IB Biology HL

Course Manual

Bend Senior High School

2011-2013

Table of Contents

The IB Learner Profile

Inquirers	They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.
Knowledgeable	They explore concepts, ideas and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.
Thinkers	They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.
Communicators	They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.
Principled	They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.
Open-minded	They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.
Caring	They show empathy, compassion and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.
Risk-takers	They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas and strategies. They are brave and articulate in defending their beliefs.
Balanced	They understand the importance of intellectual, physical and emotional balance to achieve personal well-being for themselves and others.
Reflective	They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development.

IB BIOLOGY COURSE AIMS:

Through studying any of the group 4 subjects, students should become aware of how scientists work and communicate with each other. While the "scientific method" may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that distinguishes the group 4 subjects from other disciplines and characterizes each of the subjects within group 4.

It is in this context that all the Diploma Program experimental science courses should aim to:

1. provide opportunities for scientific study and creativity within a global context that will stimulate and challenge students
2. provide a body of knowledge, methods and techniques that characterize science and technology
3. enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyze, evaluate and synthesize scientific information
5. engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills
7. develop and apply the students' information and communication technology skills in the study of science
8. raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
9. develop an appreciation of the possibilities and limitations associated with science and scientists
10. encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.

What Can You Expect?

- You can expect to spend a minimum of 4 hours of homework/study for HL per week.
- Classes are smaller and you will be treated like adults.
- You will be among other students who chose to study Biology, so learning becomes more stimulating.
- You will need to be self-motivated…read the book…review your notes…form study groups…ask for help when you need it!
- You will cover topics in greater depth, but some will be totally new to you.
- You will work with high tech equipment and carry out practical lab work that requires a high level of skill and precision.
- Be flexible…as this is the first time I have taught this course, as well as a 7 period day, our pacing and sequence is not laid in stone. It will largely depend on your input!

IB Biology HL Year 1 & Year 2

Course Information:

Instructor: Laura Cowin-Sugden **Classroom Phone**: 541.355.3867

Email: laura.sugden@bend.k12.or.us **Prep Period:** 1st period 7:45-8:35 (best time to call)

Qualifications: Biochemistry- B.S., 1994, M.S., 2002

National Board Certification Adolescent and Young Adult Science, 2007

Materials Needed: Students will need to bring a 3 ring binder (2") for handouts and notes, tabbed dividers, and filler paper solely used for IB Biology. We will fill out the tabs for the dividers as we go along.

Texts: Campbell & Reece, et al, Biology *6th Edition*, Pearson Benjamin Cummings, 2002

Website: http://laurasugden.weebly.com (I post assignment schedules, notes & handouts)

Objectives: **The objectives for all IB group 4 subjects wherever appropriate will draw upon environmental and technological contexts and identify the social, moral and economic effects of science.**

Objective 1: Demonstrate an understanding of:

a. scientific facts and concepts
b. scientific methods and techniques
c. scientific terminology
d. methods of presenting scientific information

Objective 2: Apply and use:

a. scientific facts and concepts
b. scientific methods and techniques
c. scientific terminology to communicate effectively
d. appropriate methods to present scientific information

Objective 3: Construct, analyze and evaluate:

a. hypotheses, research questions and predictions
b. scientific methods and techniques
c. scientific explanations

Objective 4: Demonstrate the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem solving.

Objective 5: Demonstrate the manipulative skills necessary to carry out scientific investigations with precision and safety.

IB Assessment:

Internal Assessments (IA's): Internal Assessments are graded by the instructor as well as an external moderator…somewhere in the world! The IA's are worth 24% of your IB grade.

1. **Group 4 Project:** A collaborative project with other IB science students that will be completed in the second year. You are expected to spend 10 hours on your group 4 project. The group 4 project is graded using the Personal Skills rubric (PS).

Personal Skills (collaboration in Science)

Levels/ Marks	**Aspect 1**	**Aspect 2**	**Aspect 3**
	Following instructions	*Carrying out techniques*	*Working Safely*
Complete / 2	Approaches the project with self-motivation and follows it through to completion.	Collaborates and communicates in a group situation and integrates the views of others.	Shows a thorough awareness of their own strengths and weaknesses and gives thoughtful consideration to their learning experience.
Partial / 1	Completes the project but sometimes lacks self-motivation.	Exchanges some views but requires guidance to collaborate with others.	Shows limited awareness of their own strengths and weaknesses and gives some consideration to their learning experience.
Not at all / 0	Lacks perseverance and motivation.	Makes little or no attempt to collaborate in a group situation.	Shows no awareness of their own strengths and weaknesses and gives no consideration to their learning experience.

2. **Manipulative Skills:** This is a one time, summative assessment at the end of the course using the Manipulative Skills (MS) rubric. This assessment shows where you are at the end of the course.

Manipulative Skills, Safety and Ethics:

Levels/ Marks	**Aspect 1**	**Aspect 2**	**Aspect 3**
	Following instructions	*Carrying out techniques*	*Working Safely*
Complete / 2	Follows instructions accurately, adapting to new circumstances (seeking assistance when required).	Competent and methodical in the use of a range of techniques and equipment.	Pays attention to safety issues.
Partial / 1	Follows instructions but requires assistance.	Usually competent and methodical in the use of a range of techniques and equipment.	Usually pays attention to safety issues.
Not at all / 0	Rarely follows instructions **or** requires constant supervision.	Rarely competent and methodical in the use a range of techniques and equipment.	Rarely pays attention to safety issues.

Internal Assessments (cont.)

3. **PSOW (Practical Scheme of Work):** The practical course planned by the instructor and acts as a summary of all the investigative activities (labs) you carry out throughout your course. You are required to spend a minimum of 50 hours on practical (lab) activities (excluding the time spent writing up work) over the 2 years of the course. This work should be recorded on form 4/PSOW and retained in the classroom. The PSOW work will be graded on 3 criteria: Design (D), Data Collection and Processing (DCP), and Conclusion and Evaluation (CE). There are rubrics for each of the 3 criteria that we will become very familiar with! You will be assessed twice in each of the three criteria. This scoring guide will be shown later when discussing lab report format on PAGE 12.

External Assessments (EA's): The EA's or IB Exams are taken at the end of the second year of the course. The examinations for 2012 in IB Biology HL are May 17th and 18th. The exams consist of 3 papers as described below. These examinations are assessed on a 1-7 scale with 4 the minimum for a passing grade.

Paper 1 (20%): 1 hour. Short 1-2 stage problems that address objectives 1 & 2 with multiple choice responses from the core topics covered in class.

Paper 2(36%): 2.25 hours. In section A of paper 2 there is a data based question addressing objectives 1,2 & 3 that require analysis and short answer questions. In section B students will choose 2/3 extended response questions from the core topics covered in class. A calculator is required.

Paper 3 (20%): 1.25 hours. Short answer and extended response questions that address objectives 1, 2 & 3, within the optional topics covered in class.

BSHS Assessment: Your transcript grade is independent of your IB assessment grade.

Category	Point Value
Formal Quizzes & End of Topic Exams	40%
Labs / IA PSOW's and Research	35%
Classwork/Homework (This includes informal quizzes, reflective essays, presentations, posters, brainstorms, & notebook checks)	15%
Midterm / Final	10%

Sugden's Assessment Expectations:

1. Turn all assignments into the appropriate in-box. DO NOT turn things into my desk or hand me things while I am occupied with another task.
2. Late work may receive a 20% reduction in credit depending on the circumstances. I will depend on your ability to communicate and our ability to form a respectful relationship with one another to determine the nature of the circumstances described previously. If late work is not complete, or it is of poor quality it will receive a Ø. These are the expectations in place for my adult OSU Cascades students as well.
3. I will do random notebook checks throughout the year. You should NEVER throw away any IB Biology work. Keep it in your notebook or if it is a completed lab in the file folder for you class.
4. You will do several reflective essays in which I ask you think about your thinking…this is called "Metacognition" and is a very important process for advanced learners. I will these essays to be mature and truly reflective in nature. You can expect these essays to be about 5% of your Classwork/Homework grade.

IB Lab / IA PSOW Report Format:

What is Experimentation About?

You have researched your topic and determined a question worth investigating. Then you developed a hypothesis that you tested. In the process you may have adjusted your ideas until you eventually collected data that could answer either your original question or a modification of it. During your procedure you chose a variable and watched for a response to it. You tried to decide what other factors might detract from the meaning of your collected data. You controlled these detractor factors. Because you collected some numeric data, you will be able to transform the data to search for more meaning. You will then draw conclusions and evaluate the quality of both the data and the procedure of the experiment. NOW you need to report this process in a formal way:

LAB REPORT FORMAT for PSOW:
Before you begin writing, do the following things:

(1) Get the notes that you took in this class

(2) Get notes you took as you planned and performed the experiment

(3) Read through this page and talk with your partners about what you think needs to be included in each section of the report--make notes if you want to do so. ***Once you begin writing, the work should be your own individual best effort.***

General Comments:

- All final reports must be typed (except for the recording of raw data).
- Raw data and observations must be recorded as neatly as possible in blue/black ink when you are doing lab work. If you type your data later for the final report, attach the raw data and observations recorded in lab as an addendum. If you record a number in error, mark through it with 1 line (no erasures or whiteout).
- Include chemical reactions in the report, where applicable.
- Do not write in 1st person singular (don't use 'I', 'we', 'he', etc…Example of an appropriate statement: The acid was added to the beaker.)
- In your reports, be sure to give references as needed
- Heading of first page: write NAME & DATE in right-hand corner

Elements of the formal report:

Whenever you are writing a formal lab report, this format is your default format. Sometimes there will be additional expectations that attend an individual assignment. This report is to be written in sections as indicated below using the language forms indicated.

Name and Date

TITLE (descriptive)

I. DESIGN

BACKGROUND OR INTRODUCTION

- Explains observations, information given in class, and previous information that led you to your question. You may include reasons for raising the question. If you changed the question during the course of the experiment, because of what happened or failed to happen, discuss the shift in this section. Write this section in *paragraph* form.

PROBLEM OR QUESTION

- Write your question in its final form. Use the *interrogative form.*

HYPOTHESIS

- Explain how what you knew led you to your experimental design. Explain your assumptions and reasoning but *not* the details of your steps. Specifically describe the factors that are to be controlled. Describe what you will watch, measure and use as your criterion. Describe independent and dependent variables. If there was a shift of questions discussed above, your hypothesis is to speak to the hypothesis that goes with your final question. Conclude your discussion of the hypothesis with a *conditional statement* of your working hypothesis ("If (having to do with the independent variable) "then" (this will happen to the dependent variable) " because" (statement relating independent and dependent variables).
- **Variables**: Independent, Dependent, Controls

MATERIALS

- List all materials *(not in* sentence format)

PROCEDURES

- Describe the steps that you took as a set of numbered *statements.* Explain adjustments that you made and the conditions that prompted these adjustments. Make your description sufficiently clear that I could repeat your experiment and get the same results that you got.
- Be certain to include quantities, dimensions, and other measurements that would be helpful to a person trying to repeat your results.
- Procedural steps should be numbered and make use of an *economy of words.*
- Note any safety concerns.
- Specifically describe the factors that needed to be controlled including how control was achieved. What factors did you monitor? If this is well covered in your hypothesis or background, do not repeat yourself.
- Draw a *diagram* of the experimental *plan* and refer to the diagram in your description.

II. DATA COLLECTION & PROCESSING

DATA TABLE & GRAPHS

- Data collected may be quantitative or qualitative
- Include units
- Express the raw data by using a *data chart.* Be careful to report only what was observed (even if unexpected), expressing the observation in measurable terms.
- Data tables should be properly formatted with title, labels on columns and rows, and units.
- Record uncertainties in your measurements
- Attach raw data to end of report (state that there is an attachment in your report
- Show the transformations of this raw data that you used to bring meaning to your observations.
- To assist you in your interpretation, you may want to process your data by finding averages, % changes, rates, ranges, or medians or modes to see if any patterns pop out.
- If the data can be expressed in the form of a graph, do so. Diagrams may be used. All graphs, tables, etc. should be clearly labeled (axes, title, units), points should be clearly plotted; graphs may be neatly hand drawn on graph paper, but I highly recommend you do them on Excel
- Calculations and other transformations should be placed in your paper in an easy to follow manner *according to the style requirements of the transformations* you have chosen. Show at least one sample calculation of each type
- Make comparisons, note trends

III. CONCLUSION & EVALUATIONS

- Restate your research problem (testable question)
- Restate your hypothesis
- Discuss how your results either support or reject your hypothesis. USE DATA (NUMBERS) to support this statement.
- Discuss sources of error and the limitations of your conclusions. Resolve any alterations in the question or hypothesis sections. In this section you are evaluating your data and its interpretation. Write this section in *paragraph* form.
- Where applicable, compare experimentally determined results with literature value; note reference
- Where applicable, calculate % error

Grading Rubric for Lab Reports / IA PSOW's

Criteria	Marks	Aspect 1	Aspect 2	Aspect 3
Design	2	• Formulates a focused problem • Provides enough background for reader to understand aim of experiment • Clear hypothesis with stated variables	Designs a method to effectively control variables (within procedure list)	Develops a method allowing for collection of sufficient relative data (within procedure list)
	1	• Formulates an incomplete problem question • Background information is not detailed enough • Not clear hypothesis or not complete variables	Designs a method that makes some attempt to control variables	Develops a method that allows for the collection of insufficient relevant data
	0	• Does not identify problem question • No background information • No hypothesis or variables	Designs a method that does not control the variables	Develops a method that does not allow for collection of any relevant data
Data Collection & Processing	2	• Records appropriate quantitative & associated qualitative raw data • Presents raw data in data chart • Includes units & uncertainties (when relevant)	Processes the quantitative raw data correctly	Presents processed data appropriately and where relevant, includes errors and uncertainties
	1	Records appropriate quantitative and qualitative raw data, but with some mistakes or omissions	Processes quantitative raw data, but with some mistakes and/or omissions	Presents data appropriately, but with some mistakes and/ or omissions
	0	Does not record any appropriate quantitative or qualitative raw data or raw data is incomprehensible	No processing of quantitative raw data is carried out or major mistakes are made in processing	Presents processed data inappropriately or incomprehensibly
Conclusion and Evaluation	2	States a conclusion with justification, based on hypothesis and a reasonable interpretation of the data	Evaluates weaknesses and limitations	Suggests realistic improvements in respect of identified weaknesses and limitations.
	1	States a conclusion based on a reasonable interpretation of data Some parts of conclusion are incomplete	Identifies some weaknesses and limitations, but the evaluation is weak or missing	Suggests only superficial improvements
	0	States no conclusion or conclusion is based on an unreasonable interpretation of data	Identifies irrelevant weaknesses and limitations or none at all	Suggests unrealistic improvements or non at all

LAB REPORT CHECK LIST

Checklist for Design

Aspect 1: defining the problem and selecting variables

- □ I have identified a focused problem or a specific research question. I have done this by, for example, stating a clear aim, a clear hypothesis, and clearly defining the variables.
- □ I have identified and stated the independent variable and the dependent variable, and I have listed the controlled variables

Aspect 2: controlling variables

- □ I describe a method for the effective control of the variables. In particular, I describe how the independent variable is manipulated and how the controlled variables are maintained at constant values
- □ I list all the apparatus and materials used, including the volumes of tubes and cylinders, the concentrations of solutions, the model and manufacturer of any complex apparatus, etc.
- □ I state the level of precision of the values for the independent variable
- □ Any standard methods that I use are fully referenced in a footnote

Aspect 3: developing a method for the collection of data

- □ I describe a method that allows for the collection of sufficient relevant data
- □ The data gathered enables the aim, the research question or the hypotheses to be adequately addressed
- □ The data gathered enables an evaluation of the reliability of the data
- □ The sample size should be adequate to allow a reasonable statistical analysis of the data (for calculating the standard deviation, at least five items per treatment)
- □ An adequately broad data range is considered
- □ An adequate number of data values within this range are considered

Checklist for data collection and processing

Aspect 1: recording raw data

- □ I have recorded my data independently
- □ I have data which is quantitative (numerical)
- □ I have chosen a suitable format in which to record the raw data
- □ The variable that is measured or recorded is clearly stated (e.g. in the column heading in a table)
- □ The units are given for every variable (e.g. in any column headings)
- □ An indication is given of the uncertainty of measurements (e.g. in any column headings)
- □ A complete and descriptive title is given to any table that is used
- □ The same level of precision (number of decimal places) is used for all the items of a variable

Aspect 2: processing raw data

- □ I have decided on a suitable manner in which to process the raw data, so that I may fully test the hypotheses or fulfil the aim (this may involve a mathematical processing, statistical analysis, or transforming the data into a suitable graphical representation)
- □ All of the raw data has been processed to a suitable extent
- □ The raw data has been processed correctly
- □ Any raw data plotted onto a graph includes a line of best-fit

Aspect 3: presenting processed data

- □ I have decided upon a suitable format in which to present the processed data.
- □ There are clear, unambiguous headings for calculations, tables or graphs
- □ Any graphs have appropriate scales, labelled axes with units and accurately plotted data points with a suitable best-fit line or curve
- □ The data has been presented so that all the stages to the final result can be followed
- □ Metric/SI units are included for the final results
- □ The final results are shown expressed to the correct number of significant figures
- □ The uncertainties and errors associated with the raw data have been taken into account and this is shown in some manner (e.g. error bars may be used, as appropriate)

Checklist for conclusion and evaluation

Aspect 1: concluding

- □ I state a conclusion which is based on a reasonable interpretation of the data
- □ If any hypotheses are being tested, I have stated whether the data supports these hypotheses
- □ I give a justification for my conclusion
- □ As appropriate, I compare different graphs, or describe the trends shown in my graphs
- □ If I am measuring an already known and accepted value, I have compared my value with that in a textbook, in order to assess the validity of the result.
- □ I fully reference any literature that is quoted.

Aspect 2: evaluating procedures

- □ I have commented on the design and method of the investigation
- □ I have commented on the quality of the data
- □ I have listed the weaknesses of the study
- □ I have assessed the importance of each of these weaknesses
- □ I have commented on the precision and accuracy of the measurements
- □ In evaluating the procedure, I have specifically looked at the processes, the use of equipment and the management of time

Aspect 3: improving the investigation

- □ My suggestions for improvements are based on the weaknesses and limitations identified in aspect 2
- □ As appropriate, I address modifications to the experimental technique and the data range
- □ The modifications that I propose are realistic and clearly specified

IB Biology Command Terms

These command terms indicate the depth of treatment required for a given assessment statement. These command terms will be used in examination questions, so it is important that you are familiar with the following definitions. READ EM', LEARN EM', LOVE EM', LIVE EM'!!!!

Objective 1

Define	Give the precise meaning of the word, phrase or physical quality.
Draw	Represent by means of pencil lines (always label unless told NOT to do so).
Label	Add labels to a diagram.
List	Give a sequence of names or other brief answers with NO explanation.
Measure	Find a value for a quantity.
State	Give a specific name, value or other brief answer without explanation or calculation.

Objective 2

Annotate	Add brief notes to the diagram or graph.
Apply	Use an idea, equation, principle, theory or law in a new situation
Calculate	Find a numerical answer showing the relevant stages in the working (unless instructed not to do so).
Describe	Give a detailed account.
Distinguish	Give the differences between two or more different items.
Estimate	Find an approximate value for an unknown quantity.
Identify	Find an answer from a given number of possibilities.
Outline	Give a brief account or summary

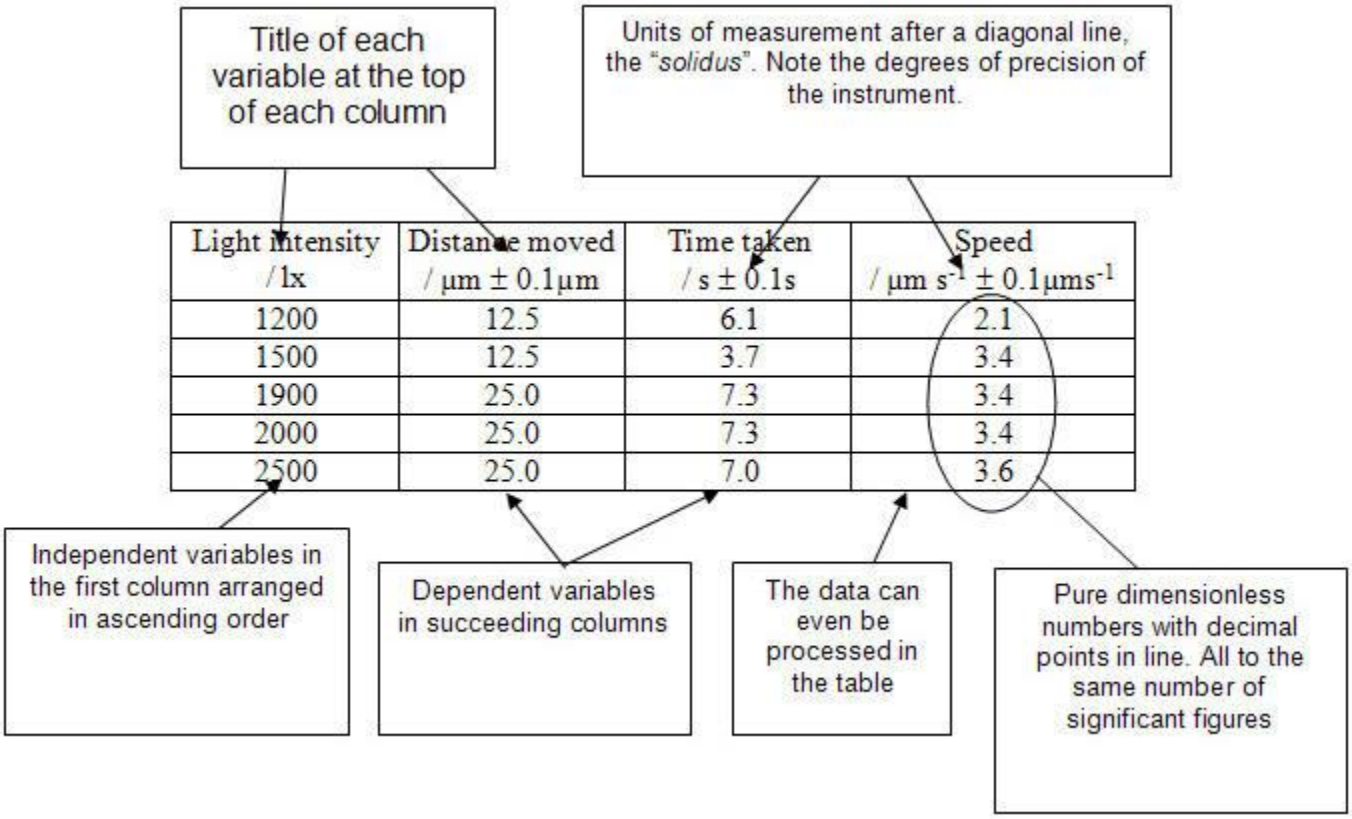
Objective 3

Analyse	Interpret data to reach conclusions.
Comment	Give a judgement based on a given statement or result of a calculation.
Compare	Give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout.
Construct	Represent or develop in graphical form.
Deduce	Reach a conclusion from the information given.
Derive	Manipulate a mathematical relationship(s) to give a new equation or relationship.
Design	Produce a plan, simulation or model.
Determine	Find the only possible answer.
Discuss	Give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.
Evaluate	Assess the implications and limitations.
Explain	Give a detailed account of causes, reasons or mechanisms.
Predict	Give an expected result.
Show	Give the steps in a calculation or derivation.
Sketch	Represent by means of a graph showing a line and labelled but unscaled axes, but with important features (for example, intercept) clearly indicated.
Solve	Obtain an answer using algebraic and/or numerical methods.
Suggest	Propose a hypothesis or other possible answer.

How to Draw Tables

Tables are a convenient way of recording data. Nevertheless they do follow certain conventions.

II. The results of an investigation on the effect of light on the cyclosis of chloroplasts



Degrees of precision

- Apply a simple rule. The degree of precision is equal to the smallest graduation on the instrument.
- You may need to estimate the degree of precision sometimes especially with stop watches. Digital stop watches are said to be accurate to 0.01s but your reaction time is only 0.1s.
- For electronic probes you may have to go to the manufacturers specifications (on their web site or in the instructions manual.
- Some instruments have not degrees of precision because their reading is relative.

Tables can be arranged horizontally too, to save space

The result of pig red blood cells exposed to different salt concentrations

Salt concentration / %	0	0.1	0.3	0.5	0.7	0.9	2.0	10.0
Colorimeter reading / % transmission	2	25	25	25	50	55	62	42

More Complex Tables

Number the table and give it a title which concisely states what the experiment is about.

Data Table 3: The rate of uptake of water by a leafy shoot under different conditions

Independent variable first…..

…….Dependent Variable next

Titles of variables at the top of each column

Use the / to separate the title from the units

	WITHOUT HAIR DYER			WITH HAIR DRYER		
TRIAL	DISTANCE / cm	TIME TAKEN / min	SPEED / cm min-1	DISTANCE / cm	TIME TAKEN / min	SPEED / cm min^{-1}
1	10	5.18	1.93	10	2.68	3.73
2	6	2.71	2.21	5	1.80	2.78
3	10	5.24	1.91	6	1.92	3.13
4	15	7.60	1.97	10	2.75	3.64
5	5	2.65	1.88	10	2.55	3.92
		Average Speed	1.98		Average Speed	3.44

Units at the top of the column. Use only SI units

No units here

Draw straight lines- **Use a RULER!!!**

Time is recorded in one unit ie minutes or seconds not both.

Note : 2 min 30s = 2.5 min **not** 2.30 min

All decimal points should

Data presented in decimals to as many significant places as your instruments will permit.

Tables courtesy of Mr. Paul Billiet

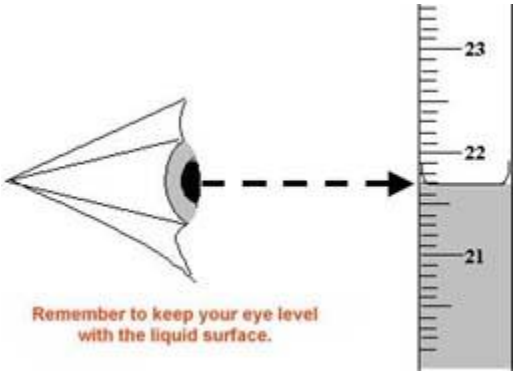
Error Analysis in Biology:

Error analysis in biology is no different from that in other sciences. Biology however is not an "exact" science in that much of the data collected by biologists is qualitative. Furthermore, biological systems are very complex and difficult to control. Biological investigations, nevertheless, do often require measurements and biologists do need to be aware of the sources of error in their data.

Human error:

Obviously data which is carefully recorded will be more reliable than data collected carelessly. Human error can occur when tools or instruments are used or read incorrectly. For example a temperature reading from a thermometer in a liquid should be taken after stirring the liquid and whilst the bulb of the thermometer is still in the liquid. Thermometers and other instruments should be read with the eye level with the liquid otherwise this results in parallax error.

Human errors can be systematic because the experimenter does not know how to use the apparatus properly or they can be random because the power of concentration of the experimenter is fading.



Systematic errors

If an electronic water bath is set to 37°C the thermometer in the water bath should also read 37°C. If they do not agree then there will be an error at any other temperature being used. Some instruments need calibrating before you use them. If this is done correctly and regularly it can reduce the risk of systematic error.

Random errors

In biological investigations, the changes in the material used or the conditions in which they are carried out can cause a lot of errors. For example the rate of respiration of a small animal measured using a manometric respirometer can be influenced by changes in air temperature and barometric pressure.

Biological material is notably variable. For example, the water potential of potato tissue may be calculated by soaking pieces of tissue in a range of concentrations of sucrose solutions. However, different pieces of tissue will vary in their water potential especially if they have been taken from different potatoes.

The problem of random errors can be kept to a minimum by careful selection of material and careful control of variables (e.g. using a water bath or a blank). As we saw above, human errors can become random when you have to make a lot of tedious measurements, your concentration span can vary. Automated measuring using a data-logger system can help reduce the likelihood of this error; alternatively you can take a break from measuring from time to time.

Replicates and samples

Because of their complexity and variability biological systems require replicate observations and multiple samples of material. As rule the lower limit is 5 measurements or a sample size of 5. Very small samples run from 5 to 20, small samples from 20 to 30 and big samples above 30.

Selecting data

Replicates permit you to see if data is consistent. If a reading is very different from the others it may be left out from the processing and analysis. However, you must always be ready to justify why you do this.

Degrees of precision

If you use a ruler, graduated in millimetres, to measure an object (e.g. the length of a leaf) you will probably find the edges of the object lie close to a millimeter division but probably not right on it. Recording the leaf is "4.5cm-and-a-bit" long is not very useful. The accepted rule is that the degree of precision is ± half the smallest division on the instrument, in this case one half millimeter. So the leaf in this example is 4.5cm ± 0.05cm.
The degree of precision will influence the instrument that you choose to make a measurement. For example of you used the same ruler to measure an object 0.5cm long the degree of precision (± 0.1cm) is 20% of the measurement, This a is very large error margin and, so, it is not very precise. Therefore, we must choose an appropriate instrument for measuring a particular length, volume, pH, light intensity etc.

act of measuring

When a measurement is taken this can affect the environment of the experiment. For example when a cold thermometer is put in a test tube of warm water, the water will be cooled by the presence of the thermometer. When the behaviour of animals is being recorded the presence of the experimenter may influence them.

Why bother?

You might think that with all these sources of error and imprecision experimental results are worthless. This is not true, it is understood that experimental results are only estimates. What is expected of a scientist is that they:

i. make the best effort to avoid errors in their design of investigations and the use of instruments.
ii. are aware of the source of errors and to appreciate their magnitude.

Biological Drawings

Drawing Materials. All drawings should be done with a sharp pencil line on white, unlined paper. Diagrams in pen are unacceptable because they cannot be corrected. Lines are clear and not smudged. There are almost no erasures or stray marks on the paper. Color is used carefully to enhance the drawing. Stippling is used instead of shading.

Positioning. Center your drawing on the page. Do not draw in a corner. This will leave plenty of room for the addition of labels.

Size. Make a large, clear drawing; it should occupy at least half a page.
Labels. Use a ruler to draw straight, horizontal lines to the right of the side of the drawing. The labels should form a vertical list. All labels should be printed (not cursive).

Accuracy. Draw what you see; as you see it, not what you imagine should be there. Avoid making "idealized" drawings. You are not necessarily drawing everything that is seen in the field of view. Draw only what is asked for. Show only as much as necessary for an understanding of the structure – a small section shown in detail will often suffice. It is time consuming and unnecessary, for example, to reproduce accurately the entire contents of a microscopic field.

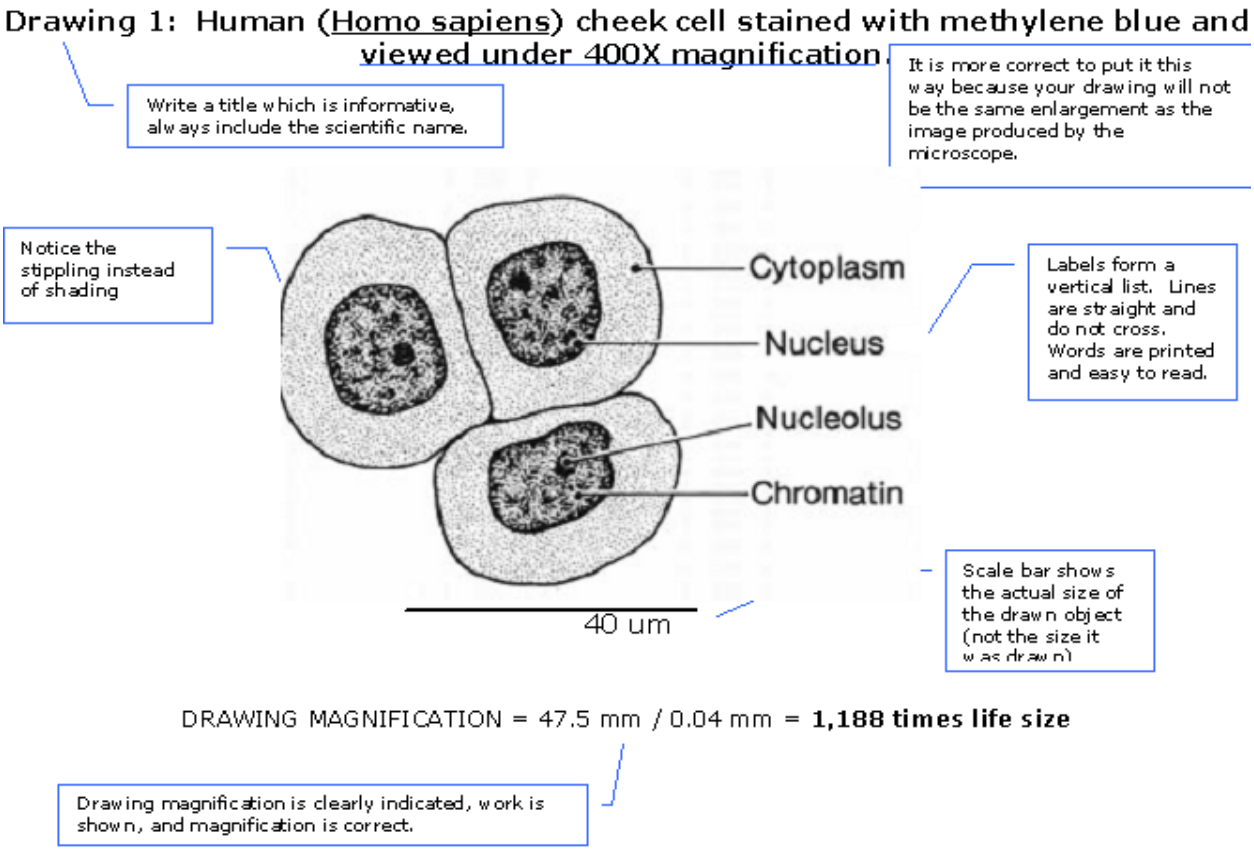
Technique. Keep looking back at your specimen whilst you are drawing. If using a microscope, while you are observing increase the magnification to observe more details and reduce the magnification to get a more general view. Use the focusing controls on the microscope to observe at different depths of the specimen. Move the specimen around; do not just concentrate on one part. Observe the general appearance first.

Title. The title should state what has been drawn and what lens power it was drawn under (for example, phrased as: drawn as seen through 400X magnification). Title is informative, centered, and larger than other text.

Scale. Include how many times larger the drawing is compared to life size and a scale line that indicates relative size. To determine magnification, use the equation:

Actual size of line / size the line represents in real life = magnification

Sample Drawing:

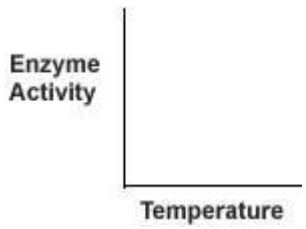


Graphing in Biology:

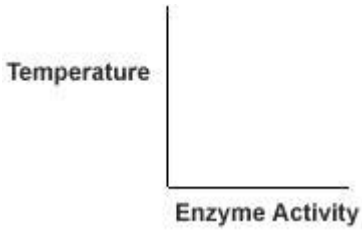
(1) Determine the dependent and independent variables

In an experiment the experimenter will determine a set of conditions. It may be a range of temperatures or pH values, or, more commonly, the experimenter may choose to observe the experiment proceeding at set intervals of time (seconds, days or even years). These are the independent variable and always go on the horizontal axis (x—axis or abscissa). The effect of the experimenter varying the independent variable is measured as the dependent variables (the part of the experiment under observation), this is always plotted on the vertical axis (y—axis or ordinate).

Thus in an experiment to determine the effect of temperature upon the activity of a particular enzyme the axis should be set up as shown below.



Like this



Not like this

(2) Note the units of measurement for each of the variables

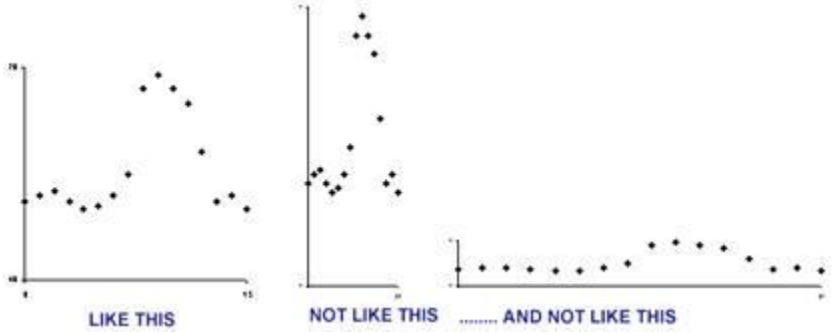
In the example above the temperature is likely to be in degrees Celsius (°C) but some chemistry and physics texts will use degrees Absolute or Kelvin (K). [NB None metric units such as Fahrenheit (°F) should be avoided in science.]

It is important to indicate to your audience what you are actually measuring your variables in. From the above example again, enzyme activity is usually measured in the amount of product produced per unit time. For example: g product/min or g product min^{-1}.

The units of measurement are presented behind the label of the axis after an oblique line not in brackets. e.g. Temperature / °C

(3) The proportions of the axes

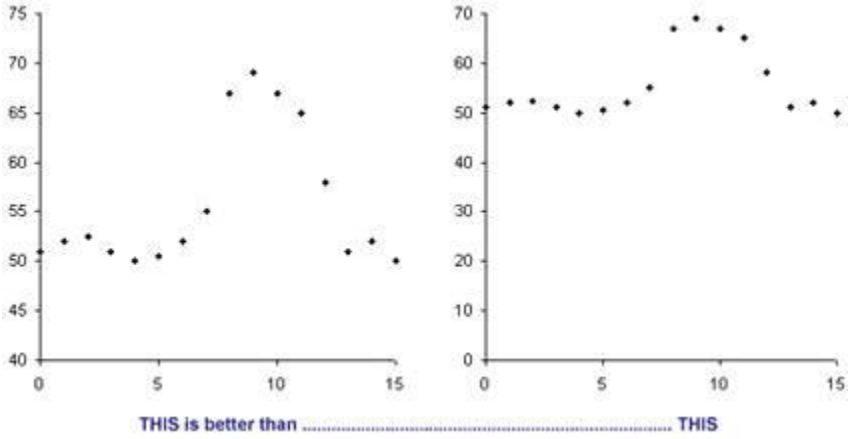
The area enclosed by the axes should be roughly square and not disproportionately exaggerated.



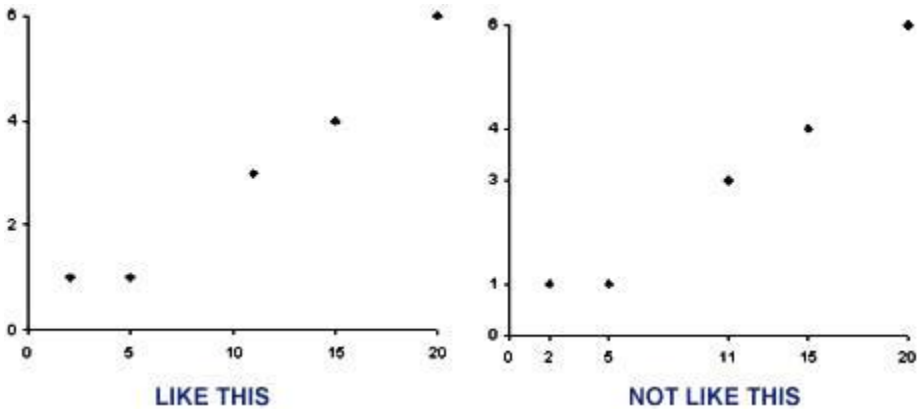
If you are drawing the graph by hand on a piece of graph paper remember to leave yourself enough margin to write in your axis labels.

(4) Analyzing your data

Look at your data carefully and determine the highest and lowest values for each of the two variables.
Values should increase as they progress away from the origin. At best this should be 0. This, however, may not be necessary especially if it wastes space and you want to maintain a roughly square graph. Start from a convenient but carefully chosen origin.



(5) Mark the quantities on both axes and number them at regular intervals



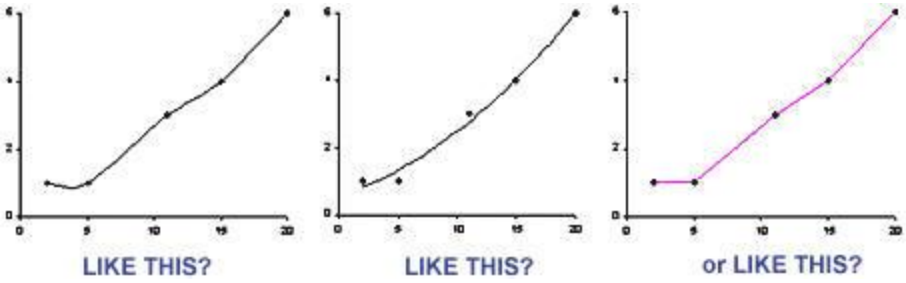
There is a temptation to space the numbers irregularly because your data, especially the dependant variable data, is often irregularly spaced. The labels on the axes should be regularly spaced so that the axis functions as a scale bar for intermediate values.

(6) Plotting and drawing the graph. Smooth curves, straight lines or trend lines?

If you are drawing the graph by hand, each point is marked clearly and boldly using a sharp pencil. Mark the data points as crosses or circles rather than dots.

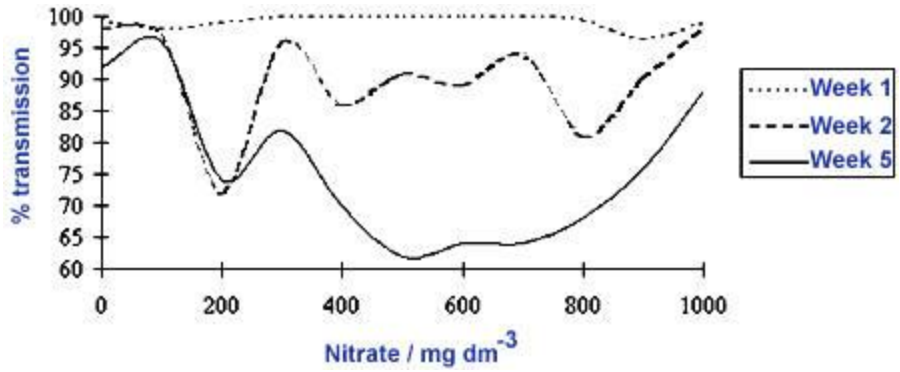
You may join the points with a smooth curve passing through the points if they fall in a clear sequence and you think that the fluctuations in the curve are significant features of the data. However, because of errors and variations, a trend line (or curve) drawn between the points is usually best. If you cannot predict what data you would get between the different data points then they should be joined by straight lines.

DO NOT extend the line beyond the first and last data points given.



(7) Label the axes clearly with the variables and units

The Effect of Nitrates on Algal Growth



(8) Giving the graph a title

The graph must have a title which should contain a brief description of what is being investigated. Other information which may go in the title, if available, includes: the date, place and name of experimenter or collector of the data. If there is more than one graph a reference number or letter is required. For example:
"Fig 2 A graph showing the change in testis weight throughout the year in the brown rat (*Rattus rattus*)"
IS BETTER THAN...
"A graph of testis weight against time" which is insufficient.
Underline or use bold type for your title, it makes it stand out and is easier to find on the page.

(9) Plotting more than one graph on a set of axes.

Sometimes two or three sets of data (though rarely more) are plotted within the same set of axes. You must distinguish between them by using different symbols (X, □ , □, ▽etc) or lines (……., _____, ----------, etc). Avoid using color for materials which is going to be printed.

Using SI Units:

You will be expected to use SI units in IB Biology. Here are some refresher tables for you.

Prefix	Symbol	Fractions	Example
pico	p	1 / 1 000 000 000 000	picometer (pm)
nano	n	1 / 1 000 000 000	nanometer (nm)
micro	u	1 / 1 000 000	mircometer (um)
milli	m	1 / 1 000	millimeter (mm)
centi	c	1 / 1 00	centimeter (cm)
deci	d	1 / 1 0	decimeter (dm)
		Multiples	
tera	T	1 000 000 000 000	terameter (Tm)
giga	G	1 000 000 000	gigameter (Gm)
mega	M	1 000 000	megameter (Mm)
kilo	k	1 000	kilometer (km)
hecto	h	1 00	hectometer (hm)
deka	da	1 0	dekameter (dam)

Quantity measured	Unit	Symbol	Relationship
Length, width, distance, thickness, girth, etc.	millimeter	mm	10 mm = 1 cm
	centimeter	cm	100 cm = 1 m
	meter	m	
	kilometer	km	1 km = 1000 m
Mass ("weight")*	milligram	mg	1000 mg = 1 g
	gram	g	
	kilogram	kg	1 kg = 1000 g
	metric ton	t	1 t = 1000 kg
Time	second	s	
Temperature	degree Celsius	°C	
Area	square meter	m^2	
	hectare	ha	1 ha = 10 000 m^2
	square kilometer	km^2	1 km^2 = 100 ha
Volume	milliliter	mL	1000 mL = 1 L
	cubic centimeter	cm^3	1 cm^3 = 1 mL
	liter	L	1000 L = 1 m^3
	cubic meter	m^3	
Speed, velocity	meter per second	m/s	

	kilometer per hour	km/h	1 km/h = 0.278 m/s
Density	kilogram per cubic meter	kg/m³	
Force	newton	N	
Pressure, stress	kilopascal	kPa	
Power	watt	W	
	kilowatt	kW	1 kW = 1000 W
Energy	kilojoule	kJ	
	megajoule	MJ	1 MJ = 1000 kJ
	kilowatt hour	kW·h	1 kW·h = 3.6 MJ
Electric current	ampere	A	

The syllabus for the "Diploma Programme" biology course is divided into three parts: the core, the AHL material and the options. A syllabus overview is provided below.

Teaching Hours: Core 80

Topic 1: Statistical analysis 2 Hours

Topic 2: Cells 12 Hours

Topic 3: The chemistry of life 15 Hours

Topic 4: Genetics 15 Hours

Topic 5: Ecology and evolution 16 Hours

Topic 6: Human health and physiology 20 Hours

AHL 55 hours

Topic 7: Nucleic acids and proteins 11 Hours

Topic 8: Cell respiration and photosynthesis 10 Hours

Topic 9: Plant science 11 Hours

Topic 10: Genetics 6 Hours

Topic 11: Human health and physiology 17 Hours

Options 15/22 hours

Options HL

Option F: Microbes and biotechnology 15/22 Hours

Option G: Ecology and conservation 15/22 Hours

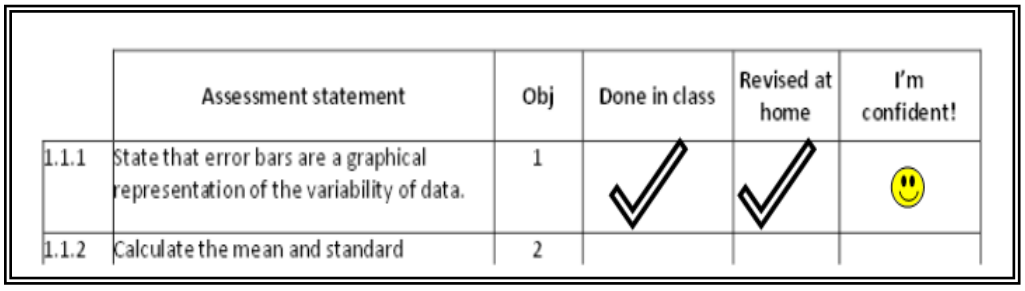
Using This Syllabus Handbook:

The next section of this handbook lists all of the topics and topic assessment statements we are to cover over the next 2 years. Think of them as standards that must be mastered to successfully complete the IB biology course.

You are expected to keep track of your progress in the content of the course using this handbook. It is essential that you cover all of the assessment statements fully over the course, and we will aim to do so in lessons as much as possible. However, there is a strong expectation that you do your own reading and make sure that you take the initiative to fill in any blanks. There are many resources available to you other than the book. Check the list of websites at the end of this manual for more information.

TRACKING YOUR PROGRESS THROUGH THE SYLLABUS:

- As you cover an assessment statement in class or as part of an assignment, highlight it with a marker and tick the "Done in class" box.
- Highlight the command term in the assessment statement: do you understand what you need to be able to do?
- Once you have revised the work, put a tick under 'revised at home'.
- If you are 100% sure that you could walk into the exam and answer a question on that statement (remember the command term and objective), stick a smiley face under 'I'm confident'.
- It's a simple, visual way to track your progress, but it just might work for you. Have a go…



	Assessment statement	Obj	Done in class	Revised at home	I'm confident!
1.1.1	State that error bars are a graphical representation of the variability of data.	1	✓	✓	☺
1.1.2	Calculate the mean and standard	2			

Remember:

- Read ahead to make best use of class time.
  You should NEVER come to class unprepared.
- Check your progress regularly, making reference to the command terms
- Take the initiative to find your own sources and **complete any assessment statements we miss in class by yourself**

Topic Assessment Statements:

Topic 1: Statistical analysis (2 hours)

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
1.1.1	State that error bars are a graphical representation of the variability of data.	1	Error bars can be used to show either the range of the data or the standard deviation.			
1.1.2	Calculate the mean and standard deviation of a set of values.	2	Students should specify the standard deviation (*s*), not the population standard deviation. Students will not be expected to know the formulas for calculating these statistics. They will be expected to use the standard deviation function of a graphic display or scientific calculator. **Aim 7:** Students could also be taught how to calculate standard deviation using a spreadsheet computer program.			
1.1.3	State that the term standard deviation is used to summarize the spread of values around the mean, and that 68% of the values fall within one standard deviation of the mean.	1	For normally distributed data, about 68% of all values lie within ±1 standard deviation (*s* or σ) of the mean. This rises to about 95% for ±2 standard deviations.			
1.1.4	Explain how the standard deviation is useful for comparing the means and the spread of data between two or more samples.	3	A small standard deviation indicates that the data is clustered closely around the mean value. Conversely, a large standard deviation indicates a wider spread around the mean.			
1.1.5	Deduce the significance of the difference between two sets of data using calculated values for *t* and the appropriate tables.	3	For the *t*-test to be applied, the data must have a normal distribution and a sample size of at least 10. The *t*-test can be used to compare two sets of data and measure the amount of overlap. Students will not be expected to calculate values of *t*. Only a two-tailed, unpaired *t*-test is expected. **Aim 7:** While students are not expected to calculate a value for the *t*-test, students could be shown how to calculate such values using a spreadsheet program or the graphic display calculator. **TOK:** The scientific community defines an objective standard by which claims about data can be made.			
1.1.6	Explain that the existence of a correlation does not establish that there is a causal relationship between two variables.	3	**Aim 7:** While calculations of such values are not expected, students who want to use *r* and r_2 values in their practical work could be shown how to determine such values using a spreadsheet program.			

Topic 2: Cells (12 hours)

2.1 Cell theory 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
2.1.1	Outline the cell theory.	2	Include the following. Living organisms are composed of cells. Cells are the smallest unit of life. Cells come from pre-existing cells.			

2.1.2	Discuss the evidence for the cell theory.	3	**TOK:** The nature of scientific theories could be introduced here: the accumulation of evidence that allows a hypothesis to become a theory; whether a theory should be abandoned when there is evidence that it does not offer a full explanation; and what evidence is needed for a theory to be adopted or rejected.	**Done in class**	**Revised at home**	**I'm Confident!**
2.1.3	State that unicellular organisms carry out all the functions of life.	1	Include metabolism, response, homeostasis, growth, reproduction and nutrition.			
2.1.4	Compare the relative sizes of molecules, cell membrane thickness, viruses, bacteria, organelles and cells, using the appropriate SI unit.	3	Appreciation of relative size is required, such as molecules (1 nm), thickness of membranes (10 nm), viruses (100 nm), bacteria (1 µm), organelles (up to 10 µm), and most cells (up to 100 µm). The three-dimensional nature/shape of cells should be emphasized. **TOK:** All the biological entities in the above list are beyond our ability to perceive directly. They must be observed through the use of technology such as the light microscope and the electron microscope. Is there any distinction to be drawn between knowledge claims dependent upon observations made directly with the senses and knowledge claims dependent upon observations assisted by technology?			
2.1.5	Calculate the linear magnification of drawings and the actual size of specimens in images of known magnification.	2	Magnification could be stated (for example, ×250) or indicated by means of a scale bar, for example:  **Aim 7:** The size of objects in digital images of microscope fields could be analysed using graticule baselines and image-processing software.			
2.1.6	Explain the importance of the surface area to volume ratio as a factor limiting cell size.	3	Mention the concept that the rate of heat production/waste production/resource consumption of a cell is a function of its volume, whereas the rate of exchange of materials and energy (heat) is a function of its surface area. Simple mathematical models involving cubes and the changes in the ratio that occur as the sides increase by one unit could be compared. **Aim 7:** Data logging could be carried out to measure changes in conductivity in distilled water as salt diffuses out of salt–agar cubes of different dimensions.			
2.1.7	State that multicellular organisms show emergent properties.	1	Emergent properties arise from the interaction of component parts: the whole is greater than the sum of its parts. **TOK:** The concept of emergent properties has many implications in biology, and this is an opportunity to introduce them. Life itself can be viewed as an emergent property, and the nature of life could be discussed in the light of this, including differences between living and non-living things and problems about defining death in medical decisions.			

2.1.8	Explain that cells in multicellular organisms differentiate to carry out specialized functions by expressing some of their genes but not others.	3		Done in class	Revised at home	I'm Confident!
2.1.9	State that stem cells retain the capacity to divide and have the ability to differentiate along different pathways.	1				
2.1.10	Outline one therapeutic use of stem cells.	2	This is an area of rapid development. In 2005, stem cells were used to restore the insulation tissue of neurons in laboratory rats, resulting in subsequent improvements in their mobility. Any example of the therapeutic use of stem cells in humans or other animals can be chosen. **Aim 8:** There are ethical issues involved in stem cell research, whether humans or other animals are used. Use of embryonic stem cells involves the death of early-stage embryos, but if therapeutic cloning is successfully developed the suffering of patients with a wide variety of conditions could be reduced. **Int:** Stem cell research has depended on the work of teams of scientists in many countries, who share results and so speed up the rate of progress. However, ethical concerns about the procedures have led to restrictions on research in some countries. National governments are influenced by local, cultural and religious traditions, which vary greatly, and these, therefore, have an impact on the work of scientists. **TOK:** This is an opportunity to discuss balancing the huge opportunities of therapeutic cloning against the considerable risks—for example, stem cells developing into tumours. Another issue is how the scientific community conveys information about its work to the wider community in such a way that informed decisions about research can be made.			

2.2 Prokaryotic cells 1 hour

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
2.2.1	Draw and label a diagram of the ultrastructure of *Escherichia coli* (*E. coli*) as an example of a prokaryote.	1	The diagram should show the cell wall, plasma membrane, cytoplasm, pili, flagella, ribosomes and nucleoid (region containing naked DNA).			
2.2.2	Annotate the diagram from 2.2.1 with the functions of each named structure.	2				
2.2.3	Identify structures from 2.2.1 in electron micrographs of *E. coli*.	2				
2.2.4	State that prokaryotic cells divide by binary fission.	1				

2.3 Eukaryotic cells 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
2.3.1	Draw and label a diagram of the ultrastructure of a liver cell as an example of an animal cell.	1	The diagram should show free ribosomes, rough endoplasmic reticulum (rER), lysosome, Golgi apparatus, mitochondrion and nucleus. The term Golgi apparatus will be used in place of Golgi body, Golgi complex or dictyosome.			
2.3.2	Annotate the diagram from 2.3.1 with the functions of each named structure.	2				
2.3.3	Identify structures from 2.3.1 in electron micrographs of liver cells.	2				
2.3.4	Compare prokaryotic and eukaryotic cells.	3	Differences should include: naked DNA *versus* DNA associated with proteins DNA in cytoplasm *versus* DNA enclosed in a nuclear envelope no mitochondria *versus* mitochondria 70S *versus* 80S ribosomes eukaryotic cells have internal membranes that compartmentalize their functions.			
2.3.5	State three differences between plant and animal cells.	1				
2.3.6	Outline two roles of extracellular components.	2	The plant cell wall maintains cell shape, prevents excessive water uptake, and holds the whole plant up against the force of gravity. Animal cells secrete glycoproteins that form the extracellular matrix. This functions in support, adhesion and movement.			

2.4 Membranes 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
2.4.1	Draw and label a diagram to show the structure of membranes.	1	The diagram should show the phospholipid bilayer, cholesterol, glycoproteins, and integral and peripheral proteins. Use the term plasma membrane, not cell surface membrane, for the membrane surrounding the cytoplasm. Integral proteins are embedded in the phospholipid of the membrane, whereas peripheral proteins are attached to its surface. Variations in composition related to the type of membrane are not required. **Aim 7:** Data logging to measure the changes in membrane permeability using colorimeter probes can be used.			

2.4.2	Explain how the hydrophobic and hydrophilic properties of phospholipids help to maintain the structure of cell membranes.	3				
2.4.3	List the functions of membrane proteins.	1	Include the following: hormone binding sites, immobilized enzymes, cell adhesion, cell-to-cell communication, channels for passive transport, and pumps for active transport.	**Done in class**	**Revised at home**	**I'm Confident!**
2.4.4	Define *diffusion* and *osmosis*.	1	Diffusion is the passive movement of particles from a region of high concentration to a region of low concentration. Osmosis is the passive movement of water molecules, across a partially permeable membrane, from a region of lower solute concentration to a region of higher solute concentration.			
2.4.5	Explain passive transport across membranes by simple diffusion and facilitated diffusion.	3				
2.4.6	Explain the role of protein pumps and ATP in active transport across membranes.	3				
2.4.7	Explain how vesicles are used to transport materials within a cell between the rough endoplasmic reticulum, Golgi apparatus and plasma membrane.	3				
2.4.8	Describe how the fluidity of the membrane allows it to change shape, break and re-form during endocytosis and exocytosis.	2				

2.5 Cell division 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
2.5.1	Outline the stages in the cell cycle, including interphase (G_1, S, G_2), mitosis and cytokinesis.	2				
2.5.2	State that tumours (cancers) are the result of uncontrolled cell division and that these can occur in any organ or tissue.	1				
2.5.3	State that interphase is an active period in the life of a cell when many metabolic reactions occur, including protein synthesis, DNA replication and an increase in the number of mitochondria and/or chloroplasts.	1				
2.5.4	Describe the events that occur in the four phases of mitosis (prophase, metaphase, anaphase	2	Include supercoiling of chromosomes, attachment of spindle microtubules to centromeres, splitting of centromeres, movement of sister chromosomes to			

	and telophase).		opposite poles, and breakage and re-formation of nuclear membranes. Textbooks vary in the use of the terms chromosome and chromatid. In this course, the two DNA molecules formed by DNA replication are considered to be sister chromatids until the splitting of the centromere at the start of anaphase; after this, they are individual chromosomes. The term kinetochore is not expected. **Aim 7:** Students could determine mitotic index and fraction of cells in each phase of mitosis. Individual groups could paste data into a database. Pie charts could be constructed with a graphing computer program. If a graphing computer program is used in DCP for internal assessment, it should be according to the IA and ICT clarifications.			
2.5.5	Explain how mitosis produces two genetically identical nuclei.	3				
2.5.6	State that growth, embryonic development, tissue repair and asexual reproduction involve mitosis.	1				

TOPIC 3:The Chemistry of Life (15 hours)

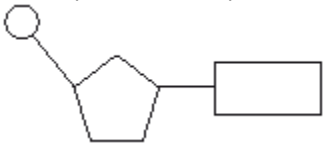
3.1 Chemical elements and water 2 hours

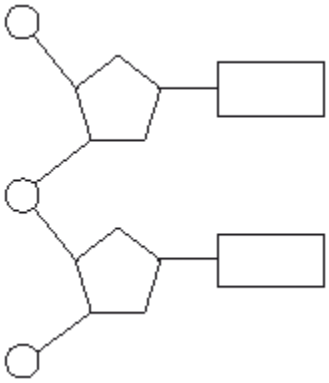
	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.1.1	State that the most frequently occurring chemical elements in living things are carbon, hydrogen, oxygen and nitrogen.	1				
3.1.2	State that a variety of other elements are needed by living organisms, including sulfur, calcium, phosphorus, iron and sodium.	1				
3.1.3	State one role for each of the elements mentioned in 3.1.2.	1	Refer to the roles in plants, animals and prokaryotes.			
3.1.4	Draw and label a diagram showing the structure of water molecules to show their polarity and hydrogen bond formation.	1				
3.1.5	Outline the thermal, cohesive and solvent properties of water.	2	**Aim 7:** Data logging could be carried out to compare the thermal properties of water with those of other liquids. **TOK:** Claims about the "memory of water" have been categorized as pseudoscientific. By what criteria can a claim be judged to be pseudoscientific?			
3.1.6	Explain the relationship between the properties of water and its uses in living organisms as a coolant, medium for metabolic reactions and transport medium.	3	Limit the properties to those outlined in 3.1.5.			

3.2 Carbohydrates, lipids and proteins 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.2.1	Distinguish between *organic* and *inorganic* compounds.	2	Compounds containing carbon that are found in living organisms (except hydrogencarbonates, carbonates and oxides of carbon) are regarded as organic.			
3.2.2	Identify amino acids, glucose, ribose and fatty acids from diagrams showing their structure.	2	Specific names of amino acids and fatty acids are not expected.			
3.2.3	List three examples each of monosaccharides, disaccharides and polysaccharides.	1	The examples used should be: glucose, galactose and fructose maltose, lactose and sucrose, starch, glycogen and cellulose.			
3.2.4	State one function of glucose, lactose and glycogen in animals, and of fructose, sucrose and cellulose in plants.	1				
3.2.5	Outline the role of condensation and hydrolysis in the relationships between monosaccharides, disaccharides and polysaccharides; between fatty acids, glycerol and triglycerides; and between amino acids and polypeptides.	2	This can be dealt with using equations with words or chemical formulas.			
3.2.6	State three functions of lipids.	1	Include energy storage and thermal insulation.			
3.2.7	Compare the use of carbohydrates and lipids in energy storage.	3				

3.3 DNA structure 1 hour

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.3.1	Outline DNA nucleotide structure in terms of sugar (deoxyribose), base and phosphate.	2	Chemical formulas and the purine/pyrimidine subdivision are not required. Simple shapes can be used to represent the component parts. Only the relative positions are required. 			
3.3.2	State the names of the four bases in DNA.	1				
3.3.3	Outline how DNA nucleotides are linked together by covalent bonds into a single strand.	2	Only the relative positions are required.			

						
3.3.4	Explain how a DNA double helix is formed using complementary base pairing and hydrogen bonds.	3				
3.3.5	Draw and label a simple diagram of the molecular structure of DNA.	1	An extension of the diagram in 3.3.3 is sufficient to show the complementary base pairs of A–T and G–C, held together by hydrogen bonds and the sugar–phosphate backbones. The number of hydrogen bonds between pairs and details of purine/pyrimidines are not required. **TOK:** The story of the elucidation of the structure of DNA illustrates that cooperation and collaboration among scientists exists alongside competition between research groups. To what extent was Watson and Crick's "discovery" of the three-dimensional structure of DNA dependent on the use of data generated by Rosalind Franklin, which was shared without her knowledge or consent?			

3.4 DNA replication 1 hour

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.4.1	Explain DNA replication in terms of unwinding the double helix and separation of the strands by helicase, followed by formation of the new complementary strands by DNA polymerase.	3	It is not necessary to mention that there is more than one DNA polymerase.			
3.4.2	Explain the significance of complementary base pairing in the conservation of the base sequence of DNA.	3				
3.4.3	State that DNA replication is semi-conservative.	1				

3.5 Transcription and translation 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.5.1	Compare the structure of RNA and DNA.	3	Limit this to the names of sugars, bases and the number of strands.			
3.5.2	Outline DNA transcription in terms of the formation of an RNA strand complementary to the DNA strand by RNA polymerase.	2				
3.5.3	Describe the genetic code in terms of codons composed of triplets of bases.	2				
3.5.4	Explain the process of translation, leading to polypeptide formation.	3	Include the roles of messenger RNA (mRNA), transfer RNA (tRNA), codons, anticodons, ribosomes and amino acids.			
3.5.5	Discuss the relationship between one gene and one polypeptide.	3	Originally, it was assumed that one gene would invariably code for one polypeptide, but many exceptions have been discovered. **TOK:** The way in which theories are modified as related evidence accumulates could be discussed, and whether contrary evidence should cause a theory to be discarded immediately if there are exceptions to it. Where a theory is suddenly and totally abandoned, to be replaced by a different theory, this is known as a paradigm shift.			

3.6 Enzymes 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.6.1	Define *enzyme* and *active site*.	1				
3.6.2	Explain enzyme–substrate specificity.	3	The lock-and-key model can be used as a basis for the explanation. Refer to the three-dimensional structure. The induced-fit model is not expected at SL.			
3.6.3	Explain the effects of temperature, pH and substrate concentration on enzyme activity.	3	**Aim 7:** Enzyme activity could be measured using data loggers such as pressure sensors, pH sensors or colorimeters. **Aim 8:** The effects of environmental acid rain could be discussed.			
3.6.4	Define *denaturation*.	1	Denaturation is a structural change in a protein that results in the loss (usually permanent) of its biological properties. Refer only to heat and pH as agents.			
3.6.5	Explain the use of lactase in the production of lactose-free milk.	3	**Aim 8:** Production of lactose-free milk is an example of an industrial process depending on biological methods (biotechnology). These methods are of huge and increasing economic importance. **Int/TOK:** Development of some techniques benefits particular human populations and not others because of			

			the natural variation in human characteristics. Lactose intolerance is found in a high proportion of the human population (for example, in Asia) but more rarely among those of European origin. Sometimes a transfer of biotechnology is needed when techniques are developed in one part of the world that are more applicable in another.			

3.7 Cell respiration 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.7.1	Define *cell respiration*.	1	Cell respiration is the controlled release of energy from organic compounds in cells to form ATP.			
3.7.2	State that, in cell respiration, glucose in the cytoplasm is broken down by glycolysis into pyruvate, with a small yield of ATP.	1				
3.7.3	Explain that, during anaerobic cell respiration, pyruvate can be converted in the cytoplasm into lactate, or ethanol and carbon dioxide, with no further yield of ATP.	3	Mention that ethanol and carbon dioxide are produced in yeast, whereas lactate is produced in humans. **Aim 7:** Data logging using gas sensors, oxygen, carbon dioxide or pH probes could be used.			
3.7.4	Explain that, during aerobic cell respiration, pyruvate can be broken down in the mitochondrion into carbon dioxide and water with a large yield of ATP.	3				

3.8 Photosynthesis 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
3.8.1	State that photosynthesis involves the conversion of light energy into chemical energy.	1				
3.8.2	State that light from the Sun is composed of a range of wavelengths (colours).	1	Reference to actual wavelengths or frequencies is not expected.			
3.8.3	State that chlorophyll is the main photosynthetic pigment.	1				
3.8.4	Outline the differences in absorption of red, blue and green light by chlorophyll.	2	Students should appreciate that pigments absorb certain colours of light. The remaining colours of light are reflected. It is not necessary to mention wavelengths or the structure responsible for the absorption. **Aim 7:** Data logging using colorimeters or light sensors could be used.			
3.8.5	State that light energy is used to produce ATP, and to split water molecules (photolysis) to form oxygen and hydrogen.	1				

3.8.6	State that ATP and hydrogen (derived from the photolysis of water) are used to fix carbon dioxide to make organic molecules.	1		Done in class	Revised at home	I'm Confident!
3.8.7	Explain that the rate of photosynthesis can be measured directly by the production of oxygen or the uptake of carbon dioxide, or indirectly by an increase in biomass.	3	The recall of details of specific experiments to indicate that photosynthesis has occurred or to measure the rate of photosynthesis is not expected.			
3.8.8	Outline the effects of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis.	2	The shape of the graphs is required. The concept of limiting factors is not expected. **Aim 7:** Data logging using gas sensors, oxygen, carbon dioxide or pH probes could be used.			

Topic 4: Genetics (15 hours)

4.1 Chromosomes, genes, alleles and mutations 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
4.1.1	State that eukaryote chromosomes are made of DNA and proteins.	1	The names of the proteins (histones) are not required, nor is the structural relationship between DNA and the proteins.			
4.1.2	Define *gene*, *allele* and *genome*.	1	Gene: a heritable factor that controls a specific characteristic. (The differences between structural genes, regulator genes and genes coding for tRNA and rRNA are not expected at SL). Allele: one specific form of a gene, differing from other alleles by one or a few bases only and occupying the same gene locus as other alleles of the gene. Genome: the whole of the genetic information of an organism.			
4.1.3	Define *gene mutation*.	1	The terms point mutation or frameshift mutation will not be used.			
4.1.4	Explain the consequence of a base substitution mutation in relation to the processes of transcription and translation, using the example of sickle-cell anemia.	3	GAG has mutated to GTG causing glutamic acid to be replaced by valine, and hence sickle-cell anemia. **Aim 8:** There is a variety of social issues associated with sickle-cell anemia, including the suffering due to anemia, personal feelings if one has either inherited or passed on the sickle-cell allele, questions relating to the desirability of genetic screening for the sickle-cell allele before having children, and the genetic counselling of carriers of the allele. There are also ethical issues relating to screening of fetuses and abortion of those found to have a genetic disease. **TOK:** Where a correlation is found, a causal link may or may not be present. The frequency of the sickle-cell allele is correlated with the prevalence of malaria in many parts of the world. In this case, there is a clear causal link. Other cases			

			where there is no causal link could be described as a contrast. There has clearly been natural selection in favour of the sickle-cell allele in malarial areas, despite it causing severe anemia in the homozygous condition. Natural selection has led to particular frequencies of the sickle-cell and the normal hemoglobin alleles, to balance the twin risks of anemia and malaria.			

4.2Meiosis 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
4.2.1	State that meiosis is a reduction division of a diploid nucleus to form haploid nuclei.	1				
4.2.2	Define *homologous chromosomes*.	1				
4.2.3	Outline the process of meiosis, including pairing of homologous chromosomes and crossing over, followed by two divisions, which results in four haploid cells.	2	Limit crossing over to the exchange of genetic material between non-sister chromatids during prophase I. Names of the stages are required.			
4.2.4	Explain that non-disjunction can lead to changes in chromosome number, illustrated by reference to Down syndrome (trisomy 21).	3	The characteristics of Down syndrome are not required.			
4.2.5	State that, in karyotyping, chromosomes are arranged in pairs according to their size and structure.	1				
4.2.6	State that karyotyping is performed using cells collected by chorionic villus sampling or amniocentesis, for pre-natal diagnosis of chromosome abnormalities.	1	**Aim 8:** There are ethical and social issues associated with karyotyping of unborn fetuses because this procedure allows parents to abort fetuses with a chromosome abnormality. There is also evidence that, in some parts of the world, abortion on the basis of gender is carried out. **TOK:** Various questions relating to karyotyping could be raised, including balancing the risks of side-effects (for example, miscarriage) against the possibility of identifying and aborting a fetus with an abnormality. There are questions about decision-making: who should make the decision about whether to perform karyotyping and allow a subsequent abortion—parents or health-care professionals or both groups? There are also questions about whether or not national governments should interfere with personal freedoms, and whether or not they should be able to ban procedures within the country and possibly also ban citizens travelling to foreign countries where the procedures are permitted.			
4.2.7	Analyse a human karyotype to determine gender and whether	3	Karyotyping can be done by using enlarged photographs of chromosomes.			

	non-disjunction has occurred.		**Aim 7:** Online simulations of karyotyping activities are available.			

4.3 Theoretical genetics 5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
4.3.1	Define *genotype*, *phenotype*, *dominant allele*, *recessive allele*, *codominant alleles*, *locus*, *homozygous*, *heterozygous*, *carrier* and *test cross*.	1	Genotype: the alleles of an organism. Phenotype: the characteristics of an organism. Dominant allele: an allele that has the same effect on the phenotype whether it is present in the homozygous or heterozygous state. Recessive allele: an allele that only has an effect on the phenotype when present in the homozygous state. Codominant alleles: pairs of alleles that both affect the phenotype when present in a heterozygote. (The terms incomplete and partial dominance are no longer used.) Locus: the particular position on homologous chromosomes of a gene. Homozygous: having two identical alleles of a gene. Heterozygous: having two different alleles of a gene. Carrier: an individual that has one copy of a recessive allele that causes a genetic disease in individuals that are homozygous for this allele. Test cross: testing a suspected heterozygote by crossing it with a known homozygous recessive. (The term backcross is no longer used.)			
4.3.2	Determine the genotypes and phenotypes of the offspring of a monohybrid cross using a Punnett grid.	3	The grid should be labelled to include parental genotypes, gametes, and both offspring genotype and phenotype. **Aim 7:** Genetics simulation software is available.			
4.3.3	State that some genes have more than two alleles (multiple alleles).	1				
4.3.4	Describe ABO blood groups as an example of codominance and multiple alleles.	2	Phenotype — Genotype O — ii A — I^AI^A or I^Ai B — I^BI^B or I^Bi AB — I^AI^B			
4.3.5	Explain how the sex chromosomes control gender by referring to the inheritance of X and Y chromosomes in humans.	3				
4.3.6	State that some genes are present on the X chromosome and absent from the shorter Y chromosome in humans.	1				
4.3.7	Define *sex linkage*.	1				
4.3.8	Describe the inheritance of colour blindness and hemophilia as	2	Both colour blindness and hemophilia are produced by a recessive sex-linked			

	examples of sex linkage.		allele on the X chromosome. X^b and X^h is the notation for the alleles concerned. The corresponding dominant alleles are X^B and X^H.			
4.3.9	State that a human female can be homozygous or heterozygous with respect to sex-linked genes.	1		**Done in class**	**Revised at home**	**I'm Confident!**
4.3.10	Explain that female carriers are heterozygous for X-linked recessive alleles.	3				
4.3.11	Predict the genotypic and phenotypic ratios of offspring of monohybrid crosses involving any of the above patterns of inheritance.	3	**Aim 8:** Statisticians are convinced that Mendel's results are too close to exact ratios to be genuine. We shall never know how this came about, but it offers an opportunity to discuss the need for scientists to be truthful about their results, whether it is right to discard results that do not fit a theory as Louis Pasteur is known to have done, and the danger of publishing results only when they show statistically significant differences. **TOK:** Reasons for Mendel's theories not being accepted by the scientific community for a long time could be considered. Other cases of paradigm shifts taking a long time to be accepted could be considered. Ways in which individual scientists are most likely to be able to convince the scientific community could be considered, and also the need always to consider the evidence rather than the views of individual scientists, however distinguished.			
4.3.12	Deduce the genotypes and phenotypes of individuals in pedigree charts.	3	For dominant and recessive alleles, upper-case and lower-case letters, respectively, should be used. Letters representing alleles should be chosen with care to avoid confusion between upper and lower case. For codominance, the main letter should relate to the gene and the suffix to the allele, both upper case. For example, red and white codominant flower colours should be represented as C^R and C^w, respectively. For sickle-cell anemia, Hb^A is normal and Hb^s is sickle cell. **Aim 8:** There are many social issues in families in which there is a genetic disease, including decisions for carriers about whether to have children, personal feelings for those who have inherited or passed on alleles for the disease, and potential problems in finding partners, employment and health or life insurance. There are ethical questions about whether personal details about genes should be disclosed to insurance companies or employers. Decisions may have to be made about whether or not to have screening. These are particularly acute in the case of Huntington disease.			

4.4 Genetic engineering and biotechnology 5 hours

	Assessment statement	Obj	Teacher's notes	Covered in class	Reviewed at home	I'm Confident!
4.4.1	Outline the use of polymerase chain reaction (PCR) to copy and amplify minute quantities of DNA.	2	Details of methods are not required.			
4.4.2	State that, in gel electrophoresis, fragments of DNA move in an electric field and are separated according to their size.	1		Done in class	Revised at home	I'm Confident!
4.4.3	State that gel electrophoresis of DNA is used in DNA profiling.	1				
4.4.4	Describe the application of DNA profiling to determine paternity and also in forensic investigations.	2	**Aim 8:** There is a variety of social implications stemming from DNA profiling, such as identity issues for a child who learns unexpectedly who his or her biological father is, self-esteem problems for someone who learns he is not a father, problems in relationships where the male partner learns that he did not father a child, but also relief for crime victims when those responsible for the crime are identified and convicted, sometimes decades later. **TOK:** A comparison could be made between blood groups and DNA profiles in their potential for determining paternity. The difficulty in assessing the chance of two individuals having the same profile could be discussed, and also the success of DNA profiling in securing convictions in some of the high-profile legal cases of recent years.			
4.4.5	Analyse DNA profiles to draw conclusions about paternity or forensic investigations.	3	The outcomes of this analysis could include knowledge of the number of human genes, the location of specific genes, discovery of proteins and their functions, and evolutionary relationships. **Aim 7:** Online bioinformatics simulations are available. **Aim 8:** We can either emphasize the large shared content of the human genome, which is common to all of us and should give us a sense of unity, or we can emphasize the small but significant allelic differences that create the biodiversity within our species, which should be treasured. Differences in the success of human races in coping with the modern world and the threat to some small human tribes could be mentioned. It is important to stress parity of esteem of all humans, whatever their genome. **TOK:** The Human Genome Project was an international endeavour, with laboratories throughout the world collaborating. However, there were also efforts in some parts of the world to gain commercial benefits from the outcomes of the project. The data from the Human Genome Project can be viewed in different ways: it could be seen as a complete account of what makes up a human, if one takes a reductionist view of life, or, alternatively, as merely the chemical instructions that have allowed a huge			

			range of more significant human characteristics to develop. This could lead to a discussion about the essential nature of humanity.			
4.4.6	Outline three outcomes of the sequencing of the complete human genome.	2				
4.4.7	State that, when genes are transferred between species, the amino acid sequence of polypeptides translated from them is unchanged because the genetic code is universal.	1	**Aim 8:** There is an ethical or moral question here: whether it is right to change the genetic integrity of a species by transferring genes to it from another species. The discussion could include the wider question of selective breeding of animals, and whether this is distinctively different and always acceptable. The possibility of animals suffering as a result of genetic modification could be considered.	**Done in class**	**Revised at home**	**I'm Confident!**
4.4.8	Outline a basic technique used for gene transfer involving plasmids, a host cell (bacterium, yeast or other cell), restriction enzymes (endonucleases) and DNA ligase.	2	The use of *E. coli* in gene technology is well documented. Most of its DNA is in one circular chromosome, but it also has plasmids (smaller circles of DNA). These plasmids can be removed and cleaved by restriction enzymes at target sequences. DNA fragments from another organism can also be cleaved by the same restriction enzyme, and these pieces can be added to the open plasmid and spliced together by ligase. The recombinant plasmids formed can be inserted into new host cells and cloned.			
4.4.9	State two examples of the current uses of genetically modified crops or animals.	1	Examples include salt tolerance in tomato plants, synthesis of beta-carotene (vitamin A precursor) in rice, herbicide resistance in crop plants and factor IX (human blood clotting) in sheep milk. **Aim 8:** The economic benefits of genetic modification to biotechnology companies that perform it could be considered. Also mention the possibility that harmful changes to local economies could result, and the danger that wealth could become more concentrated in a smaller percentage of the population if expensive but profitable new techniques are introduced. In this respect, inequalities in wealth may become greater.			
4.4.10	Discuss the potential benefits and possible harmful effects of one example of genetic modification.	3	**Aim 8:** There are ethical questions here about how far it is acceptable for humans to change other species, as well as other ecosystems, in order to gain benefit for humans. **TOK:** This is an opportunity to discuss how we can assess whether risks are great enough to justify banning techniques and how the scientific community can inform communities generally about potential risks. Informed decisions need to be made but irrational fears should not be propagated. Consideration could be given to the paradox that careful research is needed to assess the risks, but performing this research in itself could be risky. Do protesters who destroy trials of GM crops make the world safer?			

4.4.11	Define *clone*.	1	Clone: a group of genetically identical organisms or a group of cells derived from a single parent cell.			
4.4.12	Outline a technique for cloning using differentiated animal cells.	2	**Aim 8:** Ethical questions about cloning should be separated into questions about reproductive cloning and therapeutic cloning. Some groups are vehemently opposed to both types.			
4.4.13	Discuss the ethical issues of therapeutic cloning in humans.	3	Therapeutic cloning is the creation of an embryo to supply embryonic stem cells for medical use.			

Topic 5: Ecology and evolution (16 hours)

5.1Communities and ecosystems

5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
5.1.1	Define *species*, *habitat*, *population*, *community*, *ecosystem* and *ecology*.	1	Species: a group of organisms that can interbreed and produce fertile offspring. Habitat: the environment in which a species normally lives or the location of a living organism. Population: a group of organisms of the same species who live in the same area at the same time. Community: a group of populations living and interacting with each other in an area. Ecosystem: a community and its abiotic environment. Ecology: the study of relationships between living organisms and between organisms and their environment.			
5.1.2	Distinguish between *autotroph* and *heterotroph*.	2	Autotroph: an organism that synthesizes its organic molecules from simple inorganic substances. Heterotroph: an organism that obtains organic molecules from other organisms.			
5.1.3	Distinguish between *consumers*, *detritivores* and *saprotrophs*.	2	Consumer: an organism that ingests other organic matter that is living or recently killed. Detritivore: an organism that ingests non-living organic matter. Saprotroph: an organism that lives on or in non-living organic matter, secreting digestive enzymes into it and absorbing the products of digestion.			
5.1.4	Describe what is meant by a food chain, giving three examples, each with at least three linkages (four organisms).	2	Only real examples should be used from natural ecosystems. A → B indicates that A is being "eaten" by B (that is, the arrow indicates the direction of energy flow). Each food chain should include a producer and consumers, but not decomposers. Named organisms at either species or genus level should be used. Common species names can be used instead of binomial names. General names such as "tree" or "fish" should not be used.			

5.1.5	Describe what is meant by a food web.	2				
5.1.6	Define *trophic level*.	1				
5.1.7	Deduce the trophic level of organisms in a food chain and a food web.	3	Students should be able to place an organism at the level of producer, primary consumer, secondary consumer, and so on, as the terms herbivore and carnivore are not always applicable.			
5.1.8	Construct a food web containing up to 10 organisms, using appropriate information.	3		**Done in class**	**Revised at home**	**I'm Confident!**
5.1.9	State that light is the initial energy source for almost all communities.	1	No reference to communities where food chains start with chemical energy is required.			
5.1.10	Explain the energy flow in a food chain.	3	Energy losses between trophic levels include material not consumed or material not assimilated, and heat loss through cell respiration.			
5.1.11	State that energy transformations are never 100% efficient.	1	Reference to the second law of thermodynamics is not expected.			
5.1.12	Explain reasons for the shape of pyramids of energy.	3	A pyramid of energy shows the flow of energy from one trophic level to the next in a community. The units of pyramids of energy are, therefore, energy per unit area per unit time, for example, kJ m^{-2} yr^{-1}.			
5.1.13	Explain that energy enters and leaves ecosystems, but nutrients must be recycled.	3				
5.1.14	State that saprotrophic bacteria and fungi (decomposers) recycle nutrients.	1				

5.2The greenhouse effect

3 hours

	Assessment statement	**Obj**	**Teacher's notes**	**Done in class**	**Revised at home**	**I'm Confident!**
5.2.1	Draw and label a diagram of the carbon cycle to show the processes involved.	1	The details of the carbon cycle should include the interaction of living organisms and the biosphere through the processes of photosynthesis, cell respiration, fossilization and combustion. Recall of specific quantitative data is not required. **TOK:** What difference might it make to scientific work if nature were to be regarded as a machine, for example, as a clockwork mechanism, or as an organism, that is, the Gaia hypothesis? How useful are these metaphors?			
5.2.2	Analyse the changes in concentration of atmospheric carbon dioxide using historical records.	3	Data from the Mauna Loa, Hawaii, or Cape Grim, Tasmania, monitoring stations may be used.			

5.2.3	Explain the relationship between rises in concentrations of atmospheric carbon dioxide, methane and oxides of nitrogen and the enhanced greenhouse effect.	3	Students should be aware that the greenhouse effect is a natural phenomenon. Reference should be made to transmission of incoming shorter-wave radiation and re-radiated longer-wave radiation. Knowledge that other gases, including methane and oxides of nitrogen, are greenhouse gases is expected.			
5.2.4	Outline the precautionary principle.	2	The precautionary principle holds that, if the effects of a human-induced change would be very large, perhaps catastrophic, those responsible for the change must prove that it will **not do harm** before proceeding. This is the reverse of the normal situation, where those who are concerned about the change would have to prove that it will **do harm** in order to prevent such changes going ahead. **TOK:** Parallels could be drawn here between success in deterring crime by increasing the severity of the punishment or by increasing the chance of detection. If the possible consequences of rapid global warming are devastating enough, preventive measures are justified even if it is far from certain that rapid global warming will result from current human activities.			
5.2.5	Evaluate the precautionary principle as a justification for strong action in response to the threats posed by the enhanced greenhouse effect.	3	**Aim 8:** Consider whether the economic harm of measures taken now to limit global warming could be balanced against the potentially much greater harm for future generations of taking no action now. There are also ethical questions about whether the health and wealth of future human generations should be jeopardized, and whether it is right to knowingly damage the habitat of, and possibly drive to extinction, species other than humans. The environmental angle here is that the issue of global warming is, by definition, a genuinely global one in terms of causes, consequences and remedies. Only through international cooperation will a solution be found. There is an inequality between those in the world who are contributing most to the problem and those who will be most harmed.			
5.2.6	Outline the consequences of a global temperature rise on arctic ecosystems.	2	Effects include increased rates of decomposition of detritus previously trapped in permafrost, expansion of the range of habitats available to temperate species, loss of ice habitat, changes in distribution of prey species affecting higher trophic levels, and increased success of pest species, including pathogens.			

5.3 Populations 2 hours

	Assessment statement	Obj	Teacher's notes	Covered in class	Reviewed at home	I'm Confident!
5.3.1	Outline how population size is affected by natality, immigration, mortality and emigration.	2	**Aim 7:** Simulation exercises can be performed.			

5.3.2	Draw and label a graph showing a sigmoid (S-shaped) population growth curve.	1				
5.3.3	Explain the reasons for the exponential growth phase, the plateau phase and the transitional phase between these two phases.	3				
5.3.4	List three factors that set limits to population increase.	1				

5.4 Evolution 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
5.4.1	Define *evolution*.	1	Evolution is the cumulative change in the heritable characteristics of a population. If we accept not only that species can evolve, but also that new species arise by evolution from pre-existing ones, then the whole of life can be seen as unified by its common origins. Variation within our species is the result of different selection pressures operating in different parts of the world, yet this variation is not so vast to justify a construct such as race having a biological or scientific basis.			
5.4.2	Outline the evidence for evolution provided by the fossil record, selective breeding of domesticated animals and homologous structures.	2				
5.4.3	State that populations tend to produce more offspring than the environment can support.	1				
5.4.4	Explain that the consequence of the potential overproduction of offspring is a struggle for survival.	3				
5.4.5	State that the members of a species show variation.	1				
5.4.6	Explain how sexual reproduction promotes variation in a species.	3				
5.4.7	Explain how natural selection leads to evolution.	3	Greater survival and reproductive success of individuals with favourable heritable variations can lead to change in the characteristics of a population. **Aim 7:** Computer simulations can be performed.			
5.4.8	Explain two examples of evolution in response to environmental change; one must be antibiotic resistance in bacteria.	3	Other examples could include: the changes in size and shape of the beaks of Galapagos finches; pesticide resistance, industrial melanism or heavy-metal tolerance in plants.			

5.5Classification 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
5.5.1	Outline the binomial system of nomenclature.	2	**TOK:** The adoption of a system of binomial nomenclature is largely due to Swedish botanist and physician Carolus Linnaeus (1707–1778). Linnaeus also defined four groups of humans, and the divisions were based on both physical and social traits. By 21st-century standards, his descriptions can be regarded as racist. How does the social context of scientific work affect the methods and findings of research? Is it necessary to consider the social context when evaluating ethical aspects of knowledge claims?			
5.5.2	List seven levels in the hierarchy of taxa—kingdom, phylum, class, order, family, genus and species—using an example from two different kingdoms for each level.	1				
5.5.3	Distinguish between the following phyla of plants, using simple external recognition features: *bryophyta, filicinophyta, coniferophyta* and *angiospermophyta*.	2				
5.5.4	Distinguish between the following phyla of animals, using simple external recognition features: *porifera, cnidaria, platyhelminthes, annelida, mollusca* and *arthropoda*.	2				
5.5.5	Apply and design a key for a group of up to eight organisms.	3	A dichotomous key should be used.			

Topic 6: Human health and physiology (20 hours)

6.1 Digestion 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
6.1.1	Explain why digestion of large food molecules is essential.	3				
6.1.2	Explain the need for enzymes in digestion.	3	The need for increasing the rate of digestion at body temperature should be emphasized.			
6.1.3	State the source, substrate, products and optimum pH conditions for one amylase, one protease and one lipase.	1	Any human enzymes can be selected. Details of structure or mechanisms of action are not required. **Aim 7:** Data logging with pH sensors and lipase, and data logging with colorimeters and amylase can be used.			
6.1.4	Draw and label a diagram of the digestive system.	1	The diagram should show the mouth, esophagus, stomach, small intestine, large intestine, anus, liver, pancreas and			

			gall bladder. The diagram should clearly show the interconnections between these structures.			
6.1.5	Outline the function of the stomach, small intestine and large intestine.	2				
6.1.6	Distinguish between *absorption* and *assimilation*.	2				
6.1.7	Explain how the structure of the villus is related to its role in absorption and transport of the products of digestion.	3				

6.2 The transport system 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
6.2.1	Draw and label a diagram of the heart showing the four chambers, associated blood vessels, valves and the route of blood through the heart.	1	Care should be taken to show the relative wall thickness of the four chambers. Neither the coronary vessels nor the conductive system are required.			
6.2.2	State that the coronary arteries supply heart muscle with oxygen and nutrients.	1				
6.2.3	Explain the action of the heart in terms of collecting blood, pumping blood, and opening and closing of valves.	3	A basic understanding is required, limited to the collection of blood by the atria, which is then pumped out by the ventricles into the arteries. The direction of flow is controlled by atrio-ventricular and semilunar valves.			
6.2.4	Outline the control of the heartbeat in terms of myogenic muscle contraction, the role of the pacemaker, nerves, the medulla of the brain and epinephrine (adrenaline).	2	Histology of the heart muscle, names of nerves or transmitter substances are not required. **Aim 7:** Simulation and data logging involving heart rate monitors, or data logging involving an EKG sensor to measure electrical signals produced during muscle contractions, can be used.	Covered in class	Reviewed at home	I'm Confident!
6.2.5	Explain the relationship between the structure and function of arteries, capillaries and veins.	3				
6.2.6	State that blood is composed of plasma, erythrocytes, leucocytes (phagocytes and lymphocytes) and platelets.	1				
6.2.7	State that the following are transported by the blood: nutrients, oxygen, carbon dioxide, hormones, antibodies, urea and heat.	1	No chemical details are required.			

6.3 Defense against infectious disease 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
6.3.1	Define *pathogen*.	1	Pathogen: an organism or virus that causes a disease.			
6.3.2	Explain why antibiotics are effective against bacteria but not against viruses.	3	Antibiotics block specific metabolic pathways found in bacteria. Viruses reproduce using the host cell's metabolic pathways, which are not affected by antibiotics. **Aim 8:** The great benefits to people throughout the world in the control of bacterial diseases using antibiotics should be stressed. Examples of diseases that often proved fatal before the advent of antibiotics could be named.			
6.3.3	Outline the role of skin and mucous membranes in defence against pathogens.	2	A diagram of the skin is not required.			
6.3.4	Outline how phagocytic leucocytes ingest pathogens in the blood and in body tissues.	2	Details of the subdivisions and classifications of phagocytes are not required.	Done in class	Revised at home	I'm Confident!
6.3.5	Distinguish between *antigens* and *antibodies*.	2				
6.3.6	Explain antibody production.	3	Many different types of lymphocyte exist. Each type recognizes one specific antigen and responds by dividing to form a clone. This clone then secretes a specific antibody against the antigen. No other details are required.			
6.3.7	Outline the effects of HIV on the immune system.	2	The effects of HIV should be limited to a reduction in the number of active lymphocytes and a loss of the ability to produce antibodies.			
6.3.8	Discuss the cause, transmission and social implications of AIDS.	3	**Aim 8:** The social implications of AIDS are well known. Cases of AIDS are not evenly distributed in the world, and consideration could be given to the severe problems in southern Africa. Cultural and economic reasons for differences in the prevalence of AIDS could be considered. The moral obligation of those with the technology and the wealth to help others lacking these things could be discussed. **TOK:** The different methods of transmission of HIV each carry their own risk. The extent to which individuals in different societies can minimize or eliminate each of these risks could be considered.			

6.4 Gas exchange 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
6.4.1	Distinguish between *ventilation*, *gas exchange* and *cell respiration*.	2				

6.4.2	Explain the need for a ventilation system.	3	A ventilation system is needed to maintain high concentration gradients in the alveoli.			
6.4.3	Describe the features of alveoli that adapt them to gas exchange.	2	This should include a large total surface area, a wall consisting of a single layer of flattened cells, a film of moisture and a dense network of capillaries.			
6.4.4	Draw and label a diagram of the ventilation system, including trachea, lungs, bronchi, bronchioles and alveoli.	1	Students should draw the alveoli in an inset diagram at a higher magnification.			
6.4.5	Explain the mechanism of ventilation of the lungs in terms of volume and pressure changes caused by the internal and external intercostal muscles, the diaphragm and abdominal muscles.	3	**Aim 7:** Data logging involving spirometers or ventilation rate monitors is possible here.			

6.5 Nerves, hormones and homeostasis 6 hours

	Assessment statement	Obj	Teacher's notes	Covered in class	Reviewed at home	I'm Confident!
6.5.1	State that the nervous system consists of the central nervous system (CNS) and peripheral nerves, and is composed of cells called neurons that can carry rapid electrical impulses.	1	No other structural or functional divisions of the nervous system are required.			
6.5.2	Draw and label a diagram of the structure of a motor neuron.	1	Include dendrites, cell body with nucleus, axon, myelin sheath, nodes of Ranvier and motor end plates.			
6.5.3	State that nerve impulses are conducted from receptors to the CNS by sensory neurons, within the CNS by relay neurons, and from the CNS to effectors by motor neurons.	1		Covered in class	Reviewed at home	I'm Confident!
6.5.4	Define *resting potential* and *action potential* (depolarization and repolarization).	1				
6.5.5	Explain how a nerve impulse passes along a non-myelinated neuron.	3	Include the movement of Na^+ and K^+ ions to create a resting potential and an action potential.			
6.5.6	Explain the principles of synaptic transmission.	3	Include the release, diffusion and binding of the neurotransmitter, initiation of an action potential in the post-synaptic membrane, and subsequent removal of the neurotransmitter. **Aim 7:** Data logging can be used to measure changes in conductivity in distilled water as Na^+ and K^+ diffuse out of salt–agar cubes or dialysing tubing.			
6.5.7	State that the endocrine system consists of glands that release hormones that are transported in the blood.	1	The nature and action of hormones or direct comparisons between nerve and endocrine systems are not required.			

6.5.8	State that homeostasis involves maintaining the internal environment between limits, including blood pH, carbon dioxide concentration, blood glucose concentration, body temperature and water balance.	1	The internal environment consists of blood and tissue fluid.			
6.5.9	Explain that homeostasis involves monitoring levels of variables and correcting changes in levels by negative feedback mechanisms.	3				
6.5.10	Explain the control of body temperature, including the transfer of heat in blood, and the roles of the hypothalamus, sweat glands, skin arterioles and shivering.	3	**Aim 7:** Data logging using a surface temperature sensor to investigate the warming by nasal passages could be carried out here.			
6.5.11	Explain the control of blood glucose concentration, including the roles of glucagon, insulin and α and β cells in the pancreatic islets.	3	The effects of adrenaline are not required here.			
6.5.12	Distinguish between *type I* and *type II* diabetes.	2	**Aim 8:** Diabetes is having an increasing effect on human societies around the world, including personal suffering due to ill health from the diabetes directly but also from side-effects such as kidney failure. There are economic consequences relating to the health-care costs of treating diabetics. **TOK:** The causes of the variation in rates of type II diabetes in different human populations could be analysed. Rates can be particularly high when individuals consume a diet very different to the traditional one of their ancestors, for example, when having migrated to a new country. There are genetic differences in our capacity to cope with high levels of refined sugar and fat in the diet. Humans also vary considerably in how prone they are to become obese.	**Done in class**	**Revised at home**	**I'm Confident!**

6.6 Reproduction 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
6.6.1	Draw and label diagrams of the adult male and female reproductive systems.	1	The relative positions of the organs is important. Do not include any histological details, but include the bladder and urethra.			
6.6.2	Outline the role of hormones in the menstrual cycle, including FSH (follicle stimulating hormone), LH (luteinizing hormone), estrogen and progesterone.	2				
6.6.3	Annotate a graph showing hormone levels in the menstrual cycle, illustrating the relationship between changes in hormone levels and ovulation, menstruation and thickening of the endometrium.	2				

6.6.4	List three roles of testosterone in males.	1	Limit this to pre-natal development of male genitalia, development of secondary sexual characteristics and maintenance of sex drive.			
6.6.5	Outline the process of *in vitro* fertilization (IVF).	2				
6.6.6	Discuss the ethical issues associated with IVF.	3	**Aim 8:** There is great variation between human societies around the world in the views held on IVF. This is the result of cultural and religious diversity. There is little evidence to suggest that children born as a result of standard IVF protocols are different in any way from children conceived naturally. It is important that there is parity of esteem for all children, however they were conceived. **TOK:** There are potential risks in the drug treatments that the woman is given, and there are concerns about the artificial selection of sperm and the injection of them into the eggs that occurs with some IVF protocols. The natural selection of sperm with consequent elimination of unhealthy ones is bypassed, and there is evidence that there are higher rates of abnormality in the offspring as a result.			

Topic 7: Nucleic acids and proteins (11 hours)

7.1 DNA structure 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.1.1	Describe the structure of DNA, including the antiparallel strands, 3'–5' linkages and hydrogen bonding between purines and pyrimidines.	2	Major and minor grooves, direction of the "twist", alternative B and Z forms, and details of the dimensions are not required.			
7.1.2	Outline the structure of nucleosomes.	2	Limit this to the fact that a nucleosome consists of DNA wrapped around eight histone proteins and held together by another histone protein.			
7.1.3	State that nucleosomes help to supercoil chromosomes and help to regulate transcription.	1				
7.1.4	Distinguish between *unique or single-copy genes* and *highly repetitive sequences* in nuclear DNA.	2	Highly repetitive sequences (satellite DNA) constitutes 5–45% of the genome. The sequences are typically between 5 and 300 base pairs per repeat, and may be duplicated as many as 10^5 times per genome. **TOK:** Highly repetitive sequences were once classified as "junk DNA", showing a degree of confidence that it had no role. This addresses the question: To what extent do the labels and categories used in the pursuit of knowledge affect the knowledge we obtain?			
7.1.5	State that eukaryotic genes can contain exons and introns.	1				

7.2 DNA replication 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.2.1	State that DNA replication occurs in a $5' \rightarrow 3'$ direction.	1	The 5' end of the free DNA nucleotide is added to the 3' end of the chain of nucleotides that is already synthesized.			
7.2.2	Explain the process of DNA replication in prokaryotes, including the role of enzymes (helicase, DNA polymerase, RNA primase and DNA ligase), Okazaki fragments and deoxynucleoside triphosphates.	3	The explanation of Okazaki fragments in relation to the direction of DNA polymerase III action is required. DNA polymerase III adds nucleotides in the $5' \rightarrow 3'$ direction. DNA polymerase I excises the RNA primers and replaces them with DNA.			
7.2.3	State that DNA replication is initiated at many points in eukaryotic chromosomes.	1				

7.3 Transcription 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.3.1	State that transcription is carried out in a $5' \rightarrow 3'$ direction.	1	The 5' end of the free RNA nucleotide is added to the 3' end of the RNA molecule that is already synthesized.			
7.3.2	Distinguish between the *sense* and *antisense* strands of DNA.	2	The sense strand (coding strand) has the same base sequence as mRNA with uracil instead of thymine. The antisense (template) strand is transcribed.			
7.3.3	Explain the process of transcription in prokaryotes, including the role of the promoter region, RNA polymerase, nucleoside triphosphates and the terminator.	3	The following details are not required: there is more than one type of RNA polymerase; features of the promoter region; the need for transcription protein factors for RNA polymerase binding; TATA boxes (and other repetitive sequences); and the exact sequence of the bases that act as terminators.			
7.3.4	State that eukaryotic RNA needs the removal of introns to form mature mRNA.	1	Further details of the process of post-transcriptional modification of RNA are not required.			

7.4 Translation 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.4.1	Explain that each tRNA molecule is recognized by a tRNA-activating enzyme that binds a specific amino acid to the tRNA, using ATP for energy.	3	Each amino acid has a specific tRNA-activating enzyme (the name aminoacyl-tRNA synthetase is not required). The shape of tRNA and CCA at the 3' end should be included.			
7.4.2	Outline the structure of ribosomes, including protein and RNA composition, large and small subunits, three tRNA binding sites and mRNA binding sites.	2				

7.4.3	State that translation consists of initiation, elongation, translocation and termination.	1				
7.4.4	State that translation occurs in a $5' \rightarrow 3'$ direction.	1	During translation, the ribosome moves along the mRNA towards the 3' end. The start codon is nearer to the 5' end.			
7.4.5	Draw and label a diagram showing the structure of a peptide bond between two amino acids.	1				
7.4.6	Explain the process of translation, including ribosomes, polysomes, start codons and stop codons.	3	Use of methionine for initiation, details of the T factor and recall of actual stop codons are not required.			
7.4.7	State that free ribosomes synthesize proteins for use primarily within the cell, and that bound ribosomes synthesize proteins primarily for secretion or for lysosomes.	1				

7.5 Proteins 1 hour

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.5.1	Explain the four levels of protein structure, indicating the significance of each level.	3	Quaternary structure may involve the binding of a prosthetic group to form a conjugated protein. **Aim 7:** Simulation exercises showing three-dimensional molecular models of proteins are available.			
7.5.2	Outline the difference between fibrous and globular proteins, with reference to two examples of each protein type.	2				
7.5.3	Explain the significance of polar and non-polar amino acids.	3	Limit this to controlling the position of proteins in membranes, creating hydrophilic channels through membranes, and the specificity of active sites in enzymes.			
7.5.4	State four functions of proteins, giving a named example of each.	1	Membrane proteins should not be included.			

7.6 Enzymes 2 hours

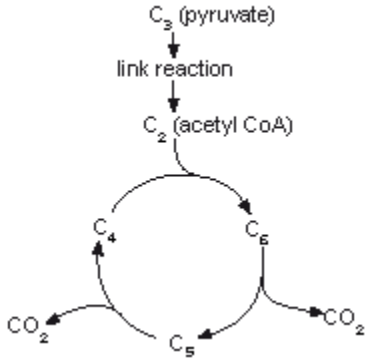
	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
7.6.1	State that metabolic pathways consist of chains and cycles of enzyme-catalysed reactions.	1				
7.6.2	Describe the induced-fit model.	2	This is an extension of the lock-and-key model. Its importance in accounting for the ability of some enzymes to bind to several substrates should be mentioned. **TOK:** Scientific truths are often pragmatic. We accept them as true because they give us predictive power, that is, they work. The German scientist Emil Fischer introduced the lock-and-key model for enzymes and their substrates			

			in 1890. It was not until 1958 that Daniel Koshland in the United States suggested that the binding of the substrate to the active site caused a conformational change, hence the induced-fit model. This is an example of one model or theory, accepted for many years, being superseded by another that offers a fuller explanation of a process.			
7.6.3	Explain that enzymes lower the activation energy of the chemical reactions that they catalyse.	3	Only exothermic reactions should be considered. Specific energy values do not need to be recalled.			
7.6.4	Explain the difference between competitive and non-competitive inhibition, with reference to one example of each.	3	Competitive inhibition is the situation when an inhibiting molecule that is structurally similar to the substrate molecule binds to the active site, preventing substrate binding. Limit non-competitive inhibition to an inhibitor binding to an enzyme (not to its active site) that causes a conformational change in its active site, resulting in a decrease in activity. Reversible inhibition, as compared to irreversible inhibition, is not required.			
7.6.5	Explain the control of metabolic pathways by end-product inhibition, including the role of allosteric sites.	3				

Topic 8: Cell respiration and photosynthesis (10 hours)

8.1 Cell respiration 5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
8.1.1	State that oxidation involves the loss of electrons from an element, whereas reduction involves a gain of electrons; and that oxidation frequently involves gaining oxygen or losing hydrogen, whereas reduction frequently involves losing oxygen or gaining hydrogen.	1				
8.1.2	Outline the process of glycolysis, including phosphorylation, lysis, oxidation and ATP formation.	2	In the cytoplasm, one hexose sugar is converted into two three-carbon atom compounds (pyruvate) with a net gain of two ATP and two NADH + H^+.			
8.1.3	Draw and label a diagram showing the structure of a mitochondrion as seen in electron micrographs.	1				
8.1.4	Explain aerobic respiration, including the link reaction, the Krebs cycle, the role of NADH + H^+, the electron transport chain and the role of oxygen.	3	In aerobic respiration (in mitochondria in eukaryotes), each pyruvate is decarboxylated (CO_2 removed). The remaining two-carbon molecule (acetyl group) reacts with reduced coenzyme A, and, at the same time, one NADH + H^+ is formed. This is known as the link reaction.			

			 In the Krebs cycle, each acetyl group (CH_3CO) formed in the link reaction yields two CO_2. The names of the intermediate compounds in the cycle are not required. Thus it would be acceptable to note: $C_2 + C_4 = C_6 \longrightarrow C_5 \longrightarrow$, and so on.			
8.1.5	Explain oxidative phosphorylation in terms of chemiosmosis.	3				
8.1.6	Explain the relationship between the structure of the mitochondrion and its function.	3	Limit this to cristae forming a large surface area for the electron transport chain, the small space between inner and outer membranes for accumulation of protons, and the fluid matrix containing enzymes of the Krebs cycle.			

8.2Photosynthesis

5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
8.2.1	Draw and label a diagram showing the structure of a chloroplast as seen in electron micrographs.	1				
8.2.2	State that photosynthesis consists of light-dependent and light-independent reactions.	1	These should not be called "light" and "dark" reactions.			
8.2.3	Explain the light-dependent reactions.	3	Include the photoactivation of photosystem II, photolysis of water, electron transport, cyclic and non-cyclic photophosphorylation, photoactivation of photosystem I, and reduction of $NADP^+$.			
8.2.4	Explain photophosphorylation in terms of chemiosmosis.	3				

8.2.5	Explain the light-independent reactions.	3	Include the roles of ribulose bisphosphate (RuBP) carboxylase, reduction of glycerate 3-phosphate (GP) to triose phosphate (TP), NADPH + H^+, ATP, regeneration of RuBP, and subsequent synthesis of more complex carbohydrates. **TOK:** The lollipop apparatus used to work out the biochemical details of the Calvin cycle shows considerable creativity. To what extent is the creation of an elegant protocol similar to the creation of a work of art?			
8.2.6	Explain the relationship between the structure of the chloroplast and its function.	3	Limit this to the large surface area of thylakoids for light absorption, the small space inside thylakoids for accumulation of protons, and the fluid stroma for the enzymes of the Calvin cycle.			
8.2.7	Explain the relationship between the action spectrum and the absorption spectrum of photosynthetic pigments in green plants.	3	A separate spectrum for each pigment (chlorophyll a, chlorophyll b, and so on) is not required.			
8.2.8	Explain the concept of limiting factors in photosynthesis, with reference to light intensity, temperature and concentration of carbon dioxide.	3	**TOK:** This is an opportunity to discuss the need for very carefully controlled experiments. If we want to investigate the effect of one factor, all other factors that could have an influence must be controlled. In photosynthesis, the situation is relatively simple, and we can ensure that factors other than the one we are investigating are maintained at a constant and optimal level. In other areas, there are much greater problems. In the many investigations of human health, there are almost always complicating factors. For example, vegetarians have a longer life expectancy than meat eaters. We would be wrong to conclude that eating meat lowers life expectancy unless we could show that the only difference between the vegetarians and the meat eaters in our trial was the meat eating.			

Topic 9: Plant science (11 hours)

9.1Plant structure and growth 4 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
9.1.1	Draw and label plan diagrams to show the distribution of tissues in the stem and leaf of a dicotyledonous plant.	1	Either sunflower, bean or another dicotyledonous plant with similar tissue distribution should be used. Note that plan diagrams show distribution of tissues (for example, xylem, phloem) and do not show individual cells. They are sometimes called "low-power" diagrams.			
9.1.2	Outline three differences between the structures of dicotyledonous and monocotyledonous plants.	2	Teachers should emphasize three differences between monocotyledonous and dicotyledonous plants (examples include: parallel *versus* net-like venation in leaves, distribution of vascular tissue in stems, number of cotyledons, floral			

			organs in multiples of 3 in monocotyledonous *versus* 4 or 5 in dicotyledonous, fibrous adventitious roots in monocotyledonous *versus* tap root with lateral branches in dicotyledonous).			
9.1.3	Explain the relationship between the distribution of tissues in the leaf and the functions of these tissues.	3	This should be restricted to dicotyledonous plants. The functions should include: absorption of light, gas exchange, support, water conservation, and the transport of water and products of photosynthesis.			
9.1.4	Identify modifications of roots, stems and leaves for different functions: bulbs, stem tubers, storage roots and tendrils.	2				
9.1.5	State that dicotyledonous plants have apical and lateral meristems.	1	Apical meristems are sometimes referred to as primary meristems, and lateral meristems as cambium. Meristems generate new cells for growth of the plant.			
9.1.6	Compare growth due to apical and lateral meristems in dicotyledonous plants.	3				
9.1.7	Explain the role of auxin in phototropism as an example of the control of plant growth.	3				

9.2 Transport in angiospermophytes 4 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
9.2.1	Outline how the root system provides a large surface area for mineral ion and water uptake by means of branching and root hairs.	2				
9.2.2	List ways in which mineral ions in the soil move to the root.	1	There are three processes: diffusion of mineral ions, fungal hyphae (mutualism), and mass flow of water in the soil carrying ions.			
9.2.3	Explain the process of mineral ion absorption from the soil into roots by active transport.	3				
9.2.4	State that terrestrial plants support themselves by means of thickened cellulose, cell turgor and lignified xylem.	1				
9.2.5	Define *transpiration*.	1	Transpiration is the loss of water vapour from the leaves and stems of plants. **Aim 7:** Data logging with pressure sensors, humidity, light or temperature probes to measure rates of transpiration can be performed.			

9.2.6	Explain how water is carried by the transpiration stream, including the structure of xylem vessels, transpiration pull, cohesion, adhesion and evaporation.	3	Limit the structure of xylem vessels to one type of primary xylem.			
9.2.7	State that guard cells can regulate transpiration by opening and closing stomata.	1				
9.2.8	State that the plant hormone abscisic acid causes the closing of stomata.	1				
9.2.9	Explain how the abiotic factors light, temperature, wind and humidity, affect the rate of transpiration in a typical terrestrial plant.	3				
9.2.10	Outline four adaptations of xerophytes that help to reduce transpiration.	2	These could include: reduced leaves, rolled leaves, spines, deep roots, thickened waxy cuticle, reduced number of stomata, stomata in pits surrounded by hairs, water storage tissue, low growth form, CAM (crassulacean acid metabolism) and C_4 physiology.			
9.2.11	Outline the role of phloem in active translocation of sugars (sucrose) and amino acids from source (photosynthetic tissue and storage organs) to sink (fruits, seeds, roots).	2	No detail of the mechanism of translocation or the structure of phloem is required.			

9.3 Reproduction in angiospermophytes 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
9.3.1	Draw and label a diagram showing the structure of a dicotyledonous animal-pollinated flower.	1	Limit the diagram to sepal, petal, anther, filament, stigma, style and ovary.			
9.3.2	Distinguish between *pollination*, *fertilization* and *seed dispersal*.	2				
9.3.3	Draw and label a diagram showing the external and internal structure of a named dicotyledonous seed.	1	The named seed should be non-endospermic. The structure in the diagram should be limited to testa, micropyle, embryo root, embryo shoot and cotyledons.			
9.3.4	Explain the conditions needed for the germination of a typical seed.	3	Seeds vary in their light requirements and, therefore, this factor need not be included.			
9.3.5	Outline the metabolic processes during germination of a starchy seed.	2	Absorption of water precedes the formation of gibberellin in the embryo's cotyledon. This stimulates the production of amylase, which catalyses the breakdown of starch to maltose. This subsequently diffuses to the embryo for energy release and growth. No further details are expected.			

9.3.6	Explain how flowering is controlled in long-day and short-day plants, including the role of phytochrome.	3	Limit this to the conversion of P_r (red absorbing) to P_{fr} (far-red absorbing) in red or white light, the gradual reversion of P_{fr} to P_r in darkness, and the action of P_{fr} as a promoter of flowering in long-day plants and an inhibitor of flowering in short-day plants.			

Topic 10: Genetics (6 hours)

10.1 Meiosis 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
10.1.1	Describe the behaviour of the chromosomes in the phases of meiosis.	2				
10.1.2	Outline the formation of chiasmata in the process of crossing over.	2				
10.1.3	Explain how meiosis results in an effectively infinite genetic variety in gametes through crossing over in prophase I and random orientation in metaphase I.	3				
10.1.4	State Mendel's law of independent assortment.	1	**TOK:** There are some interesting aspects of Mendel's work, including those mentioned in 4.3.11. The law of independent assortment was soon found to have exceptions when pairs of genes are linked on a chromosome, but the law that Mendel discovered in the 19th century does operate for the majority of pairs of genes.			
10.1.5	Explain the relationship between Mendel's law of independent assortment and meiosis.	3				

10.2 Dihybrid crosses and gene linkage 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
10.2.1	Calculate and predict the genotypic and phenotypic ratio of offspring of dihybrid crosses involving unlinked autosomal genes.	3				
10.2.2	Distinguish between *autosomes* and *sex chromosomes*.	2				
10.2.3	Explain how crossing over between non-sister chromatids of a homologous pair in prophase I can result in an exchange of alleles.	3				
10.2.4	Define *linkage group*.	1				

10.2.5	Explain an example of a cross between two linked genes.	3	Alleles are usually shown side by side in dihybrid crosses, for example, TtBb. In representing crosses involving linkage, it is more common to show them as vertical pairs, for example $\frac{TB}{tb}$ This format will be used in examination papers, or students will be given sufficient information to allow them to deduce which alleles are linked.			
10.2.6	Identify which of the offspring are recombinants in a dihybrid cross involving linked genes.	2	In a test cross of $\frac{TB}{tb}$ the recombinants will be $\frac{Tb}{tb}$ and $\frac{tB}{tb}$			

10.3Polygenic inheritance 1 hour

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
10.3.1	Define *polygenic inheritance*.	1				
10.3.2	Explain that polygenic inheritance can contribute to continuous variation using two examples, one of which must be human skin colour.	3	**Aim 8:** This is one of the most obvious opportunities to develop the theme of parity of esteem for all humans. The selective advantage of dark skin to protect against ultraviolet light and light skin to allow vitamin D production could be mentioned. The correlation between skin colour and intensity of sunlight is clear, though the selective advantages of particular skin colours can now be overcome by the use of sun-block creams and vitamin D supplements.			

Topic 11: Human health and physiology (17 hours)

11.1Defense against infectious disease 4 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
11.1.1	Describe the process of blood clotting.	2	Limit this to the release of clotting factors from platelets and damaged cells resulting in the formation of thrombin. Thrombin catalyses the conversion of soluble fibrinogen into the fibrous protein fibrin, which captures blood cells.			

11.1.2	Outline the principle of challenge and response, clonal selection and memory cells as the basis of immunity.	2	This is intended to be a simple introduction to the complex topic of immunity. The idea of a polyclonal response can be introduced here.			
11.1.3	Define *active* and *passive* immunity.	1	Active immunity is immunity due to the production of antibodies by the organism itself after the body's defence mechanisms have been stimulated by antigens. Passive immunity is immunity due to the acquisition of antibodies from another organism in which active immunity has been stimulated, including via the placenta, colostrum, or by injection of antibodies.			
11.1.4	Explain antibody production.	3	Limit the explanation to antigen presentation by macrophages and activation of helper T-cells leading to activation of B-cells which divide to form clones of antibody-secreting plasma cells and memory cells.			
11.1.5	Describe the production of monoclonal antibodies and their use in diagnosis and in treatment.	2	Production should be limited to the fusion of tumour and B-cells, and their subsequent proliferation and production of antibodies. Limit the uses to one example of diagnosis and one of treatment. Detection of antibodies to HIV is one example in diagnosis. Others are detection of a specific cardiac isoenzyme in suspected cases of heart attack and detection of human chorionic gonadotrophin (HCG) in pregnancy test kits. Examples of the use of these antibodies for treatment include targeting of cancer cells with drugs attached to monoclonal antibodies, emergency treatment of rabies, blood and tissue typing for transplant compatibility, and purification of industrially made interferon. **Aim 8:** Production of monoclonal antibodies is certain to be a growth area in biotechnology, with many potential applications and consequent economic opportunities. Some of the applications will be of most use in developing countries, raising the question of how they will be paid for, whether commercial companies should be expected to carry out *pro bono* research and development, or whether national governments should provide funds for it through aid budgets. Historically, the development of treatments for tropical diseases and parasites has lagged far behind those for the diseases prevalent in wealthier countries.			
11.1.6	Explain the principle of vaccination.	3	Emphasize the role of memory cells. The primary and secondary responses can be clearly illustrated by a graph. Precise details of all the types of vaccine (attenuated virus, inactivated toxins, and so on) for specific diseases are not required.			
11.1.7	Discuss the benefits and dangers of vaccination.	3	The benefits should include total elimination of diseases, prevention of pandemics and epidemics, decreased health-care costs and prevention of harmful side-effects of diseases. The dangers should include the possible toxic			

			effects of mercury in vaccines, possible overload of the immune system and possible links with autism. **Aim 8:** For parents there are ethical decisions to be made, to minimize risk for one's own child, but also to help to prevent epidemics that could affect other children. **Int:** The international dimension could be addressed here, given that some diseases have the potential to become pandemics and that the example of smallpox shows how effective international cooperation can be in combating infectious diseases. **TOK:** This is an area where it is important to estimate accurately the size of risks, using good scientific data. The use of double-blind trials for vaccines or for drug treatments could be discussed. The placebo effect could also be considered, together with the complex interplay between mind and body in feelings of illness and health. Does the patient or the doctor decide whether the patient is well or not? There are also questions about the relationship between the scientific community and the general public. How can the general public be given clear information about the benefits and risks of vaccination? What went wrong in the recent case of misplaced fears about the measles, mumps and rubella (MMR) vaccine in the UK? There are ethical questions here about who should decide vaccination policy in a country, and whether it is ethically acceptable to have a compulsory vaccination programme.			

11.2 Muscles and movement *4 hours*

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
11.2.1	State the roles of bones, ligaments, muscles, tendons and nerves in human movement.	1				
11.2.2	Label a diagram of the human elbow joint, including cartilage, synovial fluid, joint capsule, named bones and antagonistic muscles (biceps and triceps).	1				
11.2.3	Outline the functions of the structures in the human elbow joint named in 11.2.2.	2				
11.2.4	Compare the movements of the hip joint and the knee joint.	3	**Aim 7:** Video analysis of motion is possible here.			
11.2.5	Describe the structure of striated muscle fibres, including the myofibrils with light and dark bands, mitochondria, the sarcoplasmic reticulum, nuclei and the sarcolemma.	2				

11.2.6	Draw and label a diagram to show the structure of a sarcomere, including Z lines, actin filaments, myosin filaments with heads, and the resultant light and dark bands.	1	No other terms for parts of the sarcomere are expected.			
11.2.7	Explain how skeletal muscle contracts, including the release of calcium ions from the sarcoplasmic reticulum, the formation of cross-bridges, the sliding of actin and myosin filaments, and the use of ATP to break cross-bridges and re-set myosin heads.	3	Details of the roles of troponin and tropomyosin are not expected. **Aim 7:** Data logging could be carried out using a grip sensor to study muscle fatigue and muscle strength.			
11.2.8	Analyse electron micrographs to find the state of contraction of muscle fibres.	3	Muscle fibres can be fully relaxed, slightly contracted, moderately contracted and fully contracted.			

11.3The kidney

4 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
11.3.1	Define *excretion*.	1	Excretion is the removal from the body of the waste products of metabolic pathways.			
11.3.2	Draw and label a diagram of the kidney.	1	Include the cortex, medulla, pelvis, ureter and renal blood vessels.			
11.3.3	Annotate a diagram of a glomerulus and associated nephron to show the function of each part.	2				
11.3.4	Explain the process of ultrafiltration, including blood pressure, fenestrated blood capillaries and basement membrane.	3		Done in class	Revised at home	I'm Confident!
11.3.5	Define *osmoregulation*.	1	Osmoregulation is the control of the water balance of the blood, tissue or cytoplasm of a living organism. **Aim 7:** Data logging using colorimeters to measure the response of blood cells to changing salt concentrations is possible.			
11.3.6	Explain the reabsorption of glucose, water and salts in the proximal convoluted tubule, including the roles of microvilli, osmosis and active transport.	3				
11.3.7	Explain the roles of the loop of Henle, medulla, collecting duct and ADH (vasopressin) in maintaining the water balance of the blood.	3	Details of the control of ADH secretion are only required in option H (see H.1.5).			
11.3.8	Explain the differences in the concentration of proteins, glucose and urea between blood plasma, glomerular filtrate and urine.	3				

11.3.9	Explain the presence of glucose in the urine of untreated diabetic patients.	3				

11.4Reproduction 5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
11.4.1	Annotate a light micrograph of testis tissue to show the location and function of interstitial cells (Leydig cells), germinal epithelium cells, developing spermatozoa and Sertoli cells.	2				
11.4.2	Outline the processes involved in spermatogenesis within the testis, including mitosis, cell growth, the two divisions of meiosis and cell differentiation.	2	The names of the intermediate stages in spermatogenesis are not required.			
11.4.3	State the role of LH, testosterone and FSH in spermatogenesis.	1				
11.4.4	Annotate a diagram of the ovary to show the location and function of germinal epithelium, primary follicles, mature follicle and secondary oocyte.	2				
11.4.5	Outline the processes involved in oogenesis within the ovary, including mitosis, cell growth, the two divisions of meiosis, the unequal division of cytoplasm and the degeneration of polar body.	2	The terms oogonia and primary oocyte are not required.			
11.4.6	Draw and label a diagram of a mature sperm and egg.	1				
11.4.7	Outline the role of the epididymis, seminal vesicle and prostate gland in the production of semen.	2				
11.4.8	Compare the processes of spermatogenesis and oogenesis, including the number of gametes and the timing of the formation and release of gametes.	3				
11.4.9	Describe the process of fertilization, including the acrosome reaction, penetration of the egg membrane by a sperm and the cortical reaction.	2				
11.4.10	Outline the role of HCG in early pregnancy.	2				
11.4.11	Outline early embryo development up to the implantation of the blastocyst.	2	Limit this to several mitotic divisions resulting in a hollow ball of cells called the blastocyst.			
11.4.12	Explain how the structure and functions of the placenta, including its hormonal role in secretion of	3				

	estrogen and progesterone, maintain pregnancy.					
11.4.13	State that the fetus is supported and protected by the amniotic sac and amniotic fluid.	1	Embryonic details of the fetus and the structure of amniotic membranes are not required.			
11.4.14	State that materials are exchanged between the maternal and fetal blood in the placenta.	1				
11.4.15	Outline the process of birth and its hormonal control, including the changes in progesterone and oxytocin levels and positive feedback.	2				

Option F: Microbes and biotechnology (15/22 hours)

SL students study the core of these options and HL students study the whole option (the core and the extension material).

Core material: F1–F4 are core material for SL and HL (15 hours).

Extension material: F5–F6 are extension material for HL only (7 hours).

F1Diversity of microbes 5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.1.1	Outline the classification of living organisms into three domains.	2	Include the use of ribosomal RNA sequences in the classification of the three domains.			
F.1.2	Explain the reasons for the reclassification of living organisms into three domains.	3				
F.1.3	Distinguish between the characteristics of the three domains.	2	Include histones, introns, size of ribosomes, structure of cell walls and cell membranes. Histones are proteins associated with the three-dimensional structure of chromosomal DNA. Introns are segments of non-coding DNA within genes that are excised before translation.			
F.1.4	Outline the wide diversity of habitat in the Archae, as exemplified by methanogens, thermophiles and halophiles.	2				
F.1.5	Outline the diversity of Eubacteria, including shape and cell wall structure.	2				
F.1.6	State, with one example, that some bacteria form aggregates that show characteristics not seen in individual bacteria.	1	Some pathogens produce biofilms when they reach sufficient densities. They then produce toxins and overwhelm the host. For example, *Pseudomonas aeruginosa* is the major cause of death in patients with cystic fibrosis. *Vibrio* (*Photobacterium*) *fischeri* (*V. fischeri*) is a bacterium, found in seawater, that is able to emit light (bioluminesce). Single individuals do not emit light unless they become part of a			

			population with a high density. *V. fischeri* releases a regulatory substance into its surroundings. In a dense population, the concentration of this regulatory substance becomes high enough to trigger bioluminescence. It happens, for example, when large numbers of *V. fischeri* are living together in a mucus matrix in the light organs of a squid (*Euprymna scolopes*). This type of monitoring of population densities by a microbe is called quorum sensing.			
F.1.7	Compare the structure of the cell walls of Gram-positive and Gram-negative Eubacteria.	3	Details of Gram staining of bacteria are not required.			
F.1.8	Outline the diversity of structure in viruses including: naked capsid *versus* enveloped capsid; DNA *versus* RNA; and single stranded *versus* double stranded DNA or RNA.	2	Examples are not required.			
F.1.9	Outline the diversity of microscopic eukaryotes, as illustrated by *Saccharomyces*, *Amoeba*, *Plasmodium*, *Paramecium*, *Euglena* and *Chlorella*.	2	Limit this to mode of nutrition and locomotion, presence or absence of cell wall, chloroplasts, cilia and flagella.			

F2Microbes and the environment 4 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.2.1	List the roles of microbes in ecosystems, including producers, nitrogen fixers and decomposers.	1				
F.2.2	Draw and label a diagram of the nitrogen cycle.	1	Include the processes of nitrogen fixation (free-living, mutualistic and industrial), denitrification, nitrification, feeding, excretion, active transport of nitrate ions, and formation of ammonia by putrefaction.			
F.2.3	State the roles of *Rhizobium*, *Azotobacter*, *Nitrosomonas*, *Nitrobacter* and *Pseudomonas denitrificans* in the nitrogen cycle.	1				
F.2.4	Outline the conditions that favour denitrification and nitrification.	2				
F.2.5	Explain the consequences of releasing raw sewage and nitrate fertilizer into rivers.	3	Include pathogens in bathing or drinking water, eutrophication, algal blooms, deoxygenation, increase in biochemical oxygen demand (BOD) and subsequent recovery. Names of specific organisms are not expected. **Aim 7:** Data logging using ion-specific electrodes and/or using dissolved oxygen sensors is possible.			
F.2.6	Outline the role of saprotrophic bacteria in the treatment of sewage using trickling filter beds and reed bed systems.	2				

F.2.7	State that biomass can be used as raw material for the production of fuels such as methane and ethanol.	1				
F.2.8	Explain the principles involved in the generation of methane from biomass, including the conditions needed, organisms involved and the basic chemical reactions that occur.	3	A variety of types of organic matter, including manure from farm animals and cellulose, can be used as the feedstock. Several groups of bacteria are needed to complete methanogenesis. Bacteria to convert the organic matter into organic acids and alcohol. Other bacteria to convert these organic acids and alcohol into acetate, carbon dioxide and hydrogen. Finally, methanogenic bacteria to create the methane, either through the reaction of carbon dioxide and hydrogen or through the breakdown of acetate.			

F3 Microbes and biotechnology 3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.3.1	State that reverse transcriptase catalyses the production of DNA from RNA.	1				
F.3.2	Explain how reverse transcriptase is used in molecular biology.	3	This is an opportunity to relate some aspects of the DNA viral life cycle to that of the HIV virus (an RNA virus). This enzyme can make DNA from mature mRNA (for example, human insulin), which can then be spliced into host DNA (for example, *E. coli*), without the introns.			
F.3.3	Distinguish between *somatic* and *germ line* therapy.	2				
F.3.4	Outline the use of viral vectors in gene therapy.	2	This involves the replacement of defective genes. One method involves the removal of white blood cells or bone marrow cells and, by means of a vector, the introduction and insertion of the normal gene into the chromosome. The cells are replaced in the patient so that the normal gene can be expressed. An example is the use in SCID—a condition of immune deficiency, where the replaced gene allows for the production of the enzyme ADA (adenosine deaminase).			
F.3.5	Discuss the risks of gene therapy.	3	**TOK:** There have been some recent cases in countries around the world where subjects have died as a consequence of participating in a gene therapy research protocol. These cases could be examined to consider such issues as safety, conflicts of interest and other violations of ethical practice in research.			

F4Microbes and food production

3 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.4.1	Explain the use of *Saccharomyces* in the production of beer, wine and bread.	3				
F.4.2	Outline the production of soy sauce using *Aspergillus oryzae*.	2				
F.4.3	Explain the use of acids and high salt or sugar concentrations in food preservation.	3	Use of local and/or international examples is recommended.			
F.4.4	Outline the symptoms, method of transmission and treatment of one named example of food poisoning.	2	**TOK:** This is one of the areas where the distinction between correlation and cause could be made. A correlation may form a useful starting point in an investigation, but, ultimately, clear causal links must be established if public health is to be properly protected.			

F5 Metabolism of microbes 2 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.5.1	Define the terms *photoautotroph*, *photoheterotroph*, *chemoautotroph* and *chemoheterotroph*.	1	Photoautotroph: an organism that uses light energy to generate ATP and produce organic compounds from inorganic substances. Photoheterotroph: an organism that uses light energy to generate ATP and obtains organic compounds from other organisms. Chemoautotroph: an organism that uses energy from chemical reactions to generate ATP and produce organic compounds from inorganic substances. Chemoheterotroph: an organism that uses energy from chemical reactions to generate ATP and obtain organic compounds from other organisms.			
F.5.2	State one example of a photoautotroph, photoheterotroph, chemoautotroph and chemoheterotroph.	1				
F.5.3	Compare photoautotrophs with photoheterotrophs in terms of energy sources and carbon sources.	3				
F.5.4	Compare chemoautotrophs with chemoheterotrophs in terms of energy sources and carbon sources.	3				
F.5.5	Draw and label a diagram of a filamentous cyanobacterium.	1	Use *Anabaena* and label the photosynthetic cell and the heterocyst.			
F.5.6	Explain the use of bacteria in the bioremediation of soil and water.	3	Examples include selenium, solvents and pesticides in soil, and oil spills on water.			

HL *F6 Microbes and disease 5 hours*

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
F.6.1	List six methods by which pathogens are transmitted and gain entry to the body.	1				
F.6.2	Distinguish between *intracellular* and *extracellular* bacterial infection using *Chlamydia* and *Streptococcus* as examples.	2				
F.6.3	Distinguish between *endotoxins* and *exotoxins*.	2	Endotoxins: lipopolysaccharides in the walls of Gram-negative bacteria that cause fever and aches. Exotoxins: specific proteins secreted by bacteria that cause symptoms such as muscle spasms (tetanus) and diarrhoea.			
F.6.4	Evaluate methods of controlling microbial growth by irradiation, pasteurization, antiseptics and disinfectants.	3				
F.6.5	Outline the mechanism of the action of antibiotics, including inhibition of synthesis of cell walls, proteins and nucleic acids.	2				
F.6.6	Outline the lytic life cycle of the influenza virus.	2				
F.6.7	Define *epidemiology*.	1	Epidemiology is the study of the occurrence, distribution and control of diseases. **TOK:** This is one of the best opportunities to discuss the distinction between correlation and cause. Epidemiological studies generally look at correlations, but it can be extremely difficult to eliminate the effects of variables other than the one being studied. This is why surveys looking at the same risk factor have contradictory findings. Nonetheless, these studies continue to be carried out because of the importance of the area investigated, and because controlled experiments are often impossible. Edward Jenner's inoculation of a small boy with cowpox and then subsequently with smallpox could not be performed today. **Int:** Pathogens do not recognize national boundaries, and efforts by the medical and scientific communities to control disease must, therefore, be international. The eradication of smallpox and work towards eradicating polio are good examples of the effectiveness of international cooperation, to the benefit of all. Because of the costs and complexity of epidemiological studies, and of the research and development of control measures for diseases, developing countries are almost certain to lag behind developed ones in disease control. Programmes have been developed to aid developing countries in this area. Reasons for these aid programmes could be discussed.			

F.6.8	Discuss the origin and epidemiology of one example of a pandemic.	3	A pandemic is a very widespread epidemic that affects a large geographic area, such as a continent.			
F.6.9	Describe the cause, transmission and effects of malaria, as an example of disease caused by a protozoan.	2				
F.6.10	Discuss the prion hypothesis for the cause of spongiform encephalopathies.	3	**TOK:** The transmission of spongiform encephalopathies did not fit any of the conventional theories for transmission of infectious disease. There are still uncertainties about this issue, making it an interesting area for looking at the way in which scientific theories are developed and promulgated, and how the scientific community may or may not reach a consensus. This is also an area where risk could be considered—in this case, the risk (both perceived and genuine) of eating beef from certain countries. Data for the numbers of cases of new variant CJD (Creutzfeldt–Jakob disease) can be obtained from the Internet. These can be studied to see at what point it could be concluded beyond reasonable doubt that an exponential rise in cases was not occurring. It is now clear that advice given by the scientific community and national governments was misleading over several years. Once effective control measures were in place, many consumers then refused to accept advice about the safety of eating beef, showing that, when scientists lose the trust of the wider community, it may be hard to regain it. **Int:** Some may argue that BSE (bovine spongiform encephalopathy) was used as an excuse for protectionism by some national governments, but attitudes to risk vary around the world as a part of natural cultural differences. Should food safety be internationally rather than nationally regulated?			

Option G: Ecology and conservation (15/22 hours)

SL students study the core of these options and HL students study the whole option (the core and the extension material).

Core material: G1–G3 are core material for SL and HL (15 hours).

Extension material: G4–G5 are extension material for HL only (7 hours).

G1Community ecology 5 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
G.1.1	Outline the factors that affect the distribution of plant species, including temperature, water, light, soil pH, salinity and mineral nutrients.	2				

G.1.2	Explain the factors that affect the distribution of animal species, including temperature, water, breeding sites, food supply and territory.	3				
G.1.3	Describe one method of random sampling, based on quadrat methods, that is used to compare the population size of two plant or two animal species.	2				
G.1.4	Outline the use of a transect to correlate the distribution of plant or animal species with an abiotic variable.	2				
G.1.5	Explain what is meant by the niche concept, including an organism's spatial habitat, its feeding activities and its interactions with other species.	3				
G.1.6	Outline the following interactions between species, giving two examples of each: competition, herbivory, predation, parasitism and mutualism.	2				
G.1.7	Explain the principle of competitive exclusion.	3				
G.1.8	Distinguish between *fundamental* and *realized* niches.	2	The fundamental niche of a species is the potential mode of existence, given the adaptations of the species. The realized niche of a species is the actual mode of existence, which results from its adaptations and competition with other species.			
G.1.9	Define *biomass*.	1				
G.1.10	Describe one method for the measurement of biomass of different trophic levels in an ecosystem.	2	**Aim 8:** Ethical issues of returning the species and destructive techniques should be considered.			

G2 Ecosystems and biomes *4 hours*

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
G.2.1	Define *gross production*, *net production* and *biomass*.	1				
G.2.2	Calculate values for gross production and net production using the equation: gross production – respiration = net production.	2	GP – R = NP			
G.2.3	Discuss the difficulties of classifying organisms into trophic levels.	3				

G.2.4	Explain the small biomass and low numbers of organisms in higher trophic levels.	3				
G.2.5	Construct a pyramid of energy, given appropriate information.	3	The units are kJ m^{-2} yr^{-1}.			
G.2.6	Distinguish between *primary* and *secondary* succession, using an example of each.	2				
G.2.7	Outline the changes in species diversity and production during primary succession.	2				
G.2.8	Explain the effects of living organisms on the abiotic environment, with reference to the changes occurring during primary succession.	3	Include soil development, accumulation of minerals and reduced erosion.			
G.2.9	Distinguish between *biome* and *biosphere*.	2				
G.2.10	Explain how rainfall and temperature affect the distribution of biomes.	3	A climograph showing the biomes in G.2.11 can be used to illustrate the interaction between these two factors.			
G.2.11	Outline the characteristics of six major biomes.	2	Examples of major biomes could include: desert grassland shrubland (chaparral, matorral, maquis and garigue, dry heathlands, fynbos) temperate deciduous forest tropical rainforest tundra. The description should be limited to temperature, moisture and characteristics of vegetation.			

G3Impacts of humans on ecosystems 6 hours

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
G.3.1	Calculate the Simpson diversity index for two local communities.	2	$D = \frac{N(N-1)}{\Sigma n(n-1)}$ where D = diversity index, N = total number of organisms of all species found and n = number of individuals of a particular species. Teachers are strongly advised to make students collect actual data. This is an opportunity to use the graphic display calculator and spreadsheets.			
G.3.2	Analyse the biodiversity of the two local communities using the Simpson index.	3				
G.3.3	Discuss reasons for the conservation of biodiversity using rainforests as an example.	3	Reasons should include ethical, ecological, economic and aesthetic arguments. **Aim 8:** There are environmental issues affecting the whole planet and also ethical issues involved in conservation that could be raised here.			

G.3.4	List three examples of the introduction of alien species that have had significant impacts on ecosystems.	1	Choose one example of biological control, and one example each of accidental and deliberate release of invasive species.			
G.3.5	Discuss the impacts of alien species on ecosystems.	3	Limit the discussion to inter-specific competition, predation, species extinction and biological control of pest species, with named examples of each.			
G.3.6	Outline one example of biological control of invasive species.	2	**Aim 8:** Invasive alien species are such a widespread problem that it will almost certainly be possible to find a good local example. Such species are a real threat to the biodiversity of the planet, with many species facing extinction as a result. The uniqueness and cultural diversity of human populations are also being affected.			
G.3.7	Define *biomagnification*.	1	Biomagnification is a process in which chemical substances become more concentrated at each trophic level.			
G.3.8	Explain the cause and consequences of biomagnification, using a named example.	3	Examples can include biomagnification of mercury in fish, and organophosphorus pesticides, DDT or TBT (tributyl tin) in ecosystems.			
G.3.9	Outline the effects of ultraviolet (UV) radiation on living tissues and biological productivity.	2				
G.3.10	Outline the effect of chlorofluorocarbons (CFCs) on the ozone layer.	2	Details of the chemical reactions are not required.			
G.3.11	State that ozone in the stratosphere absorbs UV radiation.	1	There is a limit to UV absorption in the stratosphere. There is no need to mention UV-A, UV-B and UV-C.			

HL *G4 Conservation of biodiversity 3 hours*

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
G.4.1	Explain the use of biotic indices and indicator species in monitoring environmental change.	3				
G.4.2	Outline the factors that contributed to the extinction of one named animal species.	2	Examples could include the Carolina parakeet, dodo, passenger pigeon and thylacine (Tasmanian wolf).	Done in class	Revised at home	I'm Confident!
G.4.3	Outline the biogeographical features of nature reserves that promote the conservation of diversity.	2	Limit this to edge effects, size and habitat corridors. Large nature reserves usually promote conservation of biodiversity more effectively than small ones. The ecology of the edges of ecosystems is different from the central areas due to edge effects. An example of an edge effect is the egg-laying habits of the cowbird of the western United States. It feeds in open areas, but it lays its eggs in the nests of other birds near the edges of forests. Fragmentation of forests has led to a considerable increase in cowbird populations because of the increase in forest edge. Wildlife corridors allow organisms to move between different			

			parts of a fragmented habitat, for example, tunnels under busy roads.			
G.4.4	Discuss the role of active management techniques in conservation.	3	Use a local example wherever possible to illustrate this.			
G.4.5	Discuss the advantages of *in situ* conservation of endangered species (terrestrial and aquatic nature reserves).	3				
G.4.6	Outline the use of *ex situ* conservation measures, including captive breeding of animals, botanic gardens and seed banks.	2				

HL *G5Population ecology 4 hours*

	Assessment statement	Obj	Teacher's notes	Done in class	Revised at home	I'm Confident!
G.5.1	Distinguish between *r-strategies* and *K-strategies*.	2	An r-strategy involves investing more resources into producing many offspring, having a short life span, early maturity, reproducing only once and having a small body size. A K-strategy involves investing more resources into development and long-term survival. This involves a longer life span and late maturity, and is more likely to involve parental care, the production of few offspring, and reproducing more than once. There are organisms that display extreme r- or K-strategies, but most organisms have life histories that are intermediate on the continuum. Some organisms such as *Drosophila* switch strategies depending on environmental conditions.			
G.5.2	Discuss the environmental conditions that favour either r-strategies or K-strategies.	3	In a predictable environment, in order to maximize fitness, it pays to invest resources in long-term development and long life (K-strategy). In an unstable environment, it is better to produce as many offspring as quickly as possible (r-strategy). Of concern is that ecological disruption favours r-strategists such as pathogens and pest species.			
G.5.3	Describe one technique used to estimate the population size of an animal species based on a capture–mark–release–recapture method.	2	Various mark-and-recapture methods exist. Knowledge of the Lincoln index (which involves one mark–release–recapture cycle) is required, as follows. $\text{Population size} = \frac{n_1 \times n_2}{n_3}$ where n_1 = number of individuals initially caught, marked and released, n_2 = total number of individuals caught in the second sample, and n_3 = number of marked individuals in the second sample. Although simulations can be carried out (for example, sampling beans in sawdust), it is much more valuable if this is accompanied by a real exercise on a population of animals. The limitations and difficulties of the method can be fully appreciated, and some notion of the	Done in class	Revised at home	I'm Confident!

			importance of sample size can be explained. It is important that students appreciate the need for choosing an appropriate method for marking organisms.			
G.5.4	Describe the methods used to estimate the size of commercial fish stocks.	2				
G.5.5	Outline the concept of maximum sustainable yield in the conservation of fish stocks.	2	**Aim 8:** There are clear ethical, social, environmental and economic issues here, some of which conflict with each other. **TOK:** Data about fish stocks is very difficult to obtain and interpret, allowing huge differences in views on what is sustainable. In addition to fishing, whale hunting is an area where there is widespread disagreement about what is sustainable and also what is ethical.			
G.5.6	Discuss international measures that would promote the conservation of fish.	3	**Aim 8:** As in G.5.5, there are many issues involved here, and there is a chance to discuss the need for international agreement and cooperation in a world that is largely governed at a national level, with large areas of ocean under no government control at all. **TOK:** This is a chance to discuss decision-making, based partly on scientific evidence, that has to take place at an international level.			

ADDITIONAL RESOURCES:

Class Website: http://laurasugden.weebly.com

IB Biology Resources online

Click4Biology: http://click4biology.info/
Revision notes to suit the syllabus.

Science Video Resources: http://sciencevideos.wordpress.com/
Video, animation and interactive resources to suit the syllabus

Biology Powerpoints: http://www.slideshare.net/gurustip/slideshows
Presentations for (almost all of) the Biology topics

Science News and Discussion

NewScientist: http://www.newscientist.com/
Up-to-date science news and resources

Guardian Science: http://www.guardian.co.uk/science
Science news and a good weekly podcast

NotExactlyRocketScience: http://scienceblogs.com/notrocketscience/
Excellent articles based on primary research – really well explained

BadScience: http://www.badscience.net/
Exposing poor science communication in the media

BioEthics Education Project: http://www.beep.ac.uk/content/index.php
Current ethical issues in the biosciences