BIOLOGY

Subject guide

First Examinations 2016

ANATOLIA COLLEGE, IBDP

Revised September 2015,

Revised June 2018

1. Nature of the subject

Biology is the study of life. The first organisms appeared on the planet over 3 billion years ago and, through reproduction and natural selection, have given rise to the 8 million or so different species alive today. An interest in life is natural for humans; since we are living organisms ourselves and we depend on many species for our survival, we are threatened by some and we co-exist with many more.

Biologists attempt to understand the living world at all levels using many different approaches and techniques. Biologists study the cell, its molecular construction and complex metabolic reactions but at the same time investigate the interactions that make whole ecosystems function.

Many areas of research in biology are extremely challenging and many discoveries remain to be made. Biology is still a young science and great progress is expected in the 21st century. This progress is sorely needed at a time when the growing human population is placing ever-greater pressure on food supplies and on the habitats of other species, and is threatening the very planet we occupy.

Science and the International dimension

Science itself is an international endeavour-the exchange of information and ideas across national boundaries has been essential to the progress of science. This exchange was accelerated in recent times with the development of information and communication technologies.

Many international bodies now exist to promote science. United Nations bodies such as UNESCO, UNEP and WHO, where science plays a prominent role, are well known. The facilities for large scale research, such as the Human Genome Project, are expensive and only joint ventures involving funding from many countries allow this to take place. The data from such research is shared by scientists worldwide.

Apparently, many scientific problems are international in nature and this has led to a global approach to research in many areas. The reports of the Intergovernmental Panel on Climate Change is a prime example. Finally, the power of scientific knowledge to transform societies is unparalleled. Students need to be aware of the moral responsibility of scientists to ensure that scientific knowledge and data are available to all countries on an equitable basis and that they have the scientific capacity to use this for developing sustainable societies.

2. Aims and assessment objectives

Through studying biology 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 characterizes these subjects.

The aims enable students, through the overarching theme of the Nature of science, to:

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. acquire a body of knowledge, methods and techniques that characterize science and technology

3. apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills including the use of current technologies
7. develop and apply 21st century communication skills in the study of science
8. become critically aware, as global citizens, of the ethical implications of using science and technology
9. develop an appreciation of the possibilities and limitations of science and technology
10. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

The assessment objectives for biology reflect those parts of the aims that will be formally assessed either internally or externally. These assessments will centre upon the nature of science. It is the intention of these courses that students are able to fulfill the following **assessment objectives**:

1. Demonstrate knowledge and understanding of:
    a. facts, concepts and terminology
    b. methodologies and techniques
    c. communicating scientific information.
2. Apply:
    a. facts, concepts and terminology
    b. methodologies and techniques
    c. methods of communicating scientific information.
3. Formulate, analyse and evaluate:
    a. hypotheses, research questions and predictions
    b. methodologies and techniques
    c. primary and secondary data
    d. scientific explanations.
4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

Distinction between SL and HL

Group 4 students at standard level (SL) and higher level (HL) undertake a common core syllabus, a common internal assessment (IA) scheme and have some overlapping elements in the option studied. They are presented with a syllabus that encourages the development of certain skills, attributes and attitudes, as described in the "Assessment objectives" section of the guide.

While the skills and activities in biology are common to students at both SL and HL, students at HL are required to study some topics in greater depth, in the additional higher level (AHL) material and in the common options as well as an additional topic, like plant biology. The distinction between SL and HL is one of breadth and depth. The teaching hours for both theory and experimental work in biology are 6hrs/week in HL and 4hrs/week in SL.

3. Subject outline

A **summary** of:

- the content to be taught,
- concepts to be learnt,
- Skills to be developed
- real life context of material taught (incorporating relevant experiences for students),
- teaching methods.
- Could also include the «usefulness» of the subject in relation to further studies.

4. Prior learning

Past experience shows that students will be able to study a group 4 science subject at SL successfully with no background in, or previous knowledge of, science. Their approach to learning, characterized by the IB learner profile attributes, will be significant here.

However, for most students considering the study of biology at HL some previous exposure to formal science education would be necessary. Specific topic details are not specified but students who have undertaken the IB Middle Years Programme (MYP) or studied an equivalent national science qualification or a school-based science course would be well prepared for an HL subject.

5. Biology and the IB Learner Profile

Biology is a science subject, therefore students should be open-minded, inquirers, risk-takers, knowledgeable, thinkers and reflective in order to explore, experiment and evaluate research performed in different areas. Students should also be able to communicate and present experimental data in an appropriate scientific way. Being balanced, caring and principled will allow them to achieve their goals with integrity and honesty as well as being compassionate and well-respected.

Open-Minded

I appreciate my culture and the views, values, and traditions of other individuals and cultures.

Risk Taker

I am brave and courageous. I explore new roles, ideas, and strategies.

Inquirer

I am curious. I ask questions. I love to learn.

Balanced

I take care of my mind, body, and feelings.

Knowledgeable

I am smart. I know about the world near and far.

Reflective

I think about my own learning. I think about my strengths and weaknesses in a constructive manner.

Communicator

I can share and receive ideas and information in more than one way.

Thinker

I apply my thinking skills critically and creatively to make good decisions and to solve hard problems.

Caring

I show sensitivity towards the needs and feelings of others.

Principled

I am honest, fair, respectful, and responsible.

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6. Biology and Core Components

The **CAS programme** is closely related to biology since CAS deals with human life and its activities. Issues of global awareness such as health, nutrition and environmental protection are tackled in biology courses. These topics can be very helpful in raising awareness to students, which can then be able to help and support people in need and to provide related information in their communities.

The **theory of knowledge (TOK)** course engages students in reflection on the nature of knowledge and on how we know what we claim to know. The course identifies eight ways of knowing: reason, emotion, language, sense perception, intuition, imagination, faith and memory. The course also requires students to make comparisons between the different areas of knowledge, reflecting on how knowledge is arrived at in the various disciplines, what the disciplines have in common, and the differences between them.

TOK lessons can support students in their study of science, just as the study of science can support students in their TOK course. TOK provides a space for students to engage in stimulating wider discussions about questions such as what it means for a discipline to be a science, or whether there should be ethical constraints on the pursuit of scientific knowledge. It also provides an opportunity for students to reflect on the methodologies of science, and how these compare to the methodologies of other areas of knowledge.

In this way there are rich opportunities for students to make links between their science and TOK courses. Knowledge questions are open-ended questions about knowledge, and include questions such as:

- How do we distinguish science from pseudoscience?
- When performing experiments, what is the relationship between a scientist's expectation and their perception?
- How does scientific knowledge progress?
- What is the role of imagination and intuition in the sciences?
- What are the similarities and differences in methods in the natural sciences and the human sciences?

Students should be encouraged to raise and discuss such knowledge questions in both their science and TOK classes.

An **extended essay** in biology provides students with an opportunity to apply a range of skills while researching a topic of personal interest in the field of biology. The nature of an extended essay in biology is characterized by a particular biological emphasis within the more general context of a scientific investigation. It should have a clear biological emphasis. Biology is the science that deals with living organisms and life processes. Therefore, the topic chosen must allow an approach that distinctly relates to biology and will be judged solely on its biological content.

Some topics are unsuitable for investigation because of ethical issues. Investigations that are based on experiments likely to inflict pain or cause unnecessary stress to living organisms are not appropriate for submission. Similarly, investigations that might have a harmful effect on health or involve personal medical information are not appropriate.

This section should suggest ways in which the subject supports (or is supported by) core components (CAS/EE/TOK). It could include links to TOK/CAS, developing an EE in the subject concerned.

7. Course structure and planning

Course Outline

	Higher Level	Standard Level
THEORY		
Core	95	95
Additional Higher Level	60	-
Options (2)	25	15
PRACTICAL WORK		
Practical activities	40	20
Individual Investigation	10	10
Group 4 project	10	10
Total Teaching hours	**240**	**150**

Course Syllabus

1. ***Theory***

There are 6 core topics for both Standard and Higher Level students:

- Cell Biology
- Molecular Biology
- Genetics
- Ecology
- Evolution and Biodiversity
- Human Physiology

Additionally, there are 5 topics only for Higher Level students (AHL):

- Nucleic acids
- Metabolism, cell respiration and photosynthesis
- Genetics and Evolution
- Animal Physiology
- Plant biology

Students must also study 1 further option. The option would be chosen among the topics: Neurobiology and Behaviour, Biotechnology and Bioinformatics, Ecology and Conservation or Human physiology. Higher Level students have additional material in each option. See Appendix 1 for syllabus details.

2. *Practical Work*

Different investigations and activities will be carried out during the two-year course. These may include in-class activities, short experiments and experimental projects in the lab, computer simulations, analysis and processing of data from databases, data gathering through questionnaires or surveys and fieldwork.

3. *Individual Investigation (Internal Assessment)*

The internal assessment task will be one scientific investigation taking about 10 hours and the write-up should be about 6 to 12 pages long. Investigations exceeding this length will be penalized in the communication criterion as lacking in conciseness.

The task produced should be complex and commensurate with the level of the course. It should require a purposeful research question and the scientific rationale for it.

Some of the possible tasks include:

- a hands-on laboratory investigation
- using a spreadsheet for analysis and modelling
- extracting data from a database and analysing it graphically
- producing a hybrid of spreadsheet/database work with a traditional hands-on investigation
- using a simulation provided it is interactive and open-ended.

The task will have the same assessment criteria for SL and HL. The five assessment criteria are personal engagement, exploration, analysis, evaluation and communication.

Distribution of content through semesters:

SL course:

Semester	**Topics**
1st	1.1 - 1.8, 2.1 -2.6 and 2.8 - 2.9
2nd	6.1 – 6.2, option D.1-D.4 and 4.1 – 4.2
3rd	4.3 – 4.4, 6.3 – 6.6, 2.7 and 3.1 – 3.5

4th	6.7, 5.1 – 5.4

HL course:

Semester	**Topics**
1st	1.1 - 1.8, 2.1 - 2.6, 2.8 - 2.9 and 8.1- 8.3
2nd	6.1 – 6.3, option D.1-D.4 and 4.1 – 4.4
3rd	9.1 – 9.4, 6.3 – 6.6, D.5 – D.6, 2.7, 7.1 – 7.3 and 3.1 – 3.5
4th	6.7, 5.1 – 5.4

Apart from the theory taught in class, the course includes a large proportion of practical experimental work in the form of activities or investigations taking place throughout the two-year programme.

The experimental part of the Individual Investigation is carried out towards the end of the 2nd semester.

In addition, both SL and HL students should take part in group-4 project. This is an interdisciplinary project for all experimental sciences. It is held during the first months of first year classes. Students work in groups, produce a poster and present their work on a set date.

Teaching methods

The content of the course will be delivered by:

- Lectures
- Activities and demonstrations
- Experimental investigations
- Electronic sources: simulations, data-bases, videos
- Student presentations
- Peer and self evaluations
- Homework
- Review tests

- A typical double period lesson always starts with student questions on the problems encountered during their study, followed by a quiz or oral examination. Then, the next topic is introduced with incorporated activities and

the lesson ends with exercises on the topic or a student presentation. At different times experimental work will be carried out in the lab.

- At the end of each semester there is an internal exam (either mid-term or IB1 final) in which students are examined in all material covered since the beginning of the course.

Requirements from students

- It is important that students have gone through a science lesson before entering IB. Previous knowledge of Biology is not prerequisite, although it is helpful especially for HL.
- Students should be actively following the course. They are asked to take notes, make drawings, take part in simulations and activities, help in organizing activities, work in teams and, in certain cases, be involved in self- and peer-evaluation.
- For functional purposes each class is organized in teams of 3-4 students. In making the teams it is advisable that the students forming each team exhibit a variety of capabilities and dexterities. The composition of the teams may change through the year. The aims of team organization are the following:
    - ✓ Work together in in-class activities that are not assessed.
    - ✓ Prepare together, with teacher's guidance, an activity to be demonstrated in class. All teams go through this process in turn.
    - ✓ Help each other with exercises, questions etc, both in and out of class.
    - ✓ Prepare together small presentations on parts of the syllabus that they find interesting.
- Students should try not to miss lessons. In case of absence they are responsible for finding out what the homework is and to take the notes on the material discussed from a classmate. Students that have missed the previous lesson are not excused from day quizzes, oral examination or homework.
- Students should be in class on time. In case of delay without an excuse note the student is accepted in class, but is given an absence.
- Students should keep a folder divided in three parts: one for notes on the lectures, one for exercises and data-based questions and the last for lab notes, lab instructions and data collection. The teacher reserves the right to check occasionally the last two parts.
- At the end of each chapter students may find review questions along with the answers in Moodle. Students are encouraged to study them in preparation for their revision test.

Safety requirements and recommendations

While teachers are responsible for following national or local guidelines, which may differ from country to country, attention should be given to the guidelines developed for the International Council of Associations for Science Education (ICASE) Safety Committee by The Laboratory Safety Institute (LSI).

It is a basic responsibility of everyone involved to make safety and health an ongoing commitment. Any advice given will acknowledge the need to respect the local context, the varying educational and cultural traditions, the financial constraints and the legal systems of differing countries.

In-class assessment policy

- Although emphasis is given to revision tests, daily quizzes, oral examination, written assignments (including lab reports), the overall effort put by the student is also taken into account.
- Revision tests are:
  - ✓ At the end of each chapter
  - ✓ Planned well in advanced in order not to overlap with revision tests in other subjects
  - ✓ Based on past paper questions
  - ✓ Structured in the style of IB finals.
- There is no re-sit for the tests. Students should try not to miss these tests.
- Written assignment:
  - ✓ There are questions or exercises to be answered on a daily basis that are tested either orally or in the form of a quiz.
- Lab reports:
  - ✓ A detailed guide on how lab reports are written is given in the beginning of the course.
  - ✓ Experimental work is carried out to help students learn how to collect, handle and analyze data.
  - ✓ Lab reports are due the week after data is collected. If they are handed in the week after the deadline they will be accepted, but a comment for a missed deadline will be given to the student. After this no lab report is accepted.
  - ✓ After a maximum of 2 weeks students are given back their lab reports graded. Feedback includes highlighting the problematic areas and giving a hint on the type of problem (i.e. mistake, omission, lack of specificity etc), but with no written corrections or suggestions.
  - ✓ Lab reports that are not individually written (have common parts or common data presentation with other students) can not be assessed. **In case of plagiarism a comment is sent to the director.**

- Individual investigation:
  - ✓ Each investigation is an individual piece of work based on different data collected or measurements generated. It should be made clear to students that all work connected with the investigation should be their own.
  - ✓ It is the **internal assessment** of the biology course, contributing 20% to the final assessment in the SL and the HL courses.
  - ✓ Experimental work will be carried-out at the end of the 2nd semester and a first draft will be submitted in the beginning of the 3rd semester.
  - ✓ In a short time period, the teacher will give a feedback on the individual investigations and a final copy will be submitted in the beginning of the 4th semester.

8. Assessment

External assessment

Assessment outline—SL

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1+2	3	
Paper 1	20	10	10	¾
Paper 2	40	20	20	1¼
Paper 3	20	10	10	1
Internal assessment	20	Covers objectives 1, 2, 3 and 4		10

Assessment outline—HL

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1+2	3	
Paper 1	20	10	10	1
Paper 2	36	18	18	2¼
Paper 3	24	12	12	1¼
Internal assessment	20	Covers objectives 1, 2, 3 and 4		10

Detailed markschemes specific to each examination paper are used to assess students. See Appendix 2 for assessment details.

Grade Descriptors

Grade 7 Excellent performance

Displays comprehensive knowledge of factual information in the syllabus and a thorough command of concepts and principles. Selects and applies relevant information, concepts and principles in a wide variety of contexts. Analyses and evaluates quantitative and/or qualitative data thoroughly. Constructs detailed explanations of complex phenomena and makes appropriate predictions. Solves most quantitative and/or qualitative problems proficiently. Communicates logically and concisely using appropriate terminology and conventions. Shows insight or originality. Demonstrates personal skills, perseverance and responsibility in a wide variety of investigative activities in a very consistent manner. Works very well within a team and approaches investigations in an ethical manner, paying full attention to environmental impact. Displays competence in a wide range of investigative techniques, paying considerable attention to safety, and is fully capable of working independently.

Grade 6 Very good performance

Displays very broad knowledge of factual information in the syllabus and a thorough

understanding of concepts and principles. Selects and applies relevant information, concepts and principles in most contexts. Analyses and evaluates quantitative and/or qualitative data with a high level of competence. Constructs explanations of complex phenomena and makes appropriate predictions. Solves basic or familiar problems and most new or difficult quantitative and/or qualitative problems. Communicates effectively using appropriate terminology and conventions. Shows occasional insight or originality. Demonstrates personal skills, perseverance and responsibility in a wide variety of investigative activities in a very consistent manner. Works well within a team and approaches investigations in an ethical manner, paying due attention to environmental impact. Displays competence in a wide range of investigative techniques, paying due attention to safety, and is generally capable of working independently.

Grade 5 Good performance

Displays broad knowledge of factual information in the syllabus. Shows sound understanding of most concepts and principles and applies them in some contexts. Analyses and evaluates quantitative and/or qualitative data competently. Constructs explanations of simple phenomena. Solves most basic or familiar problems and some new or difficult quantitative and/or qualitative problems. Communicates clearly with little or no irrelevant material. Demonstrates personal skills, perseverance and responsibility in a variety of investigative activities in a fairly consistent manner. Generally works well within a team and approaches investigations in an ethical manner, paying attention to environmental impact. Displays competence in a range of investigative techniques, paying attention to safety, and is sometimes capable of working independently.

Grade 4 Satisfactory performance

Displays reasonable knowledge of factual information in the syllabus, though possibly with some gaps. Shows adequate comprehension of most basic concepts and principles but with limited ability to apply them. Demonstrates some analysis or evaluation of quantitative or qualitative data. Solves some basic or routine problems but shows

limited ability to deal with new or difficult situations. Communicates adequately although responses may lack clarity and include some repetitive or irrelevant material. Demonstrates personal skills, perseverance and responsibility in a variety of investigative activities, although displays some inconsistency. Works within a team and generally approaches investigations in an ethical manner, with some attention to environmental impact. Displays competence in a range of investigative techniques, paying some attention to safety, although requiring some close supervision.

Grade 3 Mediocre performance

Displays limited knowledge of factual information in the syllabus. Shows a partial comprehension of basic concepts and principles and weak ability to apply them. Shows some ability to manipulate data and solve basic or routine problems. Communicates with a possible lack of clarity and some repetitive or irrelevant material. Demonstrates personal skills, perseverance and responsibility in some investigative activities in an inconsistent manner. Works within a team and sometimes approaches investigations in an ethical manner, with some attention to environmental impact. Displays competence in some investigative techniques, occasionally paying attention to safety, and requires close supervision.

Grade 2 Poor performance

Displays little recall of factual information in the syllabus. Shows weak comprehension of basic concepts and principles and little evidence of application. Exhibits minimal ability to manipulate data and little or no ability to solve problems. Offers responses which are often incomplete or irrelevant. Rarely demonstrates personal skills, perseverance or responsibility in investigative activities. Works within a team occasionally but makes little or no contribution. Occasionally approaches investigations in an ethical manner, but shows very little awareness of the environmental impact. Displays competence in a very limited range of investigative techniques, showing little awareness of safety factors and needing continual and close supervision.

Grade 1 Very poor performance

Recalls fragments of factual information in the syllabus and shows very little understanding of any concepts or principles. Rarely demonstrates personal skills, perseverance or responsibility in investigative activities. Does not work within a team. Rarely approaches investigations in an ethical manner, or shows an awareness of the environmental impact. Displays very little competence in investigative techniques, generally pays no attention to safety, and requires constant supervision.

9. Academic Honesty

All written documents such as the individual investigation, lab reports as well as written homework should be individually performed and written. No plagiarism from different sources (internet, books, papers) or common parts/data presentation with other students is allowed. The document will not be assessed and the school-wide academic honesty policy will be applied to the case.

Appendix 1: Syllabus details

Syllabus content

	Recommended teaching hours
Core	**95 hours**
Topic 1: Cell biology	**15**
1.1 Introduction to cells	
1.2 Ultrastructure of cells	
1.3 Membrane structure	
1.4 Membrane transport	
1.5 The origin of cells	
1.6 Cell division	
Topic 2: Molecular biology	**21**
2.1 Molecules to metabolism	
2.2 Water	
2.3 Carbohydrates and lipids	
2.4 Proteins	
2.5 Enzymes	

6.1 Digestion and absorption

6.2 The blood system

6.3 Defence against infectious disease

6.4 Gas exchange

6.5 Neurons and synapses

6.6 Hormones, homeostasis and reproduction

Additional higher level (AHL)	**60 hours**
Topic 7: Nucleic acids	**9**
7.1 DNA structure and replication	
7.2 Transcription and gene expression	
7.3 Translation	
Topic 8: Metabolism, cell respiration and photosynthesis	**14**
8.1 Metabolism	
8.2 Cell respiration	
8.3 Photosynthesis	
Topic 9: Plant biology	**13**
9.1 Transport in the xylem of plants	
9.2 Transport in the phloem of plants	
9.3 Growth in plants	
9.4 Reproduction in plants	

Topic 10: Genetics and evolution **8**

10.1 Meiosis

10.2 Inheritance

10.3 Gene pools and speciation

Topic 11: Animal physiology **16**

11.1 Antibody production and vaccination

11.2 Movement

11.3 The kidney and osmoregulation

11.4 Sexual reproduction

Options	**15 hours (SL)/25 hours (HL)**

A: Neurobiology and behaviour

Core topics

A.1 Neural development

A.2 The human brain

A.3 Perception of stimuli

Additional higher level topics

A.4 Innate and learned behaviour

A.5 Neuropharmacology

A.6 Ethology

B: Biotechnology and bioinformatics

Core topics

B.1 Microbiology: organisms in industry

B.2 Biotechnology in agriculture

B.3 Environmental protection

Additional higher level topics

B.4 Medicine

B.5 Bioinformatics

C: Ecology and conservation

Core topics

C.1 Species and communities

C.2 Communities and ecosystems

C.3 Impacts of humans on ecosystems

C.4 Conservation of biodiversity

Additional higher level topics

C.5 Population ecology

C.6 Nitrogen and phosphorus cycles

D: Human physiology

Core topics

D.1 Human nutrition

D.2 Digestion

D.3 Functions of the liver

D.4 The heart

Additional higher level topics

D.5 Hormones and metabolism

D.6 Transport of respiratory gases

Appendix 2: Assessment details

External assessment details—SL

Paper 1

Duration: ¾ hour

Weighting: 20%

Marks: 30

- 30 multiple-choice questions on core material, about 15 of which are common with HL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- No marks are deducted for incorrect answers.

Paper 2

Duration: 1¼ hours

Weighting: 40%

Marks: 50

- Data-based question.
- Short-answer and extended-response questions on core material.
- One out of two extended response questions to be attempted by candidates.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)

Paper 3

Duration: 1 hour

Weighting: 20%

Marks: 35

- This paper will have questions on core and SL option material.
- Section A: candidates answer all questions, two to three short-answer questions based on experimental skills and techniques, analysis and evaluation, using unseen data linked to the core material.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)

External assessment details—HL

Paper 1

Duration: 1 hour

Weighting: 20%

Marks: 40

- 40 multiple-choice questions on core and AHL material, about 15 of which are common with SL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- No marks are deducted for incorrect answers.

Paper 2

Duration: 2¼ hours

Weighting: 36%

Marks: 72

- Data-based question.
- Short-answer and extended-response questions on core and AHL material.
- Two out of three extended response questions to be attempted by candidates.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)

Paper 3

Duration: 1¼ hours

Weighting: 24%

Marks: 45

- Section A: candidates answer all questions, two to three short-answer questions based on experimental skills and techniques, analysis and evaluation, using unseen data linked to the core and AHL material.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.

- The use of calculators is permitted. (See calculator section on the OCC.)

Internal assessment details

Internal assessment component

Duration: 10 hours

Weighting: 20%

- Individual investigation.
- This investigation covers assessment objectives 1, 2, 3 and 4.

Internal assessment criteria

The new assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned:

Personal engagement	Exploration	Analysis	Evaluation	Communication	Total
2 (8%)	6 (25%)	6 (25%)	6 (25%)	4 (17%)	24 (100%)

Levels of performance are described using multiple indicators per level. In many cases the indicators occur together in a specific level, but not always. Also, not all indicators are always present. This means that a candidate can demonstrate performances that fit into different levels. To accommodate this, the IB assessment models use markbands and advise examiners and teachers to use a **best-fit approach** in deciding the appropriate mark for a particular criterion.

Teachers should read the guidance on using markbands shown above in the section called "Using assessment criteria for internal assessment" before starting to mark. It is also essential to be fully acquainted with the marking of the exemplars in the teacher support material. The precise meaning of the command terms used in the criteria can be found in the glossary of the subject guides.

Personal engagement

This criterion assesses the extent to which the student engages with the exploration and makes it their own. Personal engagement may be recognized in different attributes and skills. These could include addressing personal interests or showing evidence of independent thinking, creativity or initiative in the designing, implementation or presentation of the investigation.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1	**The evidence of personal engagement with the exploration is limited with little independent thinking, initiative or creativity.** The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity.** There is little evidence of **personal input and initiative** in the designing,

	implementation or presentation of the investigation.
2	**The evidence of personal engagement with the exploration is clear with significant independent thinking, initiative or creativity.** The justification given for choosing the research question and/or the topic under investigation demonstrates **personal significance, interest or curiosity.** There is evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation.

Exploration

This criterion assesses the extent to which the student establishes the scientific context for the work, states a clear and focused research question and uses concepts and techniques appropriate to the Diploma Programme level. Where appropriate, this criterion also assesses awareness of safety, environmental, and ethical considerations.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**. The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation. The methodology of the investigation is only appropriate to address the research question to a very limited extent since it takes into consideration few of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of limited awareness of the significant **safety,** ethical or environmental issues that are **relevant to the methodology of the investigation***.

3–4	The topic of the investigation is identified and a relevant but not fully focused research question is described. The background information provided for the investigation is mainly appropriate and relevant and aids the understanding of the context of the investigation. The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of some awareness of the significant **safety,** ethical or environmental issues that are **relevant to the methodology of the investigation*.**
5–6	The topic of the investigation is identified and a relevant and fully focused research question is clearly described. The background information provided for the investigation is entirely appropriate and relevant and enhances the understanding of the context of the investigation. The methodology of the investigation is highly appropriate to address the research question because it takes into consideration all, or nearly all, of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. The report shows evidence of full awareness of the significant **safety,** ethical or environmental issues that are **relevant to the methodology of the investigation*.**

* This indicator should only be applied when appropriate to the investigation.

Analysis

This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	The report includes **insufficient relevant** raw data to support a valid conclusion to the research question. Some **basic** data processing is carried out but is either too **inaccurate or too insufficient to lead to a valid** conclusion. The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis. The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.

3–4	The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question. Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing. The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis. The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced.
5–6	The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question. Appropriate and sufficient data processing is carried out with **the accuracy** required to enable a conclusion to the research question to be drawn that is fully **consistent** with the experimental data. The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis. The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.

Evaluation

This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	A conclusion is **outlined** which is not relevant to the research question or is not supported by the data presented. The conclusion makes superficial comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of **the practical** or **procedural issues** faced. The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation.

3–4	A conclusion is **described** which is relevant to the research question and supported by the data presented. A conclusion is described which makes some relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **described** and provide evidence of some awareness of the **methodological issues*** involved in establishing the conclusion. The student has **described** some realistic and relevant suggestions for the improvement and extension of the investigation.
5–6	A detailed conclusion is **described and justified** which is entirely relevant to the research question and fully supported by the data presented. A conclusion is correctly **described and justified** through relevant comparison to the accepted scientific context. Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **discussed** and provide evidence of a clear understanding of the **methodological issues*** involved in establishing the conclusion. The student has **discussed** realistic and relevant suggestions for the improvement and extension of the investigation.

Communication

This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1–2	**The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.** The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way. The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. There are many errors in the use of subject-specific terminology and conventions*.

3–4	**The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes** . The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way. The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation. The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.

*For example, incorrect/missing labelling of graphs, tables, images; use of units, decimal places. For issues of referencing and citations refer to the "Academic honesty" section.