CAMBRIDGE
International Examinations

Cambridge
International
AS & A Level

Learner Guide

Cambridge International AS & A Level Biology

9700

Cambridge Advanced

Contents

How to use this guide 3

Section 1: How will you be tested?
Section 2: Examination tips
Section 3: What will you be tested on?
Section 4: What you need to know
Section 5: Useful websites
Section 6: Appendices

Section 1: How will you be tested? 5

1.1 The examinations you will take
1.2 About the examination papers
1.3 About the practical papers

Section 2: Examination tips 7

General advice
What you should look for in a question
The rest of these tips concern the individual papers

Section 3: What will you be tested on? 33

Section 4: What you need to know 37

Section 5: Useful websites 59

Section 6: Appendices 63

6.1 The mathematical skills you need
6.2 Other important information you need for your biology examination
6.3 Command words and phrases used in biology examination papers

How to use this guide

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

It can be used to help you to plan your revision programme for the theory examinations and will explain what the we are looking for in the answers you write. It can also be used to help you revise by using the table in Section 3, '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 tips

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

Section 3: What will you be tested on?

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 – AS, A2
- 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?

1.1 The examinations you will take

There are three ways you can gain an advanced level qualification.

- take the AS qualification only
- follow a **staged** assessment route to the A Level by taking the AS papers and the A2 papers in different examination sessions. Usually this means taking the AS papers at the end of one year of study and the A2 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

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

You will take Paper 1 (theory, multiple choice), Paper 2 (theory, structured questions) and Paper 3 (practical test).

A2

You will be entered for **two** examination Papers, Papers 4 and 5.

You will take Paper 4 (theory) and Paper 5 (planning, analysis and evaluation.).

1.2 About the examination 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 4 possible answers.	31	15
2	1 hour 15 min (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

Paper number	How long and how many marks?	What's in the paper?	Weighting %	
			AS	A
4	2 hours (100 marks)	Structured questions, totalling 85 marks plus a choice of free response questions that carry a further 15 marks. Based on the A2 syllabus, but a knowledge of the AS syllabus is required.	–	38
5	1 hour 15 min (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 A2.	–	12

1.3 About the practical papers

Twenty-three percent of the marks for **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:

- planning
- implementing
- interpreting and concluding

When unfamiliar materials or techniques are involved, you will be given full instructions. Questions could be set that will require the use of a microscope or hand lens.

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. 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. If they are, you will be provided with the formulae for these tests.

Section 2: Examination tips

Much of this advice is given in response to the types of answers that learners have written in the past. These tips are 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 tips.

- Make sure that you read all the general tips. 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 these tips. Note that in Section 4 the first part is the AS syllabus and the second part is A2.
- Make sure that you know the examination papers that you are taking before you look at the tips for the different papers.
- At AS, 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, 11, 12 and 13 are all multiple choice papers.

- At A2, you will take
    - Paper 4, which has a short-answer part 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 gain marks.
- 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 get more marks 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 are defined in the syllabus, so that is a good place to start when making your own dictionary. Many of the definitions in the 'Definitions' section of the syllabus are quite long. It would be a good idea to write more concise definitions for yourself and use them to start your own biological dictionary using your class notes, web sites and the glossaries from the back of text books.
  - 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.

What you should look for in a question

The number of 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 terms* used in science papers in the 'Appendix' section of 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 a tip about answering questions that have two command terms and require an extended answer.
    - The table below has a list of terms used in biology papers to tell you what to do in an 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.

What the question is about

- 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 from section A or blood from section G, 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 A, G and J.
  - 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 K 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 script towards the end of the examination.
  - Try not to leave blanks. Always check through your script 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.

Example 3

It helps to highlight the main features of a question. You cannot use a highlighter pen, so the best thing to do is to underline or circle key words in the questions.

Question

Azotobacter vinelandii is a bacterium found in the soil that is able to fix atmospheric nitrogen.

One feature of nitrogen-fixing bacteria is the ability to synthesise the enzyme nitrogenase, a molybdenum- and iron-containing, protein complex.

Molybdenum is a mineral ion found in the soil solution. It enters the cell as molybdate ions, through membrane transport proteins. The proteins have the ability to bind to, and hydrolyse, ATP.

Name **and** describe the mechanism of transport of molybdate ions into the cell. [3]

Underline or circle the important words in the introductory text – especially those that give a clue as to the topics tested. Notice *enzyme* and *nitrogen* which suggests the questions will be about sections C and K from the syllabus. The first part question began with two command words. Underline them to remind yourself that there are two different tasks – to write the answer *active transport* and describe how this occurs. *Ion*, *transport protein*, *membrane* and *ATP* are all clues as to what to write.

Command words

- You can find out more about command terms in the *Glossary of terms* towards the end of 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 of 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.
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

Command words	What you should do in response to each command word
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 one 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 A2, you should also know how to use the formulae for standard deviation, standard error, the chi-squared test and the *t*-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 pair of axes printed on the exam paper without a line or curve

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.

Use information given 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;
    - 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.

Interpret 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 ± 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.

Make 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 4

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 ensures 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 5

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.

The rest of these tips concern the individual papers

Paper 1

- 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 Section A on cells and those at the end will be on Sections J and K about immunity and ecology.
- 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 answers 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

- This paper has a mix of short answers 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

General tips

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
- choose the number of measurements to take
- decide 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 you can 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 cm^3 as g/100 cm^3. 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 AS/A Biology.

Correct and incorrect ways of showing units in tables and graphs

Correct	Incorrect
either: rate / mm cm^{-3} *or:* rate (mm cm^{-3})	rate mm/cm^3
either: concentration / g 100 cm^{-3} *or:* 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:

<table>
<tr><th>feature</th><th>specimen A</th><th>specimen B</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">similarities</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

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/$cm^3\ s^{-1}$'.

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 20 mm 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 ±0.5 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 ± 0.5 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 ± 1.0 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 ± 1.0 cm^3, then the percentage error is 1.0/7.5 × 100 = 13.3%.

Conclusions

- Conclusions are brief statements supported with explanations using your knowledge from the AS syllabus (Sections A to K).
- 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
  - 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
- calculate mean results
- use a different way to measure the dependent variable so the results are more accurate
- use 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

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. Some of them test your knowledge of the Applications part of the A2 syllabus (Sections Q to U).
- Questions on the Applications topics almost always have data to analyse and interpret.
- 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

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 such tasks as:

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

In most cases the data are 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 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. Axes labels would be 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.

- 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 grams 100 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 two statistical tests – the chi-squared test and the *t*-test
- 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 you be tested on?

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

There are three main objectives:

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

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

C – Experimental skills and investigations

The theory papers test Assessment Objective A and Assessment Objective B. The purpose of the practical paper is to test Assessment Objective C. 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	Skill area	You will need to demonstrate this skill in relation to:
A1	knowledge with understanding	biological phenomena, facts, laws, definitions, concepts and theories
A2		biological vocabulary, terminology, conventions (including symbols, quantities and units)
A3		scientific instruments and apparatus used in biology, including techniques of operation and aspects of safety
A4		scientific quantities and their determination
A5		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	Skill area	You will need to use written, symbolic, graphical and numerical forms of presentation to:
B1	handling information and solving problems	locate, select, organise and present information from a variety of sources
B2		translate information from one form to another
B3		manipulate numerical and other data
B4		use information to identify patterns, report trends and draw inferences
B5		present reasoned explanation for phenomena, patterns and relationships
B6		make predictions and propose hypotheses
B7		apply knowledge, including principles, to novel situations
B8		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	Skill area	You will need to be able to:
C1	experimental skills and investigations	follow a sequence of instructions
C2		use techniques, apparatus and materials
C3		make and record observations, measurements and estimates
C4		interpret and evaluate observations and experimental data
C5		devise and plan investigations, select techniques, apparatus and materials
C6		evaluate methods and techniques 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
A – knowledge with understanding	45	Papers 1, 2 and 4
B – handling information and solving problems	32	Papers 1, 2 and 4
C – 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 skills A and B.

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 A2.

How to use the table
The table is divided into a number of columns.

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

AS	11	(A–K)
A2	5	(L–P)

Topic – this column subdivides the main theme 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.

Those bullet points highlighted with an asterisk (*) are areas which would be suitable for practical work. You should make sure that you have done some practical work on each learning outcome with an asterisk. See the comments below about preparing yourself for Paper 3 and Paper 5.

At the end of each topic in the syllabus it says that you will be expected to '*use the knowledge gained in this section in new situations or to solve related problems*'. This means that 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 Core material

Theme	Topic	You should be able to:	Checklist	Comments
A. Cell structure	The microscope in cell studies Cells as basic units of living organisms Detailed structure of animal and plant cells, as seen under the electron microscope Outline functions of organelles in plant and animal cells Characteristics of prokaryotic and eukaryotic cells	• *use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre, nanometre) used in cell studies; • explain and distinguish between resolution and magnification, with reference to light microscopy and electron microscopy; • describe and interpret drawings and photographs of typical animal and plant cells, as seen using the electron microscope, recognising the following: rough endoplasmic reticulum and smooth endoplasmic reticulum, Golgi body (Golgi apparatus or Golgi complex), mitochondria, ribosomes, lysosomes, chloroplasts, cell surface membrane, nuclear envelope, centrioles, nucleus, nucleolus, microvilli, cell wall, the large permanent vacuole and tonoplast (of plant cells) and plasmodesmata. (knowledge that ribosomes occurring in the mitochondria and chloroplasts are 70S (smaller) than those in the rest of the cell (80S) should be included. The existence of small circular DNA in the mitochondrion and chloroplast should be noted); • outline the functions of the structures listed above; • *compare the structure of typical animal and plant cells; • *draw and label low power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves); • *calculate linear magnification of drawings and photographs; • *calculate actual sizes of specimens from drawings and photographs; • outline key structural features of prokaryotic cells (including: unicellular, 1-5µm diameter, peptidoglycan cell walls, lack of membrane-bound organelles, naked circular DNA, 70S ribosomes) and compare and contrast the structure of prokaryotic cells with eukaryotic cells (reference to mesosomes should not be included).		

Theme	Topic	You should be able to:	Checklist	Comments
B. Biological molecules	Structure of carbohydrates, lipids and proteins and their roles in living organisms Water and living organisms	• *carry out tests for reducing and non-reducing sugars (including semi-quantitative use of the Benedict's test), the iodine in potassium iodide solution test for starch, the emulsion test for lipids and the biuret test for proteins; • describe the ring forms of α-glucose and β-glucose (candidates should be familiar with the terms *monomer*, *polymer* and *macromolecule*); • describe the formation and breakage of a glycosidic bond with reference both to polysaccharides and to disaccharides including sucrose; • describe the molecular structure of polysaccharides including starch (amylose and amylopectin), glycogen and cellulose and relate these structures to their functions in living organisms; • describe the molecular structure of a triglyceride and a phospholipid and relate these structures to their functions in living organisms; • describe the structure of an amino acid and the formation and breakage of a peptide bond; • 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 the molecule in shape; • 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 2 alpha (α) chains and 2 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 collage fibres); • describe and explain the roles of water in living organisms and as an environment for organisms.		

Theme	Topic	You should be able to:	Checklist	Comments
C. Enzymes	The mode of actions of enzymes Factors that affect enzyme action	• explain that enzymes are globular proteins that catalyse metabolic reactions; • 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); • follow 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); • *investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme-catalysed reactions; • explain the effects of competitive and non-competitive inhibitors on the rate of enzyme activity.		
D. Cell membranes and transport	The fluid mosaic model of membrane structure Movement of substances into and out of cells	• describe and explain the fluid mosaic model of membrane structure, including an outline of the roles of phospholipids, cholesterol, glycolipids, proteins and glycoproteins; • outline the roles of cell surface membranes; • describe and explain the processes of *diffusion, facilitated diffusion, osmosis, active transport, endocytosis* and *exocytosis*; • *investigate the effects on plant cells and the effect on animal cells of immersion in solutions of different water potential (**no** calculations involving water potential will be set).		

Theme	Topic	You should be able to:	Checklist	Comments
E. Cell and nuclear division	Replication and division of nuclei and cells Understanding of chromosome behaviour in mitosis	• explain the importance of mitosis in the production of genetically identical cells, growth, repair and asexual reproduction; • outline the cell cycle, including growth, DNA replication, mitosis and cytokinesis; • describe, with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane, centrioles and spindle (names of the main stages are expected); • explain how uncontrolled cell division can result in the formation of a tumour and identify factors that can increase the chances of cancerous growth; • explain the meanings of the terms *haploid* and *diploid* (see 'Definitions' section) and the need for a reduction division (meiosis) prior to fertilisation in sexual reproduction (note: descriptions of homologous chromosomes are not required for AS Level).		

Theme	Topic	You should be able to:	Checklist	Comments
F. Genetic control	Structure and replication of DNA Role of DNA in protein synthesis	• describe the structure of RNA and DNA and explain the importance of base pairing and the different hydrogen bonding between bases (includes reference to adenine and guanine as purines and to cytosine, thymine and uracil as pyrimidines. Structural formulae for bases is not required but the recognition that purines have a double ring structure and pyrimidines have a single ring structure should be included); • explain how DNA replicates semi-conservatively during interphase; • 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 and state that a mutation is a change in the sequence that may result in an altered polypeptide; • describe the way in which the nucleotide sequence codes for the amino acid sequence in a polypeptide with reference to the nucleotide sequence for HbA (normal) and HbS (sickle cell) alleles of the gene for the β-globin polypeptide; • describe how the information on DNA is used during transcription and translation to construct polypeptides, including the role of messenger RNA (mRNA), transfer RNA (tRNA) and the ribosomes.		

Theme	Topic	You should be able to:	Checklist	Comments
G. Transport	The need for, and functioning of, a transport system in multicellular plants	• explain the need for transport systems in multicellular plants and animals in terms of size and surface area to volume ratios; • define the term *transpiration* and explain that it is an inevitable consequence of gas exchange in plants; • *describe how to investigate experimentally the factors that affect transpiration rate; • *describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants; • *describe the structure of xylem vessel elements, phloem sieve tube elements and companion cells and be able to recognise these using the light microscope; • relate the structure of xylem vessel elements, phloem sieve tube elements and companion cells to their functions; • explain the movement of water between plant cells and between them and their environment, in terms of water potential (no calculations involving water potential will be set); • describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves (includes reference to the symplast/symplastic pathway and apoplast/ apoplastic pathway); • outline the roles of nitrate ions and of magnesium ions in plants; • *describe how the leaves of xerophytic plants are adapted to reduce water loss by transpiration; • explain translocation as an energy-requiring process transporting assimilates, especially sucrose, between the leaves (sources) and other parts of the plant (sinks); • explain the translocation of sucrose using the mass flow hypothesis;		

Theme	Topic	You should be able to:	Checklist	Comments
G. Transport	The need for, and functioning of, a transport system in mammals The structure and functioning of the mammalian heart	• *describe the structures of arteries, veins and capillaries and be able to recognise these vessels using the light microscope; • explain the relationship between the structure and function of arteries, veins and capillaries; • *describe the structure of red blood cells, phagocytes (macrophages and neutrophils) and lymphocytes; • state and explain the differences between blood, tissue fluid and lymph; • describe the role of haemoglobin in carrying oxygen and carbon dioxide (including the role of carbonic anhydrase, the formation of haemoglobinic acid and carbaminohaemoglobin); • describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide concentrations (the Bohr effect); • describe and explain the significance of the increase in the red blood cell count of humans at high altitude; • describe the external and internal structure of the mammalian heart; • explain the differences in the thickness of the walls of the different chambers in terms of their functions; • describe the mammalian circulatory system as a closed double circulation; • describe the cardiac cycle (including blood pressure changes during systole and diastole); • explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue).		

Theme	Topic	You should be able to:	Checklist	Comments
H. Gas exchange	The respiratory system	• *describe the structure of the human gas exchange system, including the microscopic structure of the walls of the trachea, bronchioles and alveoli with their associated blood vessels; • *describe the distribution of cartilage, ciliated epithelium, goblet cells and smooth muscle in the trachea, bronchi and bronchioles; • describe the functions of cartilage, cilia, goblet cells, mucous glands, smooth muscle and elastic fibres in the gas exchange system; • describe the process of gas exchange between air in the alveoli and the blood;		
	Smoking and smoking-related diseases	• describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system; • describe the signs and symptoms that enable diagnosis of lung cancer and chronic obstructive pulmonary disease (COPD) (emphysema and chronic bronchitis); • describe the effects of nicotine and carbon monoxide on the cardiovascular system; • explain how tobacco smoking contributes to atherosclerosis and coronary heart disease (CHD); • evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death; • discuss the difficulties in achieving a balance between preventions and cure with reference to coronary heart disease, coronary by-pass surgery and heart transplant surgery.		

Theme	Topic	You should be able to:	Checklist	Comments
I. Infectious disease	Cholera, malaria, tuberculosis and AIDS Antibiotics	• define the term *disease* and explain the difference between an *infectious disease* and non-infectious diseases (limited to sickle cell anaemia and lung cancer); • state names and types of causative organism of each of the following diseases: cholera, malaria, TB, HIV/AIDS, smallpox and measles (detailed knowledge of structure is **not** required. For smallpox (Variola) and measles (Morbillivirus) names of genus only is needed); • explain how cholera, malaria, TB and HIV/AIDS are transmitted; • discuss the 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) (an appreciation of social and biological factors and how economic factors can affect these should be included); • discuss the factors that influence the global patterns of distribution of malaria, TB and HIV/AIDS and assess the importance of these diseases worldwide; • outline the role of antibiotics in the treatment of bacterial infectious diseases (knowledge of specific antibiotics and their mode of action is **not** required).		

Theme	Topic	You should be able to:	Checklist	Comments
J. Immunity	The immune system Vaccination	• *recognise phagocytes and lymphocytes under the light microscope; • state the origin and describe the mode of action of phagocytes (macrophages and neutrophils); • describe the modes of action of B-lymphocytes and T-lymphocytes; • distinguish between B-lymphocytes and T-lymphocytes in their mode of action in fighting infection and describe their origin and functions; • explain the meaning of the term *immune response*, making reference to the terms antigen, self and non-self; • explain the role of memory cells in long-term immunity; • relate the molecular structure of antibodies to their functions; • distinguish between *active* and *passive, natural* and *artificial immunity* and explain how vaccination can control disease; • discuss the reasons why vaccination programmes have eradicated smallpox but not measles, tuberculosis (TB), malaria or cholera.		
K. Ecology	Levels of ecological organisation Energy flow through ecosystems Recycling of nitrogen	• define the terms *habitat*, *niche*, *population*, *community* and *ecosystem* and be able to recognise examples of each; • explain the terms *autotroph*, *heterotroph*, *producer*, *consumer* and *trophic level* in the context of food chains and food webs; • explain how energy losses occur along food chains and discuss the efficiency of energy transfer between trophic levels; • describe how nitrogen is cycled within an ecosystem, including the roles of nitrogen-fixing bacteria (e.g. *Rhizobium*), and nitrifying bacteria (*Nitrosomonas* and *Nitrobacter*).		

A2 Core Material

Theme	Topic	You should be able to:	Checklist	Comments
L. Energy and respiration (cont.)	The need for energy in living organisms Respiration as an energy transfer process Aerobic respiration Anaerobic respiration	• outline the need for energy in living organisms, as illustrated by anabolic reactions, active transport, movement and the maintenance of body temperature; • describe the structure of ATP as a phosphorylated nucleotide; • describe the universal role of ATP as the energy currency in all living organisms; • explain that the synthesis of ATP is associated with the electron transport chain on the membranes of the mitochondrion; • outline glycolysis as phosphorylation of glucose and the subsequent splitting of hexose phosphate (6C) into two triose phosphate molecules, which are then further oxidised with a small yield of ATP and reduced NAD; • explain that, when oxygen is available, pyruvate is converted into acetyl (2C) coenzyme A, which then combines with oxaloacetate (4C) to form citrate (6C); • outline the Krebs cycle, explaining that citrate is reconverted to oxaloacetate in a series of small steps in the matrix of the mitochondrion (no further details are required); • explain that these processes involve decarboxylation and dehydrogenation and describe the role of NAD; • outline the process of oxidative phosphorylation, including the role of oxygen (no details of the carriers are required); • explain the production of a small yield of ATP from anaerobic respiration and the formation of ethanol in yeast and lactate in mammals, including the concept of oxygen debt;		

Theme	Topic	You should be able to:	Checklist	Comments
L. Energy and respiration	The use of respirometers	• explain the relative energy values of carbohydrate, lipid and protein as respiratory substrates; • define the term *respiratory quotient* (RQ); • *carry out investigations, using simple respirometers, to measure RQ and the effect of temperature on respiration rate.		
M. Photosynthesis	Photosynthesis as an energy transfer process The investigation of limiting factors	• explain that energy transferred as light is used during the light-dependent stage of photosynthesis to produce complex organic molecules; • describe the photoactivation of chlorophyll resulting in the photolysis of water and in the transfer of energy to ATP and reduced NADP (cyclic and non-cyclic photophosphorylation should be described in outline only); • describe the uses of ATP and reduced NADP in the light-independent stage of photosynthesis; • describe in outline, the Calvin cycle involving the light-independent fixation of carbon dioxide by combination with a 5C compound (RuBP) to yield two molecules of a 3C compound GP (PGA), and the conversion of GP into carbohydrates, lipids and amino acids (the regeneration of RuBP should be understood in outline only, and a knowledge of C4 and CAM plants or the biochemistry of C4 plants is not required); • *describe the structure of a dicotyledonous leaf, a palisade cell and a chloroplast and relate their structures to their roles in photosynthesis; • *discuss limiting factors in photosynthesis and carry out investigations on the effects of light intensity and wavelength, carbon dioxide concentration and temperature on the rate of photosynthesis; • *discuss the role of chloroplast pigments in absorption and action spectra, and separate them using chromatography.		

Theme	Topic	You should be able to:	Checklist	Comments
N. Regulation and control	The importance of homeostasis Excretion Control of water and metabolic wastes Nervous and hormonal communication Response to changes in the external environment	• discuss the importance of homeostasis in mammals and explain the principles of homeostasis in terms of receptors, effectors and negative feedback; • define the term *excretion* and explain the importance of removing nitrogenous waste products and carbon dioxide from the body; • *describe the gross structure of the kidney and the detailed structure of the nephron with the associated blood vessels (candidates are expected to be able to interpret the histology of the kidney, as seen in sections using the light microscope); • explain the functioning of the kidney in the control of water by ADH (using water potential terminology) and in the excretion of metabolic wastes; • outline the need for communication systems within mammals to respond to changes in the internal and external environment; • outline the role of sensory receptors in mammals in converting different forms of energy into nerve impulses; • describe the structure of a sensory neurone and a motor neurone and outline their functions in a reflex arc; • 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 the impulse transmission should be emphasised); • explain the importance of the myelin sheath (saltatory conduction) and the refractory period in determining the speed of nerve impulse transmission; • describe the structure of a cholinergic synapse and explain how it functions (reference should be made to the role of calcium ions);		

Theme	Topic	You should be able to:	Checklist	Comments
N. Regulation and control (cont.)	Regulation of the internal environment Communication and control in flowering plants Plant growth regulators	• outline the roles of synapses in the nervous system in determining the direction of nerve impulse transmission and in allowing the interconnection of nerve pathways; • explain what is meant by the term *endocrine gland*; • *describe the cellular structure of an islet of Langerhans from the pancreas and outline the role of the pancreas as an endocrine gland; • explain how the blood glucose concentration is regulated by negative feedback control mechanisms, with reference to insulin and glucagon; • outline the need for, and the nature of, communication systems within flowering plants to respond to changes in the internal and external environment; • describe the role of auxins in apical dominance; • describe the roles of gibberellins in stem elongation and in the germination of wheat or barley; • describe the role of abscisic acid in the closure of stomata.		

Theme	Topic	You should be able to:	Checklist	Comments
O. Inherited change and gene technology	Passage of information from parent to offspring Nature of genes and alleles and their role in determining the phenotype Monohybrid and dihybrid crosses	• *describe, with the aid of diagrams, the behaviour of chromosomes during meiosis, and the associated behaviour of the nuclear envelope, cell membrane and centrioles (names of the main stages are expected, but not the sub-divisions of prophase); • explain how meiosis and fertilisation can lead to variation; • explain the terms *locus*, *allele*, *dominant*, *recessive*, *codominant*, *homozygous*, *heterozygous*, *phenotype* and *genotype*; • use genetic diagrams to solve problems involving monohybrid and dihybrid crosses, including those involving sex linkage, codominance and multiple alleles (but not involving autosomal linkage or epistasis); • use genetic diagrams to solve problems involving test crosses; • *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); • explain, with examples, how mutation may affect the phenotype; • explain, with examples, how the environment may affect the phenotype; • explain how a change in the nucleotide sequence in DNA may affect the amino acid sequence in a protein and hence the phenotype of the organism.		

Theme	Topic	You should be able to:	Checklist	Comments
P. Selection and evolution	Natural and artificial selection	• explain how natural selection may bring about evolution; • explain why variation is important in selection; • explain how all organisms can potentially overproduce; • explain, with examples, how environmental factors can act as stabilising or evolutionary forces of natural selection; • describe the processes that affect allele frequencies in populations with reference to the global distribution of malaria and sickle cell anaemia; • explain the role of isolating mechanisms in the evolution of new species; • describe one example of artificial selection.		

Applications of biology

Theme	Topic	You should be able to:	Checklist	Comments
Q. Biodiversity and conservation	Classification Conservation issues	• *outline the five-kingdom classification to illustrate the diversity of organisms (a knowledge of phyla within the kingdoms is not required); • discuss the meaning of the term biodiversity; • discuss the reasons for the need to maintain biodiversity; • describe the reasons why one named species has become endangered, and use this information in the context of other endangered species; • discuss methods of protecting endangered species, including the roles of zoos, botanic gardens, conserved areas (national parks) and seed banks.		
Theme	**Topic**	**You should be able to:**	**Checklist**	**Comments**
R. Gene technology	Gene technology for insulin production	• describe the steps involved in the production of bacteria capable of synthesising human insulin: ○ identifying the human insulin gene ○ isolating mRNA and making cDNA using reverse transcriptase ○ cloning the DNA using DNA polymerase ○ inserting the DNA into a plasmid vector using restriction enzymes and DNA ligase ○ inserting the plasmid vector into the host bacterium ○ identifying genetically modified bacteria using antibiotic resistance genes ○ cloning the bacteria and harvesting the human insulin;		

Theme	Topic	You should be able to:	Checklist	Comments

	Markers for genetic engineering
	
	Benefits and hazards of gene technology
	
	DNA sequencing and genetic fingerprinting
	
	Cystic fibrosis
	
	Genetic screening and genetic counselling
		• explain the advantages of treating diabetics with human insulin produced by gene technology;
		• explain why promoters need to be transferred along with desired genes in gene technology;
		• explain why and how genes for enzymes that produce fluorescent or easily stained substances are now used instead of antibiotic resistance genes as markers in gene technology;
		• describe the benefits and hazards of gene technology, with reference to specific examples;
		• discuss the social and ethical implications of gene technology;
		• *outline the principles of electrophoresis as used in:
		  ○ genetic fingerprinting
		  ○ DNA sequencing;
		• describe the causes and outline the symptoms of cystic fibrosis (CF) as an example of a recessive genetic condition (reference should be made to CFTR protein);
		• describe the progress towards successful gene therapy for CF;
		• discuss the roles of genetic screening for genetic conditions and the need for genetic counselling.		

Theme	Topic	You should be able to:	Checklist	Comments

S. Biotechnology	Industrial applications of microorganisms
	
	Batch and continuous culture
	
	Penicillin as an antibiotic
	
	Immobilisation of enzymes
	
	Monoclonal antibodies
		• outline the use of microorganisms in the extraction of heavy metals from low grade ores;
		• explain what is meant by the terms *batch culture* and *continuous culture*;
		• compare the advantages and disadvantages of batch and continuous culture with reference to the production of secondary metabolites (e.g. penicillin), enzymes (e.g. protease) and biomass (e.g. mycoprotein);
		• describe, for penicillin as an example of an antibiotic:
		  ○ the mode of action on bacteria and why it does not affect viruses
		  ○ causes and effects of antibiotic resistance;
		• *immobilise an enzyme in alginate and compare the ease of recovering the enzyme and ease of purification of the product compared to the same enzyme that has not been immobilised;
		• explain the principles of operation of dip sticks containing glucose oxidase and peroxidise enzymes, and biosensors that can be used for quantitative measurement of glucose;
		• outline the hybridoma method for the production of a monoclonal antibody;
		• evaluate the use of monoclonal antibodies compared to conventional methods for diagnosis and treatment of disease, and testing for pregnancy.		

Theme	Topic	You should be able to:	Checklist	Comments
T. Crop plants	Crop plant reproduction Crop adaptations Methods to improve crops	• *describe and explain the structural features of a named, wind-pollinated plant; • compare the outcomes of self-pollination and cross-pollination in terms of genetic variation; • *describe the structure of the fruit in maize and explain the function of the endosperm; • *explain the significance of the grains of cereal crops in the human diet; • *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: ○ the high optimum temperatures of the enzymes involved ○ the spatial separation of initial carbon fixation from the light-dependent stage (biochemical details of the C4 pathway are not required); • *explain how sorghum is adapted to survive in arid environments; • *explain how rice is adapted to grow with the roots submerged in water in terms of tolerance to ethanol and presence of aerenchyma; • outline the following examples of crop improvement by conventional breeding techniques: ○ hybridisation leading to polyploidy in wheat ○ inbreeding and hybridisation in producing vigorous, uniform maize; • outline the following examples of crop improvement by genetic modification and include any associated detrimental effects on the environment or economy: ○ herbicide-resistant oil seed rape ○ insect-resistant maize and cotton ○ vitamin A enhanced rice.		

Theme	Topic	You should be able to:	Checklist	Comments
U. Aspects of human reproduction	Gametogenesis Roles of hormones in the menstrual cycle Controlling human reproduction	• *describe the histology of the mammalian ovary and testis; • outline gametogenesis in a male and female human as a process involving mitosis, growth, meiosis and maturation; • explain the role of hormones in maintenance of the human menstrual cycle, and link this to the changes in the ovary and uterus during the cycle; • outline the biological basis of the effect of oestrogen/progesterone contraceptive pills; • discuss and evaluate the biological, social and ethical implications of the use of contraception; • outline the technique of in-vitro fertilisation (IVF) and discuss its ethical implications.		

Section 5: Useful websites

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

http://www.biozone.co.uk
This is an excellent gateway to many other websites with useful material to support topics in both AS and A2. Click on Biolinks Database on the home page.

http://www.saburchill.com/chapters/bio.html
The Open Door Web Site – with many resources for A Level.

http://www.biologymad.com/
This site is full of useful notes to support AS and A2 topics and also useful web links and advice for learners.

http://www.s-cool.co.uk
Many web pages of structured notes to help you with most of the topics at AS and A2. There is plenty of useful advice on revision.

http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/
Kimball's Biology Pages: an American on-line textbook. This is very well organised so that you can find information easily.

http://www.biotopics.co.uk/
A private web site run by a teacher in the UK. It has many useful resources and links.

http://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/A syllabus are covered.

http://bcs.whfreeman.com/thelifewire
Notes, animations, tutorials and questions with instant feedback. This is the student support web site for the American textbook: *Life, The Science of Biology*.

http://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.

http://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.

http://www.biology.arizona.edu/default.html
The Biology Project from the University of Arizona. This has many excellent animations, tutorials and on-line tests.

http://www.dnaftb.org/dnaftb/
DNA from the beginning: on-line 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.

http://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.

http://www.biology.com/
Click on The Biology Place and find tutorials, animations and tests on a variety of topics including common A Level Biology practicals.

http://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.

http://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.

http://www.mbgnet.net/bioplants/main.html
The biology of plants – the website of the Missouri Botanic Gardens. A simple introduction to plant science.

http://images.botany.org/
This site has many useful images of plant biology to complement the web site above.

http://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.

http://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.

http://www.chemguide.co.uk/CIE/index.html
This is a site that supports CIE A Level Chemistry. You may find this useful for Section B on biological molecules if you are unsure about some basic chemistry.

http://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.

http://www.elmhurst.edu/~chm/vchembook/
Virtual Chembook. Useful web pages on aspects of metabolism including enzymes and carbohydrate, protein and lipid metabolism.

http://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.

http://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.

http://www.sumanasinc.com/webcontent/animation.html
This site has animations for a wide variety of topics in the syllabus.

http://learn.genetics.utah.edu/
This is the web site 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.

http://www.yourgenome.org/
This is the educational web site of the Wellcome Trust's Sanger Institute in Cambridge, UK. This will bring you up-to-date on many aspects of your course.

http://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.

http://www.beep.ac.uk/
The Bioethics Education Project based at Bristol in the UK. Many useful resources for the ethical issues discussed in the A2 course.

http://library.med.utah.edu/WebPath/
This site has many useful images of human anatomy and histology.

http://evolution.berkeley.edu/
Many resources on evolution from the University of California Museum of Palaeontology.

http://www.nobelprize.org/
The Nobel Prize web site 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.

http://www.wellcometreeoflife.org/
The Interactive Tree of Life from the Wellcome Trust. this will help you with biodiversity in the A2 course.

http://www.iucn.org/
The web site 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 http://www.iucnredlist.org/

http://www.kew.org/science-conservation/index.htm
These are the Science and Conservation pages of the web site of the Royal Botanic Gardens at Kew.

http://www.zsl.org/conservation/
The conservation pages of the web site of ZSL – the Zoological Society of London.

http://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, the nitrogen cycle, classification and biotechnology.

Section 6: Appendices

6.1 The mathematical skills you need

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
• recognise and use expressions in decimal and standard form		
use a calculator for the following: • addition • subtraction • multiplication • division • finding an arithmetical mean • x^2 • $1/x$ (reciprocals) • $\sqrt{x}$ (square roots) • $\log_{10}x$ (log to base 10)		
• take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is appropriate for a question		
• make estimations of the results of calculations (without using a calculator)		
• recognise and use ratios		
calculate • percentages, • percentage changes • percentage errors		
understand and use the following symbols: $<, >, \Delta, \approx, /, \propto, \Sigma$		
• calculate the areas of right-angled and isosceles triangles, the circumference and area of circles, the areas and volumes of rectangular blocks and cylinders		

You should be able to:	Checklist	Comments
• translate information between graphical, numerical and algebraic forms		
construct and interpret • frequency tables • frequency diagrams • pie charts • histograms		
• choose appropriate variables and scales for graph plotting, using standard 2 mm-square graph paper		
• find the rate of change from a linear graph		
• recognise when it is appropriate to join points on a graph with straight rules lines and when it is appropriate to use a line of best fit		
• choose, by inspection, a straight line that will serve as the best straight line through a set of data points presented graphically		
• understand, draw and use the slope of a tangent to a curve as a way to obtain the rate of change		
• understand and use the prefixes giga (G), mega (M), kilo (k), micro (μ) and nano (n).		
• understand probability and apply the concept to genetic ratios		
• understand the principles of sampling as they apply to biological situations and data		
• understand the importance of chance when interpreting data		
• understand what is meant by a normal distribution (as seen for example in a histogram)		
• calculate standard deviation and standard error		
• use the statistical tests: the chi-squared test and the *t*-test.		

You will **not** be expected to remember the following equations **nor** to remember what the symbols stand for. You are expected to be able to use the equations to calculate standard deviation, standard error, to test for significant differences between the means of two small, unpaired samples and to perform a chi-squared test on suitable data from genetics or ecology. You will be given access to the equations, the meaning of the symbols, a *t*-table and a chi-squared table.

standard deviation $$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

standard error $$S_M = \frac{s}{\sqrt{n}}$$

t-test $$t = \frac{\left|\bar{x}^1 - \bar{x}^2\right|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$ $$v = n_1 + n_2 - 2$$

χ^2 test $$\chi^2 = \Sigma\frac{(O - E)^2}{E}$$ $$v = c - 1$$

Key to symbols

s = standard deviation	$\bar{x}$ = mean	S_M = standard error	c = number of classes
Σ = 'sum of'	n = sample size (number of observations)		O = observed 'value'
x = observation	v = degrees of freedom		E = expected 'value'

6.2 Other important information you need for your biology 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.

6.2.1 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 10 000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

6.2.2 Units

The International System of units will be used (SI units). Units will be indicated in the singular not in the plural, e.g. 28 kg.

(a) SI units commonly used in biology are listed below.

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.

Quantity	*Name of unit*	*Symbol for unit*
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 are listed below.

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	*or*	$kg\ m^{-3}$
	gram per cubic centimetre	*or*	$g\ cm^{-3}$

(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.

6.2.3 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.

6.3 Command words and phrases used in biology examination papers

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.

This table gives you the command words in alphabetical order.

Command word	How you should respond
Calculate	A numerical answer is needed. You should show any working, especially when there are two or more steps in a calculation. You should always include relevant units or symbols; *e.g. calculate the magnification of a specimen.*
Deduce	This is used in a similar way to *predict*, 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.
Define	You need to state the meaning of something; *e.g. a community is all of the populations of all of the different species within a specified area at a particular time.*
Describe	You need to state the main points about something (using labelled diagrams if this helps you); *e.g. describe the events that occur during the cardiac cycle.* You may also be asked to describe a particular process; *e.g. describe the structural features of a wind-pollinated flower.* You may be asked to describe how to do a particular experiment; *e.g. describe how you can test a food for starch and reducing sugars.*
Determine	This often indicates that the quantity cannot be directly measured but has to be found by calculation. It also indicates that some practical work needs to be done to find the answer; *e.g. determine how much protein is needed in a particular diet;* *e.g. how would you determine the respiratory quotient of some germinating beans.*
Discuss	You have to write down points **for** and **against** an argument; *e.g. discuss the social and ethical implications of gene technology.*
Estimate	You need to work out an **approximate** value for a quantity, based on your knowledge of theory and the information provided; *e.g. estimate the rate of photosynthesis of some plants in an investigation.*
Explain	You may have to give reasons or refer to a theory depending on the context of the question; *e.g. explain why the rate of transpiration changes with changes in temperature.*
Find	This is a general term which can mean several similar things, such as calculate, measure, determine, etc.
Give a reason/ reasons	See 'Explain'.
List	Write down a number of separate points. Where the number of points is stated in the question, you should not write more than this number; *e.g. list three features of wind-pollinated flowers.*

Command word	How you should respond
Meant (what is meant by the term…)	See 'Understand'.
Measure	You are expected to find a quantity by using a measuring instrument e.g. length (by using a ruler), volume (by using a measuring cylinder).
Outline	State the main points briefly, do not go into any detail; *e.g. outline how monoclonal antibodies are produced.*
Predict	This may be used in two ways: (i) You find the answer by working out the patterns in the information provided and drawing logical conclusions from this; *e.g. predict the effect of the death of an organism in a food web on the populations of other food web members.* (ii) You may need to use information from tables and graphs or do calculations; *e.g. predict the optimum temperature for lipase.*
Sketch	(i) When drawing graphs, this means that you may draw the approximate shape and/or position of the graph BUT you need to make sure that any important details, such as the line passing through the origin or finishing at a certain point, are drawn accurately. (ii) When drawing a specimen or other diagrams, a simple line drawing is all that is needed, but you must make sure the proportions are correct and the most important details are shown. You should always remember to label your diagrams.
State	You should give a short answer without going into any detail, e.g. state the name of the mineral needed to make chlorophyll. BUT remember that 'state the meaning of…' is different. It is more like 'understand'.
Suggest	This may be used in two ways: (i) There may be more than one correct answer to the question; *e.g. suggest two reasons why a plant's seeds should be widely dispersed* (ii) You are being asked to apply your general knowledge of biology or reasoning skills to a topic area that is not directly on the syllabus; e.g. applying ideas about competition and feeding relationships to an unfamiliar food web.
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; *e.g. explain what you understand by the term transcription.*

Cambridge International Examinations
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
Tel: +44 (0)1223 553554 Fax: +44 (0)1223 553558
Email: info@cie.org.uk   www.cie.org.uk

A DIVISION OF
CAMBRIDGE ASSESSMENT