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AS
and A Level
Biology A

STUDENT GUIDE

Contents

Introduction

What do we mean by practical skills?

It is really important to remember that the term practical skills covers a very wide range of requirements at A level. It does not mean just the ability to handle equipment in a school laboratory or know how to use some particular piece of apparatus. It ranges from using mathematics in a practical context to understanding how scientists investigate ideas, how they analyse their data and how they are very cautious when drawing conclusions. This guide will explain each of these in more detail.

These skills are not a separate part of your biology course, they are an essential part of all that you do and will be tested in your examination papers. In this course, there 16 core practicals which provide lots of opportunities to develop all of these skills.

How is this different from GCSE?

First of all you, are undertaking what is normally a two year course. Therefore you will be expected to have shown considerable development in this time. In simple terms there might be several familiar skills and theoretical topics, but you will be expected to have a much more detailed understanding of them. Above all you will be expected to develop into a more mature scientist. You will need to keep asking 'How do we know that?' You will also be expected to realise that, even at A level, you will only have part of the story and that science is constantly changing. It is not a pile of 'facts' it is just the best model we have at the present. Even at this level you can find many A level textbooks just 15 years old that contain information that we no longer accept, or at least has been significantly modified.

For example, for many years biologists believed in the 'one gene-one enzyme' hypothesis, but, as you will find in part of this course, we now know that there are several ways in which one gene can produce different products.

How can I use these skills in the future?

Almost all of the skills you will acquire during your course will be vital if you are thinking of continuing into higher education. Most are also what are called transferable skills. This means that they are extremely useful to a wide range of employers and in your own personal life. The most obvious example is that of research and analytical skills. Finding information that is reliable and accurate and using it to make decisions based on evidence is as applicable to buying a car as it is to making conclusions from experimental data. Exactly the same is true of all the mathematical skills where practical biology provides lots of opportunities to develop your skills.

How to use this guide

There are three main aims of this guide.

1. To explain what is meant by practical skills at Advanced Level.
2. To explain what is required to progress from GCSE to Advanced Level.
3. To provide questions to help you understand and develop your practical skills to the right level.

It is important to have a clear understanding of what you are trying to achieve at the beginning of the course. In this respect the introduction and the basic principles which follow need to be understood at the very start of your course. The questions and examples which link to particular practicals are more likely to be useful at the relevant points throughout your course and for consolidation before you sit the examinations.

How will practical skills be tested?

Practical skills in exam papers

There are 3 written papers at AS level.

Paper 1: 1h 45mins. This paper tests content of Topics 1 and 2.

Paper 2: 1h 45mins. This paper tests content of Topics 3 and 4.

There are 3 written papers at A level.

Paper 1: 2h. This paper tests content of topics 1–4 and 5 and 6.

Paper 2: 2h. This paper tests content of topics 1–4 and 7 and 8.

Paper 3: 2h. This paper tests content from all topics and questions may draw on material from two or more different topics.

This means the following.

- All the papers will have questions testing your practical skills and knowledge of the core practicals.

- This will include mathematical skills, as they are applied to practical work, but all papers will test your mathematical skills in other contexts. 10% of the total marks available on all papers will be allocated to mathematical skills.

- Papers 1 and 2 will contain questions which test your knowledge and understanding of the topics listed above but they can be presented in many different forms which are linked to your practical skills e.g. topic questions may well contain data tables or graphs which you might be asked to interpret and explain – in which case, you will need to use the skills you have developed throughout the whole course.

'The Practical Endorsement'

Your teachers will discuss this with you in more detail but the important features are as follows.

- It does not carry marks which count towards your final A level grade.

- It may be an important requirement for university entrance or your chosen career.

- There are only 2 grades, 'Pass' or 'Not classified', which will appear on your A level certificate.

- It will be assessed by your teachers throughout the course.

- The skills which are included in this assessment are:

  1. Following written procedures

  2. Applying an investigative approach

  3. Using a range of apparatus and equipment safely

  4. Making and recording accurate observations

  5. Researching, referencing and reporting

As you can see, these are just the skills that you would expect to develop when carrying out the range of core practicals in the specification and this is what will form the basis of this assessment.

Developing independent thinking

Whilst there are many individual skills to be developed it is very important to remember they are not isolated parts. All are linked to how we investigate things scientifically, so this is a good place to start.

We have already touched on what it means to be a scientist in the introduction. It is important to explain this a little more here.

Scientists work by creating models which are ideas about how and why things might happen. To form useful models they need imagination, ingenuity and a good deal of background knowledge. Almost all scientists work in groups, both together in one laboratory and with other groups worldwide. From these models they make predictions and only then do they design investigations to test these predictions. As the number of investigations which confirm these predictions increases then the model explanation becomes more widely accepted in the scientific community. However it only takes one well-designed investigation that contradicts expectations to destroy the idea.

Notice scientists are very careful not to claim they have 'proved' something and are very cautious in their language. They are very unlikely to refer to anything as a 'fact'.

Here is how Watson and Crick reported one of the most important discoveries of the 20th century: 'For the moment the general scheme we have proposed for the reproduction of deoxyribonucleic acid must be regarded as speculative. Even if it is correct then much remains to be discovered. Despite these uncertainties we feel that our proposed structure may help to solve one of the fundamental biological problems.'

Scientists are human. It is not uncommon for different groups to have conflicting ideas and to argue strongly. It then takes time for evidence to accumulate in support of one or the other.

So how does this affect you? Obviously you are unlikely to be involved in research at this level and be much more interested in achieving a good grade in your examinations. The answer is quite simple. You do need to begin to think like a scientist and to question things more carefully, even when carrying out simple core practicals. Your ability to do this will be tested in examination papers.

Question 1 – How do we know that? Thinking more scientifically.

(a) Read the article entitled 'How to read the health news' to be found at
http://www.nhs.uk/news/Pages/Howtoreadarticlesabouthealthandhealthcare.aspx

(b) On the same web page you will find an archive with reviews of many claims made discoveries relating to health issues. Almost every week, newspapers report on new findings; often with remarkable claims. Take any one that you find and research the science behind it. What did the actual research really show? Does it match the claims in the newspaper?

If you cannot find your own question try the following:

(i) There are many scientific papers showing garlic has antibacterial properties but does this mean that this is a useful way of solving the problem of bacterial resistance to antibiotic?

(ii) If you wish the same question can be asked about 'Manuka' honey.

Biology practical skills: scientific methods and practices

This section of the Guide will consider a number of key skills and practices that you develop and use as you progress through your A level.

Designing investigations

Some of the core practicals offer you the opportunity to go beyond simply learning a technique by applying your knowledge to the design of an investigation. You will have met many of the requirements at GCSE level but during the two years of your A level course you will be expected to have a much more accurate understanding of the details. You might start as follows.

- Exactly what is to be measured? Is this the correct dependent variable, does it match the hypothesis and how can it be measured as accurately as possible?
- Can a single independent variable be measured or controlled accurately?
- Is it possible to control all other variables? If not, which ones are the most important to control and can we monitor others?
- How much data will be needed to come to some meaningful conclusions?

Now try the following.

Question 2 – Thinking about experimental design

A student decides to investigate the effect of light and shade on the size of leaves of one species of plant. Their initial plan is to measure the length of leaves on two sides of a single bush, one side which they can see is shaded and the other which is in full sunlight.

(a) The dependent variable chosen is length of leaf.

    (i) Name three other possible leaf measurements which might provide information on size.

    (ii) Which of these measurements would you select to provide the most useful scientific data? Give reasons for your answer.

(b) Name three other variables which need to be controlled when collecting these data.

(c) The student chose a bush with a shaded side and a sunlit side. Give three reasons why simply selecting differences in light intensity by observation might not give reliable information on 'light' and 'shade'.

Presenting data

Tables

Remember, the basic rules are really important.

- You must include all of your raw data even though you manipulate it in some way later.
- Think about designing your table to make any trends and patterns clear and show any data you might use to draw graphs.
- Include correct S.I. units.
- Use a consistent number of significant figures. Remember figures such as 2 and 2.0 are not the same.
- The number of significant figures must be justified by the method of measurement. Calculating averages or means does not increase the number of significant figures that can be supported. e.g. measuring with a 30 cm ruler allows a maximum accuracy of about 0.5 mm. Simply calculating an average of a set of measurements does not increase this to 0.05 mm or more.

Graphs

You will be expected to understand the use of different forms of graphs and be able to select the most appropriate, scientifically valid format. This means your choice must match your data but, above all, it must be directly linked to your hypothesis. You are drawing a graph to help analyse your data and illustrate important trends.

The main rules and uses of graphs do not change when you study biology, physics or chemistry but the type of graph you choose and the information we can get from it may be very different.

|	
Bar graph	The simplest form of graph with separate columns but can only be used when the data is categorical. This means completely separate sets of counts e.g. counts of blood groups or flower colour.
Histogram	This is a special form of bar graph where the columns are touching each other. The horizontal axis is normally continuous and the columns represent sets of readings covering a small range.
Scattergram	This is simply a set of points on a pair of axes and is normally used to show a pattern of correlation between the two variables. Note this does not include a line.
Line of 'best fit'	This needs to be treated carefully. Where a scattergram shows a possible straight line relationship it might be relevant, but simply wobbling your ruler around until you think you might have the best place to draw a line is scientifically very dubious. You are simply guessing and it is unlikely that some other person with the same data will draw exactly the same line.
Line graph	In biology we often collect data where the values might rise and fall or show big variations. Drawing guesswork curves or links is not at all objective. In these cases, biologists sometimes simply join the points with straight lines. This might give some indication of important trends but it is normally a sign that we are not making any assumptions about them.

It is expected that all students will be aware of the basic rules of graph drawing.

- Axes are clearly labelled with units. The title and units are separated by a solidus (/).
- The scale is chosen to ensure the graph covers at least half of the paper and the *y*-axis intercept where appropriate.
- The axis shows the full scale with any breaks clearly indicated.
- The independent variable is on the *x*-axis and the dependent variable is on the *y*-axis.

Question 3 – Spot the errors

The graph shown below was drawn by a student from data obtained from an investigation to compare the distribution of a black lichen on rocks in two different shores, one exposed to the waves and another sheltered.
25 **random** samples were taken on each shore. The horizontal axis is random sample number and the vertical axis is % cover. The bars at the top of each column are meant to show the variability in the data.

(a) The graph obviously has no labels or units which is a major error but not the most important one.

    (i) Give two reasons why this graph is scientifically meaningless.

(ii) Sketch the format of graph which could be used to illustrate the difference in distribution of the lichen on the two shores.
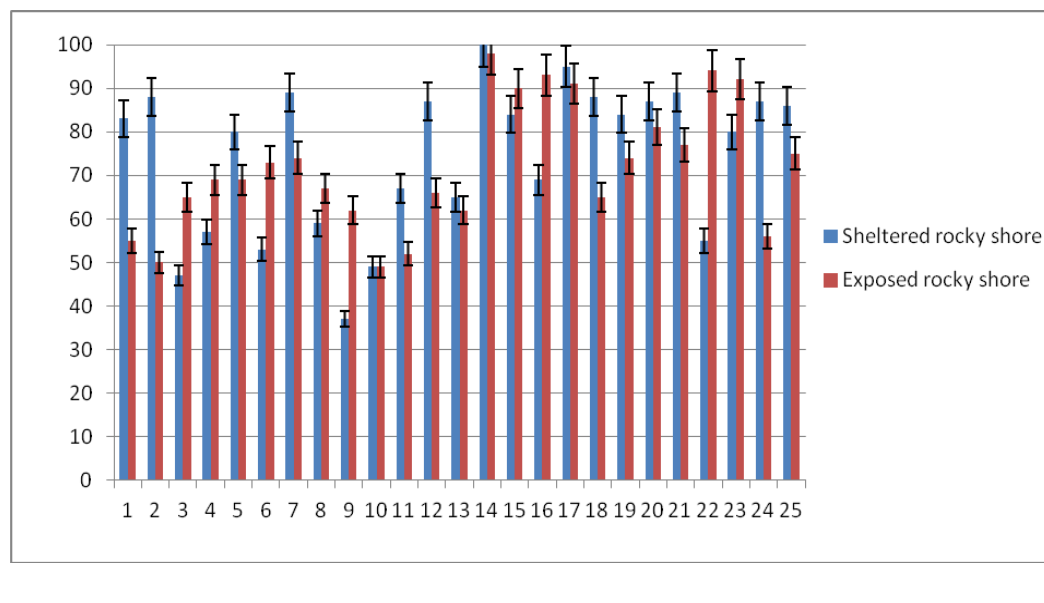
Evaluating

This is one of the most important ways in which you will be expected to show progression to A level. Evaluating is not a simple process of offering an opinion. It is an **evidence-based analytical process**. You will certainly be expected to make a judgement but this must be expressed in terms of a reasoned argument.

So what evidence might be used when coming to a judgement?

- If you have all variables under control and a high level of accuracy then every repeat will be identical. Obviously this perfection is almost impossible to achieve so the variation in repeats can provide useful information. It is likely that means will have been calculated so we can consider how much the individual readings differ from this mean.

  Standard deviation is a measure of this variation. Where the data is normally distributed then the standard deviation is a measure of this distribution, about 68% of all the data will be within one standard deviation measure of the mean and about 95% of the data will be within 2 standard deviation measures of the mean. It is best calculated using programs such as Excel.

  Standard deviation is measured in the same units as your data. Do remember when considering whether you have a large or small standard deviation that you must compare it to the mean e.g. If the mean value was 0.5mm then a SD of 0.5mm is very large but if the mean was 50mm then a SD of 0.5mm is very small.

- **Outliers or anomalies** are another line of evidence when evaluating your findings. Be careful when suggesting that readings are anomalies and need to be removed from the data set. Highest and lowest values are not anomalies. Readings which are much larger or smaller than others obviously need to be investigated as do those which show a completely different trend to others. However, remember we are dealing with living things and they often show high levels of variability.

- If you have lots of anomalies or very high levels of variability then you need to take a careful look at your methodology. Big variations can arise from **random errors** in your methods. A random error is simply something that is different each time you take a reading and therefore is not under control. e.g. if you use a colorimeter to measure absorbance and some of the tubes you use are scratched but others are not, then the scratched ones will give a higher reading so increasing the variability in your data. **Systematic errors** are more difficult to detect. In this example this would mean using scratched tubes every time. The readings will not be correct but they will all be just a bit higher than they should and therefore have little effect on the overall pattern.

- **Uncertainties of measurements** – all measuring apparatus has some level of uncertainty which affects the precision of the final data. Where several measuring devices such as thermometers, pipettes or balances etc. are used these uncertainties accumulate to affect the precision of the final readings.

- Even statistical evidence of a strong correlation does not tell us anything about what is causing this. There are very many linked factors which give the same results e.g. you can get a strong correlation between number of ice creams eaten and skin cancer but this is obviously nothing to do with the cause. Similarly you need to take great care in understanding exactly what the tests for a significant difference show (and do not show).

Biology practical skills: use of mathematics

Significant figures

Core practicals will offer opportunities for you to make a decision on the most appropriate number of significant figures.

To do this, you should take account of the nature of the data and, most of all, the level of precision of the measuring apparatus. Remember the following pointers.

- Figures such as 2 and 2.0 do not mean the same thing.
- Consistency of significant figures is important.
- Simply calculating a mean does not improve the level of precision of the data.
- It is important to make a reasoned decision, not just copy down a figure from a calculator or spreadsheet.

Statistical testing

This is another good example of progressing from GCSE to A level. Having designed a sound investigation and collected data in a reliable way how do we make a decision? It is likely that, before this stage, this decision has been a matter of opinion. Where there is a lot of overlap between two sets of data you might feel there is a difference but someone else might not. Obviously this is not a scientific way of making important decisions, so we need some rules agreed by all scientists.

The general rule is quite simple. If there is less than 5 chances in 100 (a probability of 0.05) that the data could be from the same population then scientists state that there is a **significant** difference between them. The word significant is important here because other scientists will understand exactly what rules you have applied when making your judgement. Do not use this word unless it is clearly in the context commenting on a statistical test and its meaning.

The complicated part of the statistics is exactly how we calculate the overall probability from the measurements we take. This has some difficult mathematics but if this is not your strong point you need not worry! Provided that you understand the basic idea then you can simply use some basic instructions and formulae to carry out the calculation to find a statistical test value and then look up the probability in a table. You will learn more about the individual tests during your course but what follows is a description of the basic rules. (Question 19 will help you to check if you have understood what you have learned.)

Statistics – the basic principles

Most statistical tests can be used to measure the probability that your two sets of data are from the same population. In other words there is no significant difference between them. For this reason it is usual to start with a **null hypothesis**. It is important to understand that this is not saying that the two sets of data are identical! On the contrary, most data you will deal with as a biologist is likely to show significant variation. The tests show how likely it would be to obtain the data you collect if these were just random variations within the same populations.

Having formed a null hypothesis we then select a suitable test and input the measurements we have taken into the chosen formula. This gives us our test statistic which we can then check in a table to find the probability of this occurring simply by chance from the same population.

If the probability is less than 0.05 (5%) then we reject the null hypothesis and we can state that there is a significant difference.

Exactly the same rules apply if we are testing for a significant correlation or a 'goodness of fit / association.

Common tests

The common tests you will meet are:

● tests for a significant difference – t-test, z-test or Mann-Whitney U test

● test for a significant correlation – Spearman's rank correlation test

● test for a 'goodness of fit' or association – Chi-squared test.

So you must learn to substitute your data into the correct formula and calculate the result: but it is not necessary to understand all of the mathematics used to devise that formula. What is really important is that you understand what the results of your statistical analysis show (and do not show!)

Some common terminology in statistics

Mean	The average value calculated as the total of the samples divided by the number of measurements.
Median	This is the value above which half of the sample lie and below which the other half lie – in other words, the middle value. Where there is an even number of samples this is calculated as the mid-point between the pair of values to which this applies.
Mode	The value which occurs most frequently in a set of measurements.
Standard deviation	This provides a numerical value for the average spread of data from the mean.
Range	This is a much simpler measure of the spread of data in a sample: simply, it is the difference between the highest and lowest values.

A simple example

A student uses a quadrat to count the number of clover plants in a fixed area. The student uses the quadrat 10 times in a field and records the number of plants in each quadrat. His results are:

12, 6, 7, 4, 11, 8, 5, 9, 11, 13

MEAN = (12 + 6 + 7 + 4 + 11 + 8 + 5 + 9 + 11 + 13) ÷ 10 = 8.6

MEDIAN = 8.5 (the middle two numbers are 8 and 9)

MODE = 11

Notice that the mean and median are similar. Why is this? What sort of data might produce very different values for the mean and the median?

Errors and uncertainties

The terms error and uncertainty are often confused.

An error arises in a practical work through:

- in-built precision of equipment, or a consistent design fault (systematic error)
- poor technique or lack of careful measurement (random error).

Uncertainties arise whenever a measurement is taken because, even with careful use of equipment, measuring instruments we use have a particular level of precision e.g. a laboratory thermometer might have +/- 0.5°C.

Some useful definitions when considering errors and uncertainties appear in the table.

Validity	A measurement is valid if it measures what it is supposed to be measuring – this depends both on the method and the instruments.
True value	The value that would have been obtained in an ideal measurement.
Accuracy	A measurement result is considered accurate if it is judged to be close to the true value. It is influenced by random and systematic errors.
Precision	A quality denoting the closeness of agreement (consistency) between values obtained by repeated measurement. It is influenced by random effects and can be expressed numerically by the standard deviation. A measurement is precise if the values 'cluster' closely together.
Repeatability	A measurement is repeatable when similar results are obtained by students from the same group using the same method. Students can use the precision of their measurement results to judge this.
Reproducibility	A measurement is reproducible when similar results are obtained by students from different groups using different methods or apparatus.
Uncertainty	Any measurement will have some uncertainty about the result, this will come from variation in the data obtained and be subject to systematic or random effects. This can be estimated by considering the instruments and the method and will usually be expressed as a range such as 20°C ± 2°C.
Error	The difference between the measurement result and the true value if a true value is thought to exist. This is not a mistake in the measurement. The error can be due to both systematic and random effects and an error of unknown size is a source of uncertainty.

Core practicals

The core practicals are an integral part of your course. They are not there to get you to demonstrate some text book 'fact' or recall some simple information. They are there to help you develop the whole range of practical and mathematical skills which are essential to biologists and which will be tested in the written assessments.

List of core practicals

1. Investigate the effect of caffeine on heart rate in Daphnia
2. Investigate the vitamin C content of food and drink
3. Investigate membrane structure, including the effect of alcohol concentration or temperature on membrane permeability
4. Investigate the effect of enzyme and substrate concentrations on the initial rates of reactions
5. Prepare and stain a root tip squash to observe the stages of mitosis
6. Identify sclerenchyma fibres, phloem sieve tubes and xylem vessels and their location within stems through a light microscope
7. Investigate plant mineral deficiencies
8. Determine the tensile strength of plant fibres
9. Investigate the antimicrobial properties of plants, including aseptic techniques for the safe handling of bacteria
10. Carry out a study on the ecology of a habitat, such as using quadrats and transects to determine distribution and abundance of organisms, and measuring abiotic factors appropriate to the habitat
11. Investigate photosynthesis using isolated chloroplasts (the Hill reaction)
12. Investigate the effect of temperature on the rate of an enzyme-catalysed reaction, to include Q10
13. Investigate the effects of temperature on the development of organism (such as seedling growth rate, brine shrimp hatch rates)
14. Use gel electrophoresis to separate DNA fragments of different length
15. Investigate the effect of different antibiotics on bacteria
16. Investigate rate of respiration practically
17. Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation and oxygen consumption using data from spirometer traces
18. Investigate habituation to a stimulus

Questions on core practicals

1. Investigate the effect of caffeine on heart rate in Daphnia

Question 4

(a) Give some advantages and disadvantages of using Daphnia for this study.

(b) How might the accuracy of the investigation be improved?

2. Investigate the vitamin C content of food and drink

Question 5

Explain what is meant by oxidation and reduction.

3. Investigate membrane structure, including the effect of alcohol concentration or temperature on membrane permeability

Question 6

(a) Name the red pigment found in beetroot cells.

(b) Where exactly in the cell is the pigment stored?

(c) Name the membranes that the pigment must cross in order to pass into the surrounding water.

(d) The following is an extract from a student's report explaining how they controlled variables in this investigation.

'I used identical discs of beetroot and placed them in temperatures from 15–80°C for exactly 5 mins.'

Explain why this might mean that the discs at different temperatures were not treated in exactly the same way.

4. Investigate the effect of enzyme and substrate concentrations on the initial rates of reactions

Question 7

(a) Why is it important to test the initial rate of enzyme-controlled reactions?

(b) What are the SI units of rate of reaction?

(c) Why is 1/t not recognised by scientists as a rate?

There are many ways of investigating enzymes so the exact method you use will depend upon your teacher.

5. Prepare and stain a root tip squash to observe the stages of mitosis
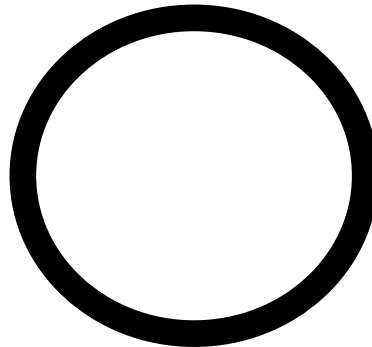
Question 8

(a) Name one suitable stain which could be used to show the chromosomes clearly.

(b) Explain why it is necessary to squash the root tip before viewing under the microscope.

(c) How is the root tip macerated?

6. Identify sclerenchyma fibres, phloem sieve tubes and xylem vessels and their location within stems through a light microscope

In this practical you will make some measurements of the cells and other structures that you see through the microscope. So this is a very important opportunity to practise some mathematical skills.

Question 9

(a) How many mms are there in 3×10^{-2} m?

(b) Write 32 μm as a measurement in standard form expressed in metres.

(c) A student draws a single cell of diameter 2.8 cm. She calculates that this is a magnification of ×870. What is the size of the original cell?

(d) The diagram below represents a student's drawing of a single xylem vessel. His teacher shows him that the original cell has a lumen (hole) in the centre of the vessel, which is approximately ×20 larger than the thickness of the wall. Use measurements of the diagram to calculate if the student has drawn a cell, which matches the proportions of the original xylem vessel.

7. Investigate plant mineral deficiencies

Question 10

Thinking about your chosen dependent variable state how you will ensure your measurements are

i) accurate

ii) precise

iii) valid

8. Determine the tensile strength of plant fibres

Sometimes you will need to do some preliminary work before you can do the actual main experiment. One aim of this is to decide on suitable conditions in which to carry out the experiment. Those conditions might be to do with abiotic factors such as the temperature, the pH, the light intensity or wavelength etc. They may be to do with the biological material itself, factors such as age, sex, size etc.

Question 11

(a) What are the likely factors that might affect the results of this practical?

(Before you can answer this you will need to decide what question you are actually asking or which hypothesis you are testing. You might, for example be asking 'does fibre length affect tensile strength?' In this case, length would be the independent variable, and you would need to control other factors. On the other hand, if you were testing the hypothesis 'New Zealand flax fibres are stronger than nylon', length may be something you need to always have the same).

(b) How would you control the factors you have listed in (a)?

9. Investigate the antimicrobial properties of plants, including aseptic techniques for the safe handling of bacteria

This is your first real chance at A level to think about handling microorganisms safely and successfully. These aims are achieved by a variety of procedures called aseptic techniques.

Question 12

(a) List two aseptic techniques you use or used in this practical and explain the precise purpose of each.

10. Carry out a study on the ecology of a habitat, such as using quadrats and transects to determine distribution and abundance of organisms, and measuring abiotic factors appropriate to the habitat

Quadrats are one of the most common ways in which to sample ecological sites. However, they can be used in several ways so it is very important to choose the one which will be most appropriate to the organisms and the site you are investigating.

The two quadrats shown are parts of transects. A is taken from a sand dune close to the sea and B is taken from a rocky shore.

continued

Quadrat A: Sand dune

Quadrat B: Rocky shore

Question 13

Both quadrats are formed of a grid.

Describe two ways in which the grid could be used to estimate the percentage cover of one of the organisms present.

continued

For the next questions it would be useful to view the quadrats in more detail and you can find Quadrat A at

http://www.takeyouvirtuallyeverywhere.com/sanddunetour/skegness_transect/003.JPG

and Quadrat B at

http://www.takeyouvirtuallyeverywhere.com/0085.JPG

Don't worry at this stage if you cannot recognise the organisms in the photos.

Question 14

(a) Quadrat A has one main plant species. First of all look at the picture overall and make a visual estimate of the % cover of this plant without any further counting. Next count all the squares that contain at least some of this plant. Finally count all the squares that are at least half covered by this plant. How do your estimates differ? Which do you think is the best measurement of % cover? Explain your answer.

(b) (i) How many different species can you see in Quadrat B?

(ii) The cone shaped cells are limpets. How would you measure the distribution of limpets using a quadrat of this size?

There are complete virtual transects plus much else at

http://www.takeyouvirtuallyeverywhere.com/

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11. Investigate photosynthesis using isolated chloroplasts (the Hill reaction)

As it stands this is a demonstration of the simple fact that chloroplast emit electrons when illuminated. The demonstration involves a colour change, from blue to colourless in a dye called DCPIP. This change can be quantified using a colorimeter. You should have met this piece of apparatus in CP 3. Once this is understood, it become possible to design investigations to test the effect of various factors on this process, which is essentially the first step in the light-dependent reactions of photosynthesis.

In exam questions you will be expected to suggest modifications to procedures you know to achieve stated aims.

Question 15

(a) Explain the practical procedure used in CP 11 could be modified to investigate the effect of light wavelength on the Hill reaction.

(b) Draw a sketch graph to predict the results you would expect in red, green and blue light.

12. Investigate the effect of temperature on the rate of an enzyme-catalysed reaction, to include Q_{10}

In this investigation you will be using techniques developed in CP4, especially that to do with initial reaction rate.

Question 16

(a) Some bacteria are found living in hot springs at temperatures as high as 80°C. How does this compare with your ideas about the effects of temperature on enzyme activity?

(b) What are the control variables in this CP and how can they be controlled?

(c) Linking this to photosynthesis, which requires enzymes in the Light Independent Reactions what value would you expect Q10 to have in low light and in high light?

13. Investigate the effects of temperature on the development of organism (such as seedling growth rate, brine shrimp hatch rates)

Question 17

(a) Explain the ethical issues involved in the use of brine shrimps egg cysts and seedlings in this experiment.

(b) This experiment will need to run for a few days. Explain how you would both control and monitor the incubation temperature over this time.

14. Use gel electrophoresis to separate DNA fragments of different length

Question 18

Gel electrophoresis is simply a technique for separating molecules of fragments of molecules (such as DNA). It is the uses to which it is put which are exciting.

(a) On the basis of which feature(s) of DNA fragments does electrophoresis separate them?

(b) To which pole (+ or -) would DNA fragments move?

(c) How can DNA fragments be created?

15. Investigate the effect of different antibiotics on bacteria

Question 19

The techniques here are more or less the same as those used in CP9. The efficacy of the antibiotic is measured by the size of a zone of inhibition.

(a) Is the size of this zone affected only by the bacteriocidal or bacteriostatic properties of the antibiotic? If not, what other factors may affect it?

(b) Would this method allow you to distinguish between bacteriocidal and bacteriostatic antibiotics?

16. Investigate rate of respiration practically

Question 20

(a) Name a compound which could be used to absorb carbon dioxide in the apparatus.

(b) Explain why removing the carbon dioxide and then recording the change in volume of gas in the respirometer chamber gives a measure of the oxygen taken up in respiration

(c) Blowfly larvae (maggots) are often used in this investigation. Maggots are also often used as fishing bait by piercing them with hooks. Using higher animals in this way is illegal and would cause a public outcry. Do you feel that invertebrate or cold-blooded organisms should have the same protection as other animals? Describe three reasons why you feel this way.

(d) The apparatus was used to investigate anaerobic respiration in yeast cells. Describe the movement of the liquid with carbon dioxide absorbent present and with it absent.

17. Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation and oxygen consumption using data from spirometer traces

You are not required to carry out this experiment, only to interpret its results. However it is very useful to at least see a simulation or film of a spirometer in use. There is a simulation on snabonline and a video here
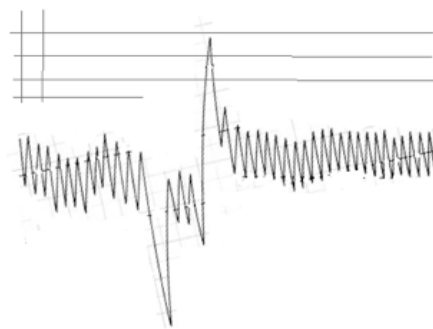https://www.youtube.com/watch?v=blltTva35Bc&feature=youtu.be

Question 21

(a) Below are two traces, one is without carbon dioxide absorbent and the other with it. Identify which is which and explain the difference.
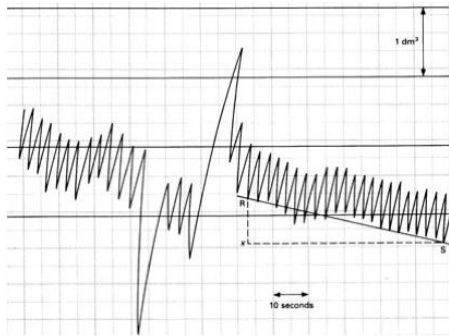
Trace A   *Trace B*

(b) Why is it dangerous to allow a subject to do the experiment with carbon dioxide absorbent?

(c) Calculate the oxygen consumption shown by the subject in the traces above.

18. Investigate habituation to a stimulus

Question 22

The following table shows data from an actual study, which can be viewed here

https://youtu.be/MslbUpxC1-A

Number of Stimuli	Recovery Time / seconds
1	70.5
2	53.9
3	55.9
4	50.5
5	35.9
6	31.6
7	27.1
8	18.8
9	10.1
10	7.5
11	3.6
12	5.2
13	1.1
14	0
15	0

Refer to the Maths guide pages 33-37 to help you to calculate a correlation coefficient (Spearman's rank correlation test) for these data.

Start by writing a null hypothesis and then use a table of critical values to accept or reject it.