetre | | dm^2 |
| | square centimetre | | cm^2 |
| | square millimetre | | mm^2 |
| volume | cubic kilometre | | km^3 |
| | cubic metre | | m^3 |
| | cubic decimetre (preferred to litre) | | dm^3 |
| | litre | | dm^3 (not l) |
| | cubic centimetre | | cm^3 (not ml) |
| | cubic millimetre | | mm^3 |
| density | kilogram per cubic metre | <i>or</i> | kg m^{-3} |
| | gram per cubic centimetre | <i>or</i> | g cm^{-3} |

(d) Use of Solidus

The solidus (/) will not be used for a quotient, e.g. m/s will not be used for metres per second.

Presentation of data

This section is relevant to Papers 3 and 5. You should follow these conventions when presenting data in tables and graphs.

The solidus (/) is to be used for separating the quantity and the unit in tables, graphs and charts, e.g. time/s for time in seconds.

(a) Tables

- (i) Each column of a table will be headed with the physical quantity and the appropriate unit, e.g. time/s. There are three acceptable methods of stating units, e.g. metres per sec or m per s or m s^{-1} .
- (ii) The column headings of the table can then be directly transferred to the axes of a constructed graph.

(b) Graphs

- (i) The independent variable should be plotted on the *x*-axis (horizontal axis) and the dependent variable plotted on the *y*-axis (vertical axis).
- (ii) Each axis will be labelled with the physical quantity and the appropriate unit, e.g. time/s.
- (iii) The graph is the whole diagrammatic presentation. It may have one or several curves plotted on it.
- (iv) Curves and lines joining points on the graph should be referred to as 'curves'.
- (v) Points on the curve should be clearly marked as crosses (x) or by dots within circles. If a further curve is included, vertical crosses (+) may be used to mark the points.

(c) Pie charts

These should be drawn with the sectors in rank order, largest first, beginning at 'noon' and proceeding clockwise. Pie Charts should preferably contain no more than six sectors.

(d) Bar charts

These are drawn when one of the variables is not numerical, e.g. percentage of vitamin C in different fruits. They should be made up of narrow blocks of equal width that do not touch.

(e) Column graphs

These are drawn when plotting frequency graphs from discrete data, e.g. frequency of occurrence of leaves with different numbers of prickles or pods with different numbers of seeds. They should be made up of narrow blocks of equal width that do **not** touch.

(f) Histograms

These are drawn when plotting frequency graphs with continuous data, e.g., frequency of occurrence of leaves of different lengths. The blocks should be drawn in order of increasing or decreasing magnitude and they **should** be touching.

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