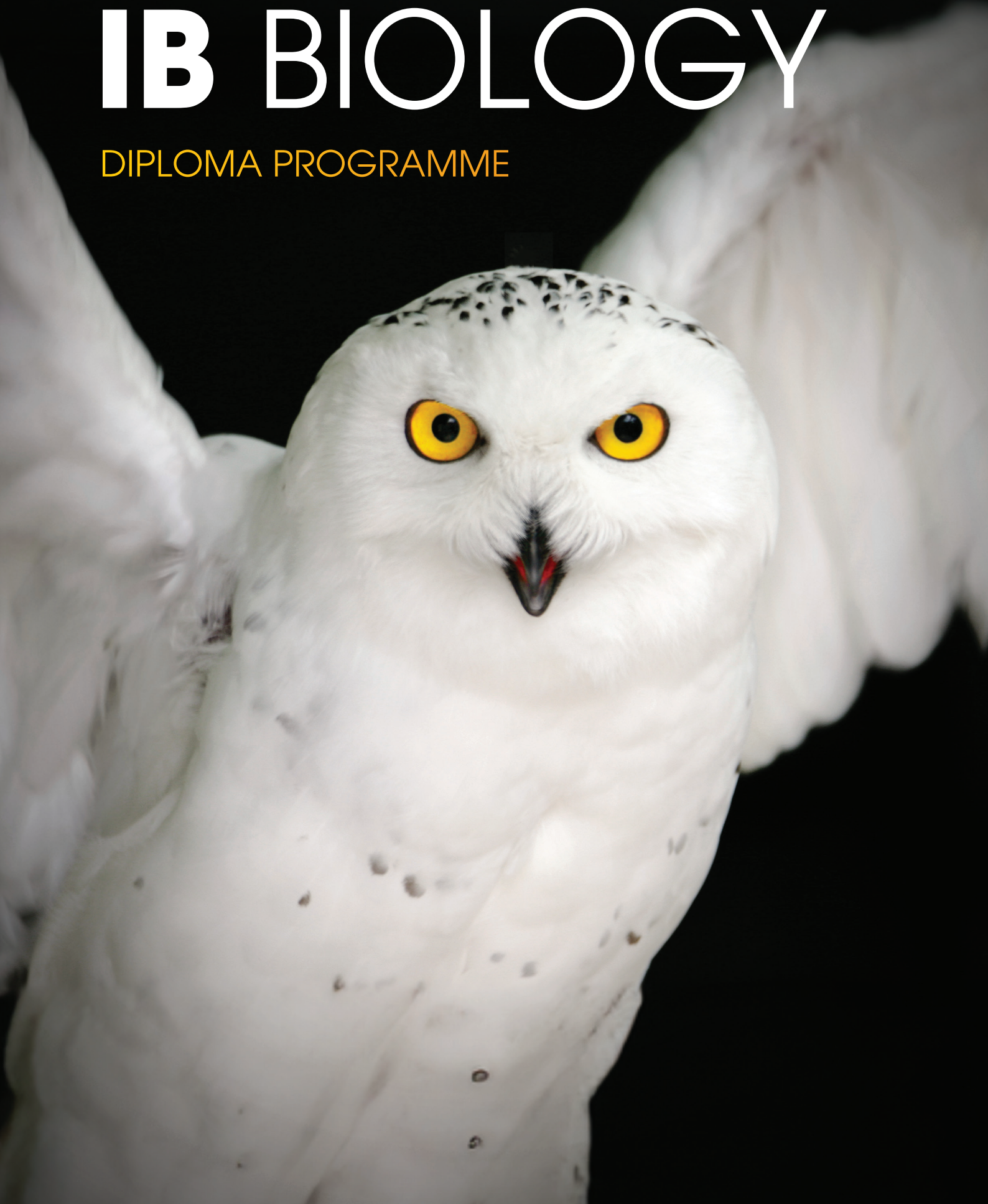


# IB BIOLOGY

DIPLOMA PROGRAMME



# Contents

|  |      |
|--|------|
| Using this Classroom Guide .....           | CG3  |
| An Introduction to IB Biology.....         | CG3  |
| BIOZONE's Pedagogy .....                   | CG4  |
| The Teacher Toolkit.....                   | CG5  |
| Syllabus Roadmap .....                     | CG7  |
| Theme Sections.....                        | CG9  |
| Theme and Chapter Structure .....          | CG10 |
| The Contents: A Planning Tool.....         | CG11 |
| Chapter Introductions .....                | CG12 |
| Features of the Activity Pages .....       | CG13 |
| Understanding the Tab System .....         | CG14 |
| Supporting the Experimental Programme..... | CG15 |
| Evaluating Student Performance .....       | CG18 |
| Identifying SL and HL Content .....        | CG20 |
| Identifying AOS and NOS Components.....    | CG21 |
| Teaching Strategies for Classroom Use..... | CG22 |

Copyright ©2024 Richard Allan  
Published by BIOZONE International Ltd

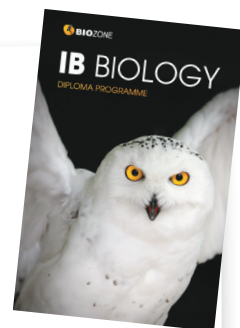


**BIOZONE International Ltd.**  
32 Somerset Street, Frankton,  
Hamilton 3204, New Zealand

PH: +64 7 856 8104  
FAX: +64 7 856 9243  
Email: sales@biozone.com

**www.BIOZONE.com**

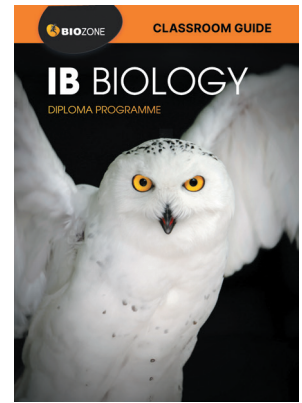
## FAQs ABOUT IB BIOLOGY



|   |           |
|---|-----------|
| Tell me more about IB Biology.  | CG3       |
| Does IB Biology cater for students doing the SL and the HL course?                  | CG3, CG20 |
| What is a worktext?   | CG4       |
| What is BIOZONE's pedagogical approach to delivery?                                 | CG4       |
| Are there support resources for teachers?   | CG5-CG6   |
| Is there a digital version of the worktext?   | CG5       |
| Is there a translation feature in the digital platform?                             | CG5       |
| How can the Resource Hub save me planning time?                                     | CG6       |
| Are there model answers?  | CG6       |
| Where can I find the syllabus roadmap for the IB course?                            | CG7-CG8   |
| Can I teach the course based on organizational level?                               | CG8       |
| How is the IB Biology worktext structured ?   | CG7-CG10  |
| How are the themes and organizational levels addressed?                             | CG7-CG10  |
| How do I use the contents and chapter introductions to navigate through the course? | CG11-CG12 |
| How have the activity pages been structured?  | CG13-CG14 |
| How do I decode and use the tabs?   | CG14      |
| Is there support for the experimental programme?                                    | CG15-CG17 |
| Are there practical investigations? Do I need to buy kits?                          | CG16      |
| Are there assessments to test student understanding?                                | CG18-CG19 |
| How can I distinguish between SL and HL material?                                   | CG20      |
| How is Nature of Science content identified?  | CG21      |
| How is Application of Skills content identified?                                    | CG21      |

# Using this Classroom Guide

This Classroom Guide has been designed to help teachers fully understand the features of *IB Biology* and provides some suggestions for how the worktext and associated resources can be used within your classroom. To find out about all of our support resources for *IB Biology*, and to get the best out of this resource, we recommend reviewing this guide before you begin using *IB Biology* in your classroom.

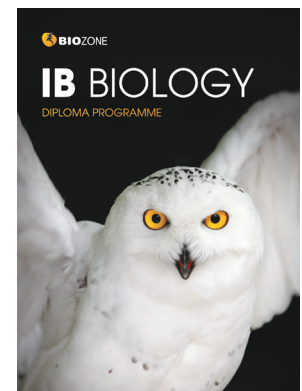


## An Introduction to IB Biology

*IB Biology* has been specifically written for the two year International Baccalaureate (IB) Biology Diploma Programme (first assessed in 2025). This resource integrates BOTH standard level (SL) and additional higher level (AHL) material, ensuring comprehensive delivery of the IB Biology syllabus.

A simple structure allows for easy navigation and identification of the theme and organizational level being addressed at any time. Additional key components, including Nature of Science, Application of Skills, and tasks to support the experimental programme, have been built into the activities and are easily identifiable using our coding and tab systems. Inbuilt assessments conclude each chapter and also each theme (section) providing convenient ways to assess student understanding of the content. Use the contents and FAQs in this Classroom Guide to quickly find the answers to your questions about the syllabus roadmap (course structure), identifying key components, distinguishing between SL and AHL material, carrying out practical activities, and assessment tasks.

*IB Biology* is available as a print or digital resource, allowing teachers the flexibility of delivering the content across dual media if required. We provide a suite of resources, the Teacher Toolkit, to help teachers plan and deliver an engaging programme. More information about our delivery options and the Teacher Toolkit is provided in this Classroom Guide.

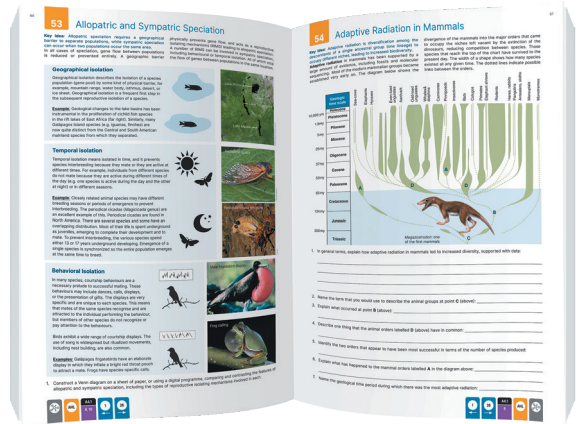


# BIOZONE's Pedagogy

## A worktext approach

BIOZONE's delivery method is a departure from a traditional textbook. We combine the very best features of a textbook with the utility of a workbook, producing a worktext resource. Importantly, the worktext is owned by the student: it is their own resource to utilize. Whether they are using the print or digital version, students customize their worktext with notes and annotations, checking off their progress in the contents and chapter introductions, and input their answers on the pages as they work through the activities.

Using a highly graphical approach and short blocks of text, we deliver textbook quality information in an accessible and engaging way, ensuring students are not overwhelmed by large amounts of information. As students interact with the stimulus material and work through activities, they are encouraged to input their answers directly onto the page. This simple act reinforces the learning moment and forms a record of work as they progress through the material. Students find revision a breeze because the stimulus material, questions, and their answers are in one place.

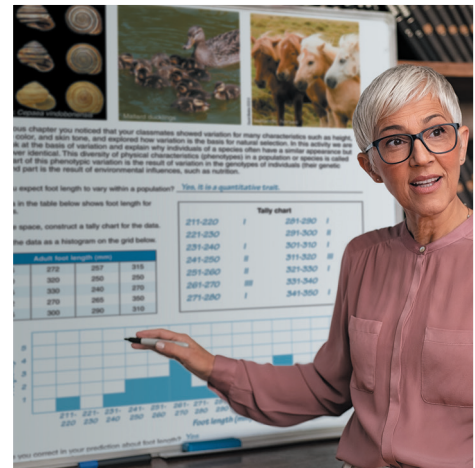


We have included a wide range of activity types in *IB Biology*. These include practical activities (experimental investigations, modelling, and simulations), research activities, and assessment tasks. The variety of activity types provides flexibility in the way teachers can assign them. For example, work can be assigned to be carried out as homework, completed in class, or set for revision. Teachers can assign students to work on activities individually or set work as a group. The activity based approach simplifies assigning work, and teachers can utilize this approach to set work for substitute teachers in their absence.

## Not all answers need to be graded!

Within the activities, there are plenty of opportunities for students to record answers to the questions. This approach reinforces the learning moment, provides space for students to record their work, and acts as a revision tool when students are preparing for assessments. This approach does not mean that teachers are expected to review or grade all student responses. We suggest that only key activities or questions are graded. This might be assessment tasks at the end of each chapter or at the conclusion of a unit. You may also choose to grade activities with content that students have traditionally found challenging, or where there is often a misunderstanding of the topic. Teachers can also choose to share answers with students. Sharing the model answers allows students to self report grades: an exercise known to be a powerful pedagogical learning tool (Hattie(2009)). Having access to model answers also allows students to refine their initial response if needed. This provides a powerful second learning moment to consolidate and extend understanding.

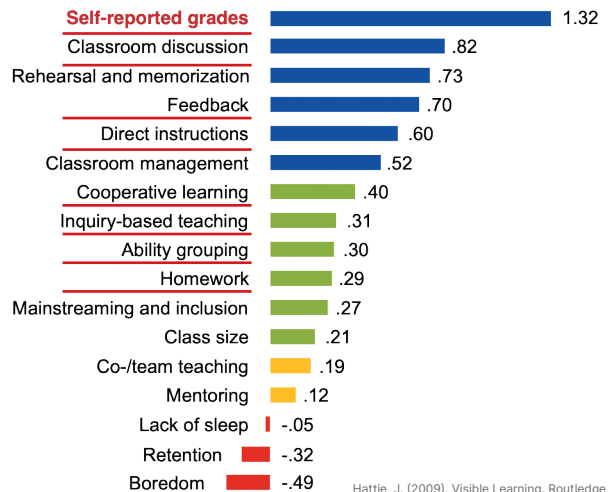
Teachers can utilize the show/hide model answer feature in the digital platform to share answers.



## Features to accelerate student learning

Student learning can be influenced by many factors. A synthesis of more than 1,400 meta studies by Hattie (2009) involving over 80,000 individual studies and 300 million students has revealed some of the major influences to student learning. Some factors negatively influence student learning (red, right) while others have positive effects (yellow, green, and blue, right).

BIOZONE's approach incorporates many of the factors shown to positively influence student learning, these are underlined in red on the diagram (right). By utilizing *IB Biology*, these factors are organically incorporated into content delivery and enhance the teacher and learner experience.



Hattie, J. (2009). Visible Learning. Routledge

# The Teacher Toolkit

BIOZONE's *IB Biology* worktext is supported by the Teacher Toolkit, a suite of resources specifically developed to help plan and deliver an engaging programme. A brief description of the tools available are provided below and on the next page.

## BIOZONE WORLD

BIOZONE WORLD, our **digital science platform**, brings our digital worktexts and rich collection of digital resources together in a single location for easy use. Click on an activity to access the additional resources provided. These include: presentation slides, interactive 3D models, and curated videos and weblinks. Educators can easily plan lessons, assign work, and grade student responses using BIOZONE WORLD.

- ▶ **Students' access** to BIOZONE WORLD allows them to use tools to markup, highlight, and bookmark content. They can also answer questions online, and submit their work for review or grading. Students have access to the curated collection of digital resources (presentation slides, 3D models, and curated videos and weblinks).
- ▶ **Teacher access** to BIOZONE WORLD includes the features available to students plus teacher-only additional features, including:
  - Managing class student enrolments.
  - The ability to view, grade, and give feedback on submitted student work.
  - Forced hand-in feature.
  - Ability to display the content on a shared screen (e.g. interactive whiteboard) to introduce or review an activity, or highlight areas of particular importance, e.g. an important step in a practical investigation.
  - Model answers in place. Show/hide buttons toggle answers on and off; ideal for sharing data or answers with students. *Students do not have access to model answers on BIOZONE WORLD.*
- ▶ The **translation tool** within BIOZONE WORLD translates the content into over 150 languages.

Find out more: [biozone.com/us/biozone-world](https://biozone.com/us/biozone-world)

**20 Eukaryotic Cell Structures**

**Key Idea:** Eukaryotic cells have many features in common. However, there are several differences between plant, animal and fungal cells. Some specialised cells have special structures. Animal cells, unlike plant cells, do not have a regular shape. In fact, some animal cells, such as phagocytes, are able to alter their shape for various purposes, e.g. engulfing foreign material. Plant and Fungal cells have a cell wall, giving rigidity and structure. Some specialised cells, e.g. erythrocytes, have lost many cell components in order to maximize the cells capacity to carry oxygen. Other specialised cells, such as skeletal muscle fibres and skeletal muscle fibres have lost their individuality and become fused to become multinucleated cells. Sieve tube elements in plant cells lose their nuclei, in development, to maximize their capacity for transport of substances through the plant.

**Generic animal cell**      **Generic plant cell**      **Generic fungal cell**

**Animal cell components**

1. Cell wall - not present.
2. Vacuole - small and temporary. Used to expel waste products from cells.
3. Chloroplasts not present.
4. Other plastids - not present.
5. Centrioles - composed of a protein called tubulin. Used in spindle fibre formation during cell division.
6. Cilia/Flagella - yes, but not shown in above image. Found in sperm cells to provide motility and in mucosal membrane cells, to help move mucus that can contain pathogens, out of the body.

**Plant cell components**

1. Cell wall - composed of cellulose.
2. Vacuole - large and permanent. Maintains turgor pressure to assist in cell rigidity.
3. Chloroplasts - yes, can be many or few, depending on the type of cell.
4. Other plastids - these are double membrane structures for manufacturing/ storing food. Amyloplasts store starch. Leucoplasts (by root cells) can synthesise fatty acids and some amino acids.
5. Centrioles - found in lower plants but absent from conifers and flowering plants.
6. Cilia/Flagella - found in lower plants but absent from conifers and flowering plants.

**Fungi cell components**

1. Cell wall - composed of chitin.
2. Nucleus - large and permanent. Maintains turgor pressure to assist in cell rigidity.
3. Chloroplasts - not present.
4. Other plastids - not present.
5. Centrioles - not present (except for a few exceptions).
6. Cilia/Flagella - not present in true fungi. An exception is the primitive fungi, Cryptomyxozoa, which possesses a flagellum but no cell wall.

1. What is the difference between vacuoles in plant and animal cells? **Vacuoles in plant cells are large and have important roles in turgor, storage, waste disposal, and growth. In animal cells, vacuoles are small with minor roles in endocytosis and autophagy.**

2. Plant and fungi cells both have a cell wall - what would indicate the structure evolved independently in each? **Made of different substances. Chitin in fungi (like insect exoskeletons) and cellulose in plants.**

**13 The Cell is the Unit of Life**

**Key Idea:** All living organisms are composed of cells. Cells are broadly classified as prokaryotic or eukaryotic.

Utilizando el razonamiento deductivo y aplicando la teoría celular, podemos entonces predecir que cualquier forma de vida recién descubierta debe comprender uno o más células. Las teorías se pueden utilizar para hacer predicciones deductivas.

Using deductive reasoning and applying the cell theory, we can then predict that any newly discovered life form must comprise one or more cells. Theories can be used to make deductive predictions.

**A pop up of the translated text appears in BIOZONE WORLD.**

**Living things**      **Prokaryotic (bacterial) cells**

**Movement**  
**Respiration**  
**Sensitivity**  
**Growth**  
**Reproduction**  
**Excretion**  
**Nutrition**  
**Homeostasis**

## PRESENTATION SLIDES

Presentation Slides are a very popular way for teachers to deliver a lesson in a presentation style format either in class or via remote delivery. The Presentation Slides are a sizeable collection of slides specifically designed to support and enhance the content of the worktext. A set of slides is available for each chapter of *IB Biology*.

The Presentation Slides automatically appear in the resource list when an activity is selected.

**Water in Living Systems**

Water's molecular structure accounts for its unique properties and its central role in life's processes.

- Water (H<sub>2</sub>O) is the main component of living organisms.
- Most organisms are made up of around 70% water.
- Many reactants and products of cell chemistry are water.
- The cohesive, adhesive, thermal, and solvent properties are mostly due to water's polarity and the formation of hydrogen bonds.

**Oxygen Transport and Haemoglobin**

- Haemoglobin is an oxygen carrying protein complex that is found in erythrocytes.
- Oxygen does not easily dissolve in blood but is carried in a chemical combination with haemoglobin (Hb) in erythrocytes.

1. Haemoglobin binds to oxygen as red blood cells travel through the lungs.

2. Red blood cells transport circulating oxygen to organs where they need them.

3. When red blood cells reach their target, haemoglobin releases oxygen.

## RESOURCE HUB

The BIOZONE **Resource Hub** is a free resource, available to students and teachers. It offers a curated collection of Open Educational Resources (OER) specifically chosen to support the content of the worktext. Resources include videos, animations, games, 3D models, spreadsheets, and source material.

Print users access BIOZONE's **Resource Hub** content through QR codes and links provided on page x of the worktext. The codes have also been provided in this guide for easy reference (right). For digital users, the resources are embedded in BIOZONE WORLD and appear in the resource list when an activity is selected.

The BIOZONE **Resource Hub** is an effective tool to engage students of all abilities within a differentiated classroom. Most resources can be used by students of all abilities. 3D models, videos, games, and simulations are great tools for engaging students in a topic, or supporting striving students in their learning journey.

Some components have been tagged as extension material and can be used to extend capable or gifted students. These types of resources may require more reading or synthesis of information. Our spreadsheet models can be used as is, or you can have students graph the information themselves. You may wish to challenge more capable students to build their own models, or manipulate the ones provided to observe the outcomes.

Some Resource Hub material is tagged as a teacher resource. Teacher resources often provide background or additional material to an activity. Capable students, or students with a particular interest in the topic can be assigned this material at your discretion.

### SUMMARY OF RESOURCE HUB MATERIALS FOR IB BIOLOGY

| Resource type | Number of resources* |
|---------------|----------------------|
| PDFs          | 16                   |
| 3D models     | 233                  |
| Videos        | 489                  |
| Weblinks      | 216                  |
| Interactives  | 90                   |
| Spreadsheets  | 5                    |

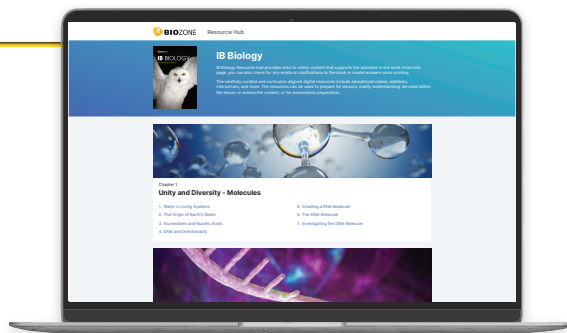
\* approximate number of resources

## MODEL ANSWERS

Model answers are provided for each activity. Teachers can choose to provide model answers to students at their discretion.

Model answers can be accessed in two different ways:

1. Via the digital platform (BIOZONE WORLD). Using the teacher view, answers can be projected onto a shared screen (e.g. interactive whiteboard) and be revealed by toggling the show/hide buttons.
2. A physical printed booklet.



The BIOZONE **Resource Hub** content is easily shared with your students through your LMS. You can provide notes and guidance about what you want students to do with the resource. The BIOZONE **Resource Hub** can be accessed directly via the QR code below:



Or bookmark the following link:

[www.BIOZONEhub.com](http://www.BIOZONEhub.com)

Then enter this code:

**IB3-4108**

## QUESTION LIBRARY

All embedded questions in *IB Biology* are extracted into Question Library files. Provided in QTI and RTF files, the questions can be ingested into a range of learning management systems or other digital delivery tools.

The Question Library content is fully editable, providing teachers with flexibility and control in assigning questions within a differentiated classroom. The questions can be customized to match a student's learning ability or reading level.

Access to the question library is complementary with multi-year purchases.

# Syllabus Roadmap

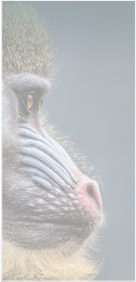
The IB syllabus comprises four themes and four organizational levels. BIOZONE's approach to delivering the syllabus has been to structure the worktext using the roadmap presented within the IB syllabus document. In this approach, the themes create four distinct sections and each organizational level is addressed within each theme. This spiralling approach allows exploration of the organizational levels (and the related understandings) within four different thematic contexts. The general hierarchical structure and sectioning of content using themes is outlined below.

| Theme   | Organizational Level           | Understandings                            | Content statement                        |
|---|--------------------------------|---|--|
| <b>Theme A: Unity and Diversity</b> ← <b>Theme (1 of 4)</b> |                                |   |  |
| <b>1. Molecules</b> <i>page 1</i>                           | <b>2. Cells</b> <i>page 15</i> | <b>3. Organisms</b> <i>page 46</i>        | <b>4. Ecosystems</b> <i>page 75</i>      |
| <b>A1.1</b> Water   | <b>A2.1</b> Origins of Cells   | <b>A3.1</b> Diversity of Organisms        | <b>A4.1</b> Evolution and Speciation     |
| <b>A1.2</b> Nucleic acids                                   | <b>A2.2</b> Cell Structure     | <b>A3.2</b> Classification and Cladistics | <b>A4.2</b> Conservation of Biodiversity |
| <b>A2.3</b> Viruses   |                                |   |  |

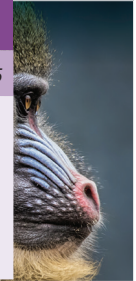
**Level of organization**

**Numbered understandings**

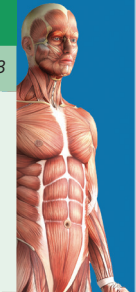
**Content statements** are summarized in the chapter introductions



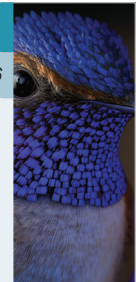
| <b>Theme A: Unity and Diversity</b> |                                |   |  |
|-------------------------------------|--------------------------------|---|--|
| <b>1. Molecules</b> <i>page 1</i>   | <b>2. Cells</b> <i>page 15</i> | <b>3. Organisms</b> <i>page 46</i>        | <b>4. Ecosystems</b> <i>page 75</i>      |
| <b>A1.1</b> Water                   | <b>A2.1</b> Origins of Cells   | <b>A3.1</b> Diversity of Organisms        | <b>A4.1</b> Evolution and Speciation     |
| <b>A1.2</b> Nucleic acids           | <b>A2.2</b> Cell Structure     | <b>A3.2</b> Classification and Cladistics | <b>A4.2</b> Conservation of Biodiversity |
|                                     | <b>A2.3</b> Viruses            |   |  |




| <b>Theme B: Form and Function</b>    |   |                                     |                                       |
|--------------------------------------|---|-------------------------------------|---------------------------------------|
| <b>5. Molecules</b> <i>page 104</i>  | <b>6. Cells</b> <i>page 122</i>                 | <b>7. Organisms</b> <i>page 156</i> | <b>8. Ecosystems</b> <i>page 208</i>  |
| <b>B1.1</b> Carbohydrates and Lipids | <b>B2.1</b> Membranes and Membrane Transport    | <b>B3.1</b> Gas Exchange            | <b>B4.1</b> Adaptation to Environment |
| <b>B1.2</b> Proteins                 | <b>B2.2</b> Organelles and Compartmentalization | <b>B3.2</b> Transport               | <b>B4.2</b> Ecological Niches         |
|                                      | <b>B2.3</b> Cell Specialization                 | <b>B3.3</b> Muscle and Motility     |                                       |



| <b>Theme C: Interaction and Interdependence</b> |                                  |   |  |
|---|----------------------------------|---|--|
| <b>9. Molecules</b> <i>page 239</i>             | <b>10. Cells</b> <i>page 283</i> | <b>11. Organisms</b> <i>page 306</i>    | <b>12. Ecosystems</b> <i>page 356</i>      |
| <b>C1.1</b> Enzymes and Metabolism              | <b>C2.1</b> Chemical Signalling  | <b>C3.1</b> Integration of Body Systems | <b>C4.1</b> Populations and Communities    |
| <b>C1.2</b> Cell Respiration                    | <b>C2.2</b> Neural Signalling    | <b>C3.2</b> Defence Against Disease     | <b>C4.2</b> Transfers of Energy and Matter |
| <b>C1.3</b> Photosynthesis                      |                                  |   |  |



| <b>Theme D: Continuity and Change</b>  |                                       |                                      |                                       |
|--|---------------------------------------|--------------------------------------|---------------------------------------|
| <b>13. Molecules</b> <i>page 411</i>   | <b>14. Cells</b> <i>page 441</i>      | <b>15. Organisms</b> <i>page 470</i> | <b>16. Ecosystems</b> <i>page 535</i> |
| <b>D1.1</b> DNA Replication            | <b>D2.1</b> Cell and Nuclear Division | <b>D3.1</b> Reproduction             | <b>D4.1</b> Natural Selection         |
| <b>D1.2</b> Protein Synthesis          | <b>D2.2</b> Gene Expression           | <b>D3.2</b> Inheritance              | <b>D4.2</b> Stability and Change      |
| <b>D1.3</b> Mutations and Gene Editing | <b>D2.3</b> Water Potential           | <b>D3.3</b> Homeostasis              | <b>D4.3</b> Climate Change            |



Our tab system (CG14) allows teachers to readily identify the syllabus components covered in each activity. The coding can be used as a roadmap for teachers wishing to deliver the course from an organizational based framework, i.e. using the four organizational levels to divide the course into sections. In this approach, the themes form the spiralling context of study. A road map is provided below.

| Organizational Level   | Theme   | Understandings   | Content statement  |
|--|---|--|--|
| <b>Organizational Level: Molecules</b>                               |   |  |  |
| <b>Theme A:<br/>Unity and Diversity</b><br><i>Chapter 1: Page 1</i>  | <b>Theme B:<br/>Form and Function</b><br><i>Chapter 5: Page 104</i> | <b>Theme C:<br/>Interaction and Interdependence</b><br><i>Chapter 9: Page 239</i>  | <b>Theme D:<br/>Continuity and Change</b><br><i>Chapter 13: Page 411</i> |
| <b>A1.1</b> Water  | <b>B1.1</b> Carbohydrates and Lipids                                | <b>C1.1</b> Enzymes and Metabolism   | <b>D1.1</b> DNA Replication  |
| <b>A1.2</b> Nucleic Acids  | <b>B1.2</b> Proteins  | <b>C1.2</b> Cell Respiration   | <b>D1.2</b> Protein Synthesis  |
|  |   | <b>C1.3</b> Photosynthesis   | <b>D1.3</b> Mutations and Gene Editing                                   |
| <b>Organizational Level: Cells</b>                                   |   |  |  |
| <b>Theme A:<br/>Unity and Diversity</b><br><i>Chapter 2: Page 15</i> | <b>Theme B:<br/>Form and Function</b><br><i>Chapter 6: Page 122</i> | <b>Theme C:<br/>Interaction and Interdependence</b><br><i>Chapter 10: Page 283</i> | <b>Theme D:<br/>Continuity and Change</b><br><i>Chapter 14: Page 441</i> |
| <b>A2.1</b> Origin of Cells  | <b>B2.1</b> Membranes and Membrane Transport                        | <b>C2.1</b> Chemical Signalling  | <b>D2.1</b> Cell and Nuclear Division                                    |
| <b>A2.2</b> Cell Structure   | <b>B2.2</b> Organelles and Compartmentalization                     | <b>C2.2</b> Neural Signalling  | <b>D2.2</b> Gene Expression  |
| <b>A2.3</b> Viruses  | <b>B2.3</b> Cell Specialization                                     |  | <b>D2.3</b> Water Potential  |
| <b>Organizational Level: Organisms</b>                               |   |  |  |
| <b>Theme A:<br/>Unity and Diversity</b><br><i>Chapter 3: Page 46</i> | <b>Theme B:<br/>Form and Function</b><br><i>Chapter 7: Page 156</i> | <b>Theme C:<br/>Interaction and Interdependence</b><br><i>Chapter 11: Page 306</i> | <b>Theme D:<br/>Continuity and Change</b><br><i>Chapter 15: Page 470</i> |
| <b>A3.1</b> Diversity of Organisms                                   | <b>B3.1</b> Gas Exchange  | <b>C3.1</b> Integration of Body Systems  | <b>D3.1</b> Reproduction   |
| <b>A3.2</b> Classification and Cladistics                            | <b>B3.2</b> Transport   | <b>C3.2</b> Defence Against Disease  | <b>D3.2</b> Inheritance  |
|  | <b>B3.3</b> Muscle and Motility                                     |  | <b>D3.3</b> Homeostasis  |
| <b>Organizational Level: Ecosystems</b>                              |   |  |  |
| <b>Theme A:<br/>Unity and Diversity</b><br><i>Chapter 4: Page 75</i> | <b>Theme B:<br/>Form and Function</b><br><i>Chapter 8: Page 208</i> | <b>Theme C:<br/>Interaction and Interdependence</b><br><i>Chapter 12: Page 356</i> | <b>Theme D:<br/>Continuity and Change</b><br><i>Chapter 16: Page 535</i> |
| <b>A4.1</b> Evolution and Speciation                                 | <b>B4.1</b> Adaptation to Environment                               | <b>C4.1</b> Populations and Communities  | <b>D4.1</b> Natural Selection  |
| <b>A4.2</b> Conservation of Biodiversity                             | <b>B4.2</b> Ecological Niches                                       | <b>C4.2</b> Transfers of Energy and Matter   | <b>D4.2</b> Stability and Change   |
|  |   |  | <b>D4.3</b> Climate Change   |



# Theme Sections

*IB Biology* is divided into four sections based on the four themes identified in the IB Biology syllabus. Each theme consists of four levels of organization: Molecules, Cells, Organisms, and Ecosystems. Each section is introduced with a title page clearly identifying the theme, its summary statement, and the understandings for each level of biological organization. Use these for easy navigation for the course and to quickly identify the understandings which will be covered in each chapter.



Theme A:  
**Unity and Diversity**

Common ancestry has given living organisms many shared features while evolution has resulted in the rich biodiversity of life on Earth.

**Understandings:**

**Molecules**

- A1.1 Water
- A1.2 Nucleic acids

**Cells**

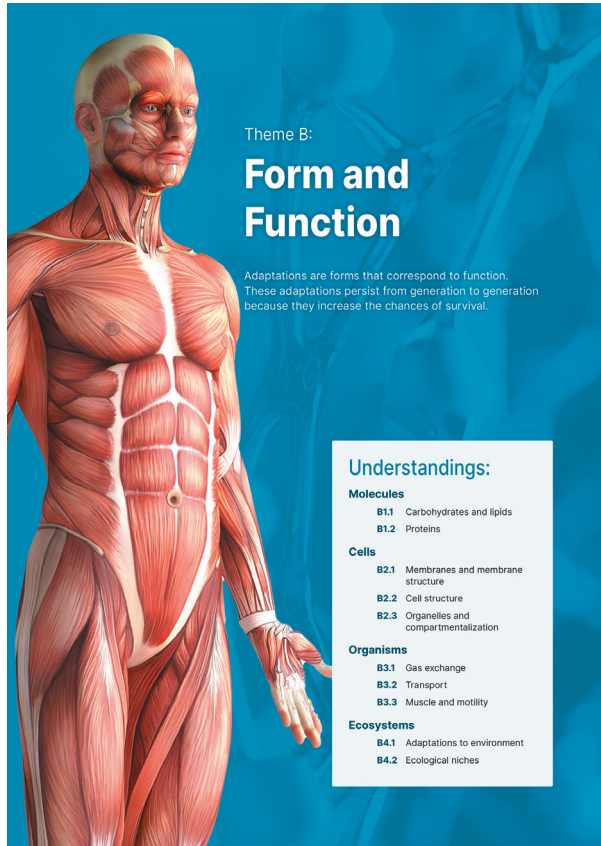
- A2.1 Origins of cells
- A2.2 Cell structure
- A2.3 Viruses

**Organisms**

- A3.1 Diversity of organisms
- A3.2 Classification and cladistics

**Ecosystems**

- A4.1 Evolution and speciation
- A4.2 Conservation of biodiversity



Theme B:  
**Form and Function**

Adaptations are forms that correspond to function. These adaptations persist from generation to generation because they increase the chances of survival.

**Understandings:**

**Molecules**

- B1.1 Carbohydrates and lipids
- B1.2 Proteins

**Cells**


- B2.1 Membranes and membrane structure
- B2.2 Cell structure
- B2.3 Organelles and compartmentalization

**Organisms**

- B3.1 Gas exchange
- B3.2 Transport
- B3.3 Muscle and motility

**Ecosystems**

- B4.1 Adaptations to environment
- B4.2 Ecological niches



Theme C:  
**Interaction and Interdependence**

Effective systems at all biological organizational levels require the coordinated interaction and interdependence of components, leading to the emergence of new properties.

**Understandings:**

**Molecules**

- C1.1 Enzymes and metabolism
- C1.2 Cell respiration
- C1.3 Photosynthesis

**Cells**

- C2.1 Chemical signalling
- C2.2 Neural signalling

**Organisms**

- C3.1 Integration of body systems
- C3.2 Defence against disease

**Ecosystems**

- C4.1 Populations and communities
- C4.2 Transfers of energy and matters



Theme D:  
**Continuity and Change**

Natural selection is driven by environmental change leading to the ever-changing biodiversity on Earth, while each organism processes complex homeostatic mechanisms to enable continuity.

**Understandings:**

**Molecules**

- D1.1 DNA replication
- D1.2 Protein synthesis
- D1.3 Mutations and gene editing

**Cells**

- D2.1 Cell and nuclear division
- D2.2 Gene expression
- D2.3 Water potential

**Organisms**

- D3.1 Reproduction
- D3.2 Inheritance
- D3.3 Homeostasis

**Ecosystems**

- D4.1 Natural selection
- D4.2 Stability and change
- D4.3 Climate change

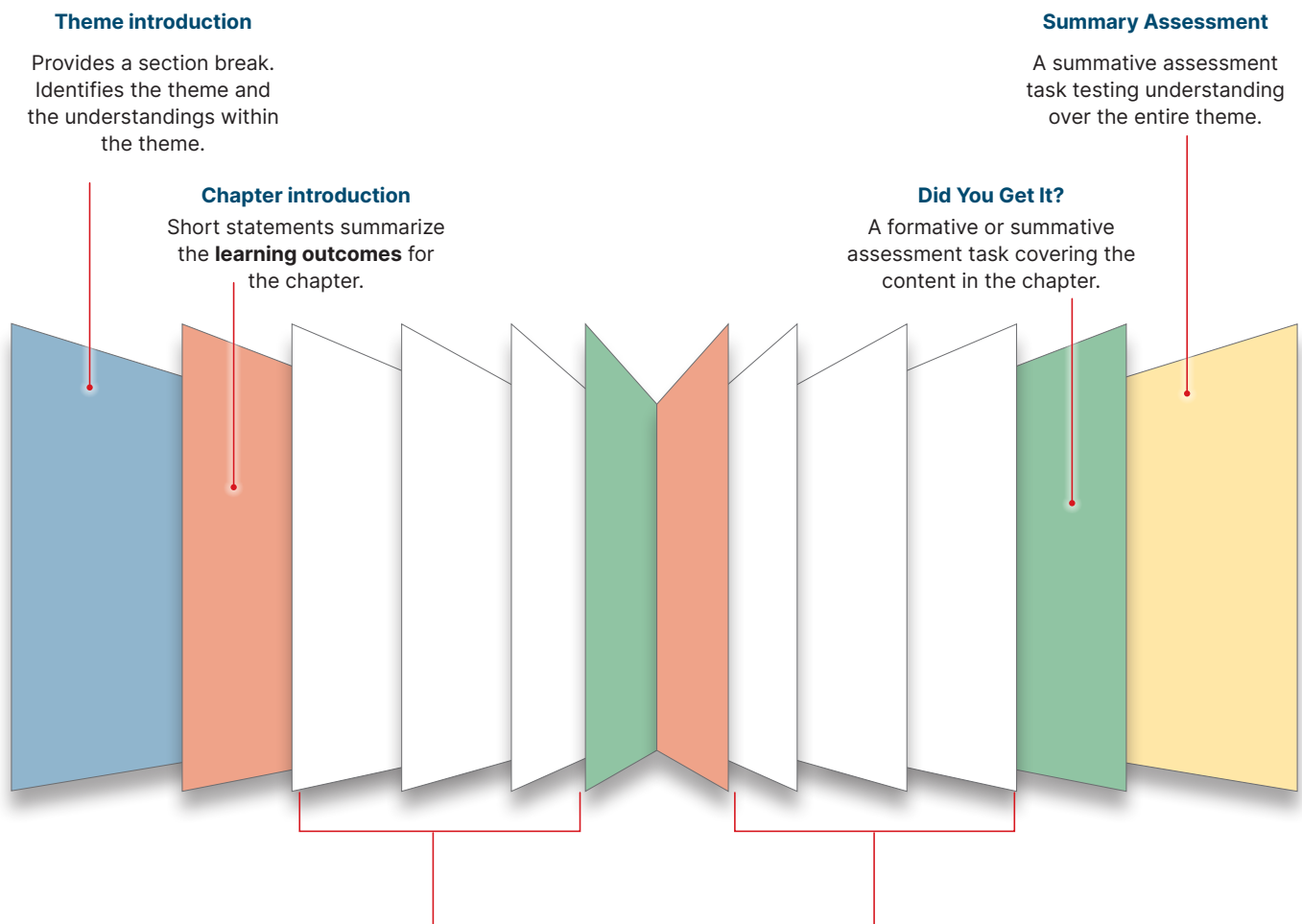
# Theme and Chapter Structure

Each theme (section) contains four chapters. Each chapter follows the four levels of biological organization:

1. Molecules
2. Cells
3. Organisms
4. Ecosystems

The levels of biological organization act as conceptual lenses for exploring each theme. This approach allows for scaffolding of biological knowledge from the microscopic to the ecosystem level within each theme. This spiralling delivery provides opportunities for revisiting each of the levels of biological organization within a different conceptual lens, encouraging learners to see the interconnectedness of the themes and ideas as they progress through the syllabus.

## Organizational structure



### Theme introduction

Provides a section break. Identifies the theme and the understandings within the theme.

### Chapter introduction

Short statements summarize the **learning outcomes** for the chapter.

### Did You Get It?

A formative or summative assessment task covering the content in the chapter.

### Summary Assessment

A summative assessment task testing understanding over the entire theme.

### Activity Pages

The activity pages have been designed to address the **content statements** of the course. **Application of Skills** and **Nature of Science** are also embedded and identified where applicable. Most activities have questions for students to answer. This forms a record of the student's work and allows them to demonstrate their understanding of the content.

# The Contents: A Planning Tool

The contents pages are not merely a list of the activities. Encourage your students to use them as a planning tool for their programme of work. Students can identify the activities they are to complete and then tick them off when completed. Ticking off the activities as they are completed gives students a sense of progression and helps them to be more personally organized in their work and time management. Teachers can see at a glance how a student is progressing through the set work. Any concerns with progress can be addressed early.

iii

## Contents

Using This Worktext .....vii  
 Using BIOZONE's Resource Hub ..... X  
 Themes in IB Diploma Biology .....xi

### Theme A: Unity and Diversity

#### Chapter 1: A1 - Molecules

|                                     |                                 |   |
|-------------------------------------|---------------------------------|---|
|                                     | Learning Outcomes.....          | 1 |
|                                     | 1 Metabolic Living Systems..... | 2 |
| <input checked="" type="checkbox"/> | 2                               | 3 |
| <input checked="" type="checkbox"/> | 3                               | 4 |
| <input checked="" type="checkbox"/> | 4                               | 5 |
| <input checked="" type="checkbox"/> | 5                               | 6 |
| <input checked="" type="checkbox"/> | 6                               | 7 |
| <input checked="" type="checkbox"/> | 7                               | 8 |
| <input checked="" type="checkbox"/> | 8                               |   |

Students can mark the check boxes to indicate the activities they should complete. This helps them to quantify the work to be done and plan their workflow.

#### Chapter 2: A2-Cells

|                                     |  |    |
|-------------------------------------|--|----|
|                                     | Learning Outcomes.....                       | 15 |
| <input checked="" type="checkbox"/> | 9 The Origin of Life on Earth.....           | 17 |
| <input type="checkbox"/>            | 10   | 18 |
| <input type="checkbox"/>            | 11   | 19 |
| <input type="checkbox"/>            | 12   | 20 |
| <input checked="" type="checkbox"/> | 13   | 22 |
| <input checked="" type="checkbox"/> | 14   | 23 |
| <input checked="" type="checkbox"/> | 15   | 25 |
| <input type="checkbox"/>            | 16   | 26 |
| <input type="checkbox"/>            | 17 Common Features of Cells.....             | 28 |
| <input type="checkbox"/>            | 18 Prokaryote and Eukaryote Cells.....       | 29 |
| <input type="checkbox"/>            | 19 The Processes of Life in Unicellular..... | 30 |
| <input type="checkbox"/>            | 20   | 32 |
| <input checked="" type="checkbox"/> | 21 Application of Skills.....                | 34 |
| <input checked="" type="checkbox"/> | 22   | 35 |
| <input type="checkbox"/>            | 23   | 37 |
| <input type="checkbox"/>            | 24   | 38 |
| <input type="checkbox"/>            | 25   | 40 |
| <input type="checkbox"/>            | 26 Viruses.....                              | 41 |
| <input type="checkbox"/>            | 27 Replication in Viruses.....               | 42 |
| <input type="checkbox"/>            | 28 Rapid Virus Evolution.....                | 43 |
| <input type="checkbox"/>            | 29 Did You Get It?.....                      | 45 |

Activities containing Nature of Science content are identified with a **red circle** in the contents page.

Activities containing Application of Skills content are identified with a **green circle** in the contents page.

#### Chapter 3: A3-Organisms

|                                     |   |    |
|-------------------------------------|---|----|
|                                     | Learning Outcomes.....                    | 46 |
| <input type="checkbox"/>            | 30 Variation in Organisms.....            | 47 |
| <input type="checkbox"/>            | 31 What is a Species?.....                | 49 |
| <input type="checkbox"/>            | 32 Problems in Defining a Species.....    | 51 |
| <input checked="" type="checkbox"/> | 33 Karyotypes.....                        | 52 |
| <input checked="" type="checkbox"/> | 34 Evolution of the Human Karyotype.....  | 54 |
| <input checked="" type="checkbox"/> | 35 Making a Karyogram.....                | 55 |
| <input type="checkbox"/>            | 36 Diversity in Genomes.....              | 58 |
| <input type="checkbox"/>            | 37 Genome Size.....                       | 59 |
| <input type="checkbox"/>            | 38 Chromosomes and Species.....           | 60 |
| <input type="checkbox"/>            | 39 Using Whole Genome Sequencing.....     | 61 |
| <input type="checkbox"/>            | 40 Classification Keys.....               | 62 |
| <input type="checkbox"/>            | 41 Making a Classification Key.....       | 64 |
| <input type="checkbox"/>            | 42 DNA Barcodes.....                      | 65 |
| <input type="checkbox"/>            | 43 Classifying Organisms.....             | 66 |
| <input type="checkbox"/>            | 44 Cladistics and Phylogenetic Trees..... | 69 |
| <input type="checkbox"/>            | 45 Molecular Evidence and Cladistics..... | 72 |
| <input type="checkbox"/>            | 46 Did You Get It?.....                   | 74 |

#### Chapter 4: A4-Ecosystems

|                                     |  |     |
|-------------------------------------|--|-----|
|                                     | Learning Outcomes.....                                 | 75  |
| <input checked="" type="checkbox"/> | 47 The Theory of Evolution.....                        | 76  |
| <input type="checkbox"/>            | 48 Molecular Sequencing as Evidence for Evolution..... | 78  |
| <input type="checkbox"/>            | 49 Evolution and Selective Breeding.....               | 80  |
| <input type="checkbox"/>            | 50 Homologous Structures.....                          | 82  |
| <input type="checkbox"/>            | 51 Convergent Evolution.....                           | 83  |
| <input type="checkbox"/>            | 52 Speciation.....                                     | 84  |
| <input type="checkbox"/>            | 53 Allopatric and Sympatric Speciation.....            | 86  |
| <input type="checkbox"/>            | 54 Adaptive Radiation in Mammals.....                  | 87  |
| <input type="checkbox"/>            | 55 Barriers to Hybridization.....                      | 88  |
| <input type="checkbox"/>            | 56 Abrupt Speciation in Plants.....                    | 89  |
| <input checked="" type="checkbox"/> | 57 Earth's Biodiversity.....                           | 90  |
| <input type="checkbox"/>            | 58 The Sixth Mass Extinction.....                      | 92  |
| <input checked="" type="checkbox"/> | 59 Human Activity and Ecosystem Loss.....              | 94  |
| <input checked="" type="checkbox"/> | 60 Conservation Strategies.....                        | 97  |
| <input type="checkbox"/>            | 61 Did You Get It?.....                                | 100 |
| <input type="checkbox"/>            | 62 Summary Assessment.....                             | 101 |

### Theme B: Form and Function

#### Chapter 5: B1-Molecules

|                                     |   |     |
|-------------------------------------|---|-----|
|                                     | Learning Outcomes.....                          | 104 |
| <input checked="" type="checkbox"/> | 63 Carbon Chemistry.....                        | 105 |
| <input type="checkbox"/>            | 64 Carbohydrate Chemistry.....                  | 106 |
| <input type="checkbox"/>            | 65 Co.....                                      | 107 |
| <input type="checkbox"/>            | 66 Po.....                                      | 108 |
| <input type="checkbox"/>            | 67 Fu.....                                      | 109 |
| <input type="checkbox"/>            | 68 Lip.....                                     | 110 |
| <input type="checkbox"/>            | 69 Ph.....                                      | 112 |
| <input type="checkbox"/>            | 70 Cr.....                                      | 113 |
| <input type="checkbox"/>            | 71 Am.....                                      | 114 |
| <input type="checkbox"/>            | 72 Amino Acids and Proteins.....                | 115 |
| <input type="checkbox"/>            | 73 R-Groups.....                                | 116 |
| <input checked="" type="checkbox"/> | 74 Protein Structure.....                       | 117 |
| <input type="checkbox"/>            | 75 Comparing Globular and Fibrous Proteins..... | 119 |
| <input type="checkbox"/>            | 76 Did You Get It?.....                         | 121 |

The orange text indicates that an activity addresses Additional Higher Learning content.

#### Chapter 6: B2-Cells

|                                     |  |     |
|-------------------------------------|--|-----|
|                                     | Learning Outcomes.....                               | 122 |
| <input type="checkbox"/>            | 77 The Plasma Membrane.....                          | 124 |
| <input type="checkbox"/>            | 78 Proteins of the Plasma Membrane.....              | 126 |
| <input type="checkbox"/>            | 79 Movement Across the Plasma Membrane.....          | 128 |
| <input type="checkbox"/>            | 80 Active Transport and Pump Proteins.....           | 131 |
| <input type="checkbox"/>            | 81 Membrane Fluidity.....                            | 132 |
| <input type="checkbox"/>            | 82 Cytosis and Membrane Fluidity.....                | 133 |
| <input type="checkbox"/>            | 83 Gated Ion Channels.....                           | 134 |
| <input type="checkbox"/>            | 84 Exchange Transporters and Cotransporters.....     | 135 |
| <input type="checkbox"/>            | 85 Cell-Adhesion Molecules and Junctions.....        | 136 |
| <input type="checkbox"/>            | 86 Compartmentalization in Cells.....                | 137 |
| <input type="checkbox"/>            | 87 Techniques in Cellular Visualization.....         | 139 |
| <input type="checkbox"/>            | 88 Adaptations in Mitochondria and Chloroplasts..... | 140 |
| <input type="checkbox"/>            | 89 The Nucleus and Endoplasmic Reticulum.....        | 142 |
| <input type="checkbox"/>            | 90 Membranes and the Production of Proteins.....     | 143 |
| <input type="checkbox"/>            | 91 Stem Cells and Cell Specialization.....           | 144 |
| <input checked="" type="checkbox"/> | 92 Comparing Human Cell Sizes.....                   | 146 |
| <input checked="" type="checkbox"/> | 93 Constraints to Cell Size.....                     | 147 |
| <input checked="" type="checkbox"/> | 94 Investigating the Effect of Cell Size.....        | 149 |

**CODING** Activity is marked:  to be done  when completed

■ AHL content   
 ● AOS   
 ● NOS

A legend at the bottom of the page provides an explanation of the colour coding.

# Chapter Introductions

The chapter introductions are a quick reference guide to help navigate the content. They provide access to the BIOZONE Resource Hub via a QR code and can be used by students to plan their workflow. Concise learning outcomes list the knowledge and skills students will need to master as they work through the IB Biology syllabus. Colour coding allows for quick identification of AHL, NOS, and AOS material. Key features of the chapter introductions are explained below.

Encourage your students to use the chapter introductions as a planning tool to set their workflow. Students can identify the activities they are to complete and then tick them off when completed. The teacher can also see at a glance how quickly the student is progressing through the assigned material.

**Chapter Title**  
Identifies the chapter number, theme, and level of organization.

**Numbered Understandings**  
Learning outcome statements indicate what is required to effectively cover each content statement in the chapter.

Use the check boxes to identify activities to be done (•) and tick them off (✓) when you have completed the learning outcome.

Application of Science (AOS) content is identified with green text.

Nature of Science (NOS) content is identified with a red text tag.

**BIOZONE Resource Hub**  
A quick link to the BIOZONE Resource Hub using QR code or bit.ly URL

**Guiding Questions**  
These help to identify important areas of study within this chapter.

The activity in the book related to this learning outcome.

Learning statements on a white background denote standard level content and it should be assigned to both SL and HL students.

An orange AHL tag and a yellow shaded box identify Advanced Higher Learning content statements. This material should only be assigned to students doing the higher level course.

**Chapter 1** Unity and Diversity

## Molecules

**A1.1 Water** Activity Number

**Guiding Questions:**

- ▶ What properties of water make it essential for life?
- ▶ What are the advantages and disadvantages of water as a habitat?

**Learning Outcomes:**

|                            |   |   |
|----------------------------|---|---|
| <input type="checkbox"/> 1 | Explain the significance of water as a medium for cellular processes, and as a requirement for the origin of cells.   | 1 |
| <input type="checkbox"/> 2 | Draw and correctly annotate a model water molecule, showing hydrogen bonding.   | 1 |
| <input type="checkbox"/> 3 | Link water's cohesive properties to important biological processes including transport in the xylem, and surface tension that allows movement of organisms on its surface.                        | 1 |
| <input type="checkbox"/> 4 | Link water's adhesive properties to its significance for organisms, including soil and plant cell wall capillary action.  | 1 |
| <input type="checkbox"/> 5 | Explain how the solvent properties of water allow it to function as a medium for plant and animal metabolism and transport in plants and animals, for both hydrophilic and hydrophobic molecules. | 1 |
| <input type="checkbox"/> 6 | Compare and contrast the physical properties of water and air and how they impact animals in aquatic habitats.  | 1 |
| <input type="checkbox"/> 7 | <b>AHL:</b> Evaluate the extraterrestrial asteroid hypothesis for the origin and retention of water on Earth.   | 2 |
| <input type="checkbox"/> 8 | <b>AHL:</b> Explain the relationship between water on 'Goldilocks zone' planets and the possibility of finding extraterrestrial life.   | 2 |

**A1.2 Nucleic acids** Activity Number

**Guiding Questions:**

- ▶ How does nucleic acid structure enable hereditary information to be stored?
- ▶ How does the structure of DNA enable accurate replication?

**Learning Outcomes:**

|                             |   |      |
|-----------------------------|---|------|
| <input type="checkbox"/> 1  | Identify DNA as the universal genetic material found in all living organisms.   | 3    |
| <input type="checkbox"/> 2  | Draw a diagram of a nucleotide, identifying and annotating the components.  | 3, 8 |
| <input type="checkbox"/> 3  | Link the properties of the sugar-phosphate bond to its role as the backbone of DNA and RNA.   | 3, 5 |
| <input type="checkbox"/> 4  | Recall nitrogenous base names in both DNA and RNA.  | 3    |
| <input type="checkbox"/> 5  | Draw diagrams of single nucleotide monomers and RNA polymers, representing the condensation reaction in the polymer formation.  | 3    |
| <input type="checkbox"/> 6  | Name the shape of DNA as a double helix. Draw a diagram of DNA antiparallel 3' and 5' strands, demonstrating base pairing.  | 3, 8 |
| <input type="checkbox"/> 7  | Construct models to compare and contrast the components of DNA and RNA.   | 3, 5 |
| <input type="checkbox"/> 8  | Explain how complementary base pairing enables DNA to function as genetic material. Explain the role of hydrogen bonds connecting base pairs, and therefore strands, together.  | 3    |
| <input type="checkbox"/> 9  | Link the structure of DNA to its ability to economically store huge quantities of information with almost limitless sequence combinations.  | 3    |
| <input type="checkbox"/> 10 | Explain how the universality of genetic code in DNA of all living organisms is evidence of common ancestry.   | 3    |
| <input type="checkbox"/> 11 | <b>AHL:</b> Connect DNA and RNA 5' to 3' linkage directionality to the processes of replication, transcription, and translation.  | 4    |
| <input type="checkbox"/> 12 | <b>AHL:</b> Explain the purpose of purine-to-pyrimidine bonding in enabling DNA helix stability.  | 4    |
| <input type="checkbox"/> 13 | <b>AHL:</b> Identify histone proteins as the molecule forming the core of a nucleosome.<br><b>AOS:</b> Use digital molecular visualization to investigate the structure of a nucleosome.  | 6    |
| <input type="checkbox"/> 14 | <b>AHL:</b> Provide evidence from the Hershey Chase experiment to support the conclusion that DNA is the genetic material.<br><b>NOS:</b> Explain how technological developments, such as use of radioisotopes, enabled Hershey and Chase to carry out their innovative investigation into DNA. | 7    |
| <input type="checkbox"/> 15 | <b>NOS:</b> Investigate Chargaff's pyrimidine and purine data and explain how their ratios addressed the 'problem of induction' and falsified the tetranucleotide hypothesis.   | 7    |

# Features of the Activity Pages

The activity pages have been carefully designed to provide high quality information to students in an easily accessible format. They include a number of features designed to engage students and help them unpack and understand the information. Guide students through the features of the activity pages to ensure that they make the most of each activity.

Features include:

- ▶ Short blocks of text so that students do not feel overwhelmed with too much reading.
- ▶ High quality, informative graphics.
- ▶ QR codes link directly to 3D models (following page). These provide fun engagement and learning moments.
- ▶ Question and answer sections allow students to demonstrate their understanding of the content. By having the stimulus material and their answers in one place, students can easily revise for assessments.
- ▶ The tab system identifies when there is support material on the **Resource Hub**. Tabs also identify the applicable syllabus components (see following page).

The **activity number**. This orange activity tab indicates an AHL only activity. A blue activity tab identifies standard level content.

An **introductory paragraph** provides background or introductory information to the topic.

A **Key Idea** provides a focus for the activity.

274


## Genetic Technology

**Key Idea:** CRISPR is a complex made up of Cas9 enzymes and RNA. The CRISPR complex cuts DNA at very specific sequences and can be used to edit genes. CRISPR-Cas9 (shortened to CRISPR and pronounced crisper) is an endonuclease complex occurring naturally in bacteria which use it to edit the DNA of invading viruses. CRISPR is able to target specific stretches of DNA and edit it at very precise locations. Two key components are required for CRISPR to work: an RNA guide that locates and binds to the target piece of DNA and the Cas9 endonuclease that unwinds and cuts the DNA. The technology has potential applications in correcting mutations responsible for disease, switching faulty genes off, adding new genes to an organism, or studying the effect of specific genes. It represents a major advance because it allows more precise and efficient gene editing at much lower cost than ever before.

**How does CRISPR-Cas9 work?**  
CRISPR-CAS9 was adapted from a bacterial defence mechanism against viruses. It is an enzyme used to guide RNA to cut target DNA sequence.

**can CRISPR-Cas9 be used for?**  
**Resistance:** immunity against turnip mosaic, tobacco etch virus, gemini virus, potyvirus.  
**Disease resistance:** transgenic plants resistant to rice blast, mildew, rice blast.  
**Production enhancement:** improving crop yield, nutritional value, concentration.  
**Herbicide and chemical resistance:** against herbicide, insecticides, post-harvesting processes.  
**Producing bioactive compounds:** impacting flavonoids, hormones.  
**Research:** create cell and animal models, screening studies for drug discovery, manufacturing stem cells.  
**Medical:** cell and gene therapy, diagnostic tool (as used for Covid-19).  
**Biofuels:** engineering algae to produce lipids.

**Gene knockout - 'gene silencing'**  
Frame-shift mutations can change the way the nucleotide sequence is read, either disabling gene function or producing a STOP signal. This technique can be used to silence a faulty gene. An existing gene may be deleted or deactivated (switched off) to prevent the expression of a trait, e.g. the deactivation of the ripening gene in tomatoes produced by the Flavr-Savr tomato.  
Humans can not be used in knockout research for ethical reasons, so animal models such as mice are used. Many hundreds of strains of mice with different knockout genes are available in a living 'library' for genetic studies. The animal models can be genetically manipulated to more accurately represent a disease.



Manipulating gene action is one way to control processes such as ripening in fruit so that it stays fresher for longer.

**Diagrams:** Full color diagrams and photos help students visualize important information or concepts.

**QR codes** provide a quick link to engaging, interactive 3D models.

**Activity based questions:** Students input their answers directly onto the page (print and digital products) to help reinforce the learning moment. This approach also makes revision easy because the stimulus material and answers are in one place.

The tabs provide information about the content in the activity and if support material is available on the BIOZONE Resource Hub.

©2024 BIOZONE International  
ISBN: 978-1-99-10-10-1-0  
Photocopying prohibited

D1.3

8 - 9

NOS

AHL

©2024 BIOZONE International

## The QR codes link directly to 3D models

426

### Peptide bonding

As amino acids are delivered to the large subunit of the ribosome by tRNA, the two closest molecules undergo a hydrolysis reaction to remove a water molecule and form a peptide bond. This process continues and the peptide chain grows as more amino acids are linked.

$H_2O$  removed to bond amine group ( $NH_2$ ) to carboxyl group ( $COOH$ ) forming a peptide bond between amino acids.

Protein synthesis begins when the ribosome reads the start codon (AUG).

Protein synthesis stops when a stop codon is reached (UGA, UAA, or UAG). The ribosome falls off the mRNA and the polypeptide is released.

### Mutations and protein structure

Mutations can occur in the DNA that affect polypeptide chain synthesis. A single base change is known as a point mutation and is the substitution of a single nucleotide, e.g. A to G, or deletion/insertion of a base. Deletion or addition mutations involve a frame shift of codon reading, and every codon will therefore be different in the remainder of the chain. Redundancy of genetic code allows for some substitution mutations to still code for the same amino acid. However, some substitutions cause an amino acid change which can lead to significant changes in the final protein form, and therefore its function. Sickle cell anemia is an example of one base substitution mutation leading to significant overall changes in the protein structure.

4. List the sequence of events that occurs in the ribosomes from tRNA arrival to polypeptide chain formation:

5. Using a researched example other than sickle cells, discuss why a point mutation may cause a change in protein structure and function.

© 2024 BIOZONE International  
ISBN: 978-1-99-101410-8  
Photocopying prohibited

Some activities have QR codes on the pages (circled, left). These link directly to informative and engaging 3D models. All models can be rotated and zoomed, and some contain informative annotations.

If your school does not allow students to access phones in class time, students can still access the 3D models through the Resource Hub and via BIOZONE WORLD.



## Understanding the Tab System

A tab system is found at the bottom of the first page of each activity, providing information about the content. Use the tabs to identify the theme and content statement components of the activity, whether it is an AHL activity, and if Nature of Science (NOS) and Application of Skills (AOS) content is embedded. Blue connection tabs identify if there are connections to other activities, and the grey tabs indicate whether support material is provided on BIOZONE's **Resource Hub**. The tab system is explained below.

The **grey hub tab** indicates that the activity has online support via BIOZONE's **Resource Hub**. This may include videos, animations, articles, 3D models, and interactives.

The **orange AHL** tab indicates that the activity addresses Additional Higher Learning content. This activity will also have an orange activity tab at the top of the first page.

The **black top** of the tab indicates the theme and understanding that the activity addresses. The lower, **coloured section** reflects the theme and the numerical identification of one or more content statements covered in the activity.

The **red NOS** tab indicates that a Nature of Science theme is covered in the activity.

The **green AOS** tab indicates that Application of Skills content is covered in the activity.

**Concept connection** tabs point you forward or back to activities with related concepts.

# Supporting the Experimental Programme

The IB syllabus includes an experimental programme comprising three components: practical work, a collaborative science project, and an independent scientific investigation. This comprehensive experimental programme encourages the development of skills and attributes essential to a successful IB learner. Through the varied experimental programme, learners develop scientific skills, demonstrate safe and competent practices, demonstrate analysis and problem solving skills, work collaboratively, and communicate ideas and outcomes effectively. Support for the experimental programme is embedded within *IB Biology* and is explained below and on the following pages.

## Collaborative sciences project

The collaborative sciences project is an interdisciplinary project requiring students to work collaboratively to develop a solution-focussed result in response to a complex issue. The ability to work on a real world problem brings relevance to the project, and provides opportunities to address problems at a local, national, or global level. The interdisciplinary nature of the project allows students to apply their skills and ideas from a range of disciplines to find a solution. Exposure to other ways of thinking and working enriches all students and encourages open mindedness and communication to achieve the desired outcome.

Throughout *IB Biology*, students are presented with a range of tasks, questions, and activities that support the development of the skills required for success in the collaborative sciences project. These include:

- ▶ Real world case studies and data sets requiring students to analyse problems and find solutions provide excellent practise for the analysis and problem solving goals required in the collaborative sciences project. For example, carbon sequestration techniques to lower atmospheric CO<sub>2</sub> levels.
- ▶ Providing case studies and examples from around the world encourages students to have a global perspective and allows them to see that issues can traverse local, regional, and global boundaries. For example, international conservation strategies, or the international response to the Covid-19 pandemic.
- ▶ All learners have opportunities to apply existing knowledge to new or more complex situations. This skill is well utilized in the collaborative project where learners must extend their knowledge base and skills to novel situations.
- ▶ Encouraging students to become involved in citizen science projects, e.g. local biodiversity projects, promotes awareness that science is all around and that individual contributions contribute to larger data sets and wider projects.
- ▶ Inclusion of research questions hones research skills, e.g. research the effect of the increasing human population on biodiversity. Students can practise analysing the credibility of information sources, evaluating information for bias and accuracy, and summarizing their findings.
- ▶ Collaborative work (investigations and research tasks) encourages the development and refinement of communication skills, highlights the need to appreciate the insight and needs of others, and provides opportunities to resolve conflict (should any arise).
- ▶ Information and case studies requiring students to evaluate and defend social and ethical implications of science and technology, or debate an issue, require students to consider and reflect on the perspectives of others while broadening their own understanding. For example, debating the pros and cons of using CRISPR technology to genetically engineer genes in humans.



# Practical Investigations

Throughout *IB Biology*, students are given opportunities to explore through investigations. These are opportunities for students to develop competency in laboratory procedures, practice and refine skills in observation and analysis, manipulate data, and analyse findings. Investigations can take several forms including paper practicals, modelling activities, and wet lab experiments. The practical investigations provide students with experience and skills needed to carry out the experimental investigation required for Assessment Objective AO4.

The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities for these tasks. Confident students can guide and encourage less able students and by working together students can share their own observations and ideas. Collaboration through paired practical work provides an excellent opportunity for students to consolidate their scientific vocabulary, communication, and social skills. English language learners can interact in meaningful ways to practise and extend their English language skills.

Each investigation is clearly numbered sequentially through the chapter.

Where applicable, the investigations provide students with health and safety information at the start of the investigation.

Ensure the students read through the procedure fully before beginning the investigation.

Highlight any hazardous steps or important steps where extra care may be required.

Ensure students have all the equipment assembled and know if there are pinch points in the process. If necessary, have the groups allocate specific people to steps, e.g. timing, collecting samples, recording data or observations etc.

**355 Modelling Ecosystems**

Key idea: mesocosms, which are small-scale ecosystems, can be used to investigate stability in a closed system. Aspects of ecosystem function, including responses to changes in inputs and long-term stability, can be investigated using physical representations of ecosystems called mesocosms. Some mesocosm studies allow a natural community to be studied in situ (in place), but still allow the researcher to control the environmental conditions. Others are carried out at research facilities in specially designed containers. Mesocosms can be open or sealed (enclosed) systems. Sealed mesocosms allow the researcher to fully control the experimental conditions, including the entry and exit of matter. Mesocosms, especially small ones, are generally not stable in the long term, and change over time as a result of their smaller scale and isolated nature. A simple mesocosm model can be developed in the school laboratory.

**Investigation 16.2** A mesocosm model of an ecosystem

See appendix for equipment list.

**Warning:** Living organisms should be handled with care and respect. See IB experimental guidelines.

1. In this investigation, you will make a simple ecobottle to model stability in a small closed ecosystem. Your group will be provided with the following equipment: A large, clear soda bottle with a lid; Filtered pond water; aquarium gravel; a source of detritus, e.g. dead leaves; aquatic plants (such as *Elodea*).

2. Make a simple ecobottle to model stability in a small closed ecosystem. Your group will be provided with the following equipment: A large, clear soda bottle with a lid; Filtered pond water; aquarium gravel; a source of detritus, e.g. dead leaves; aquatic plants (such as *Elodea*).

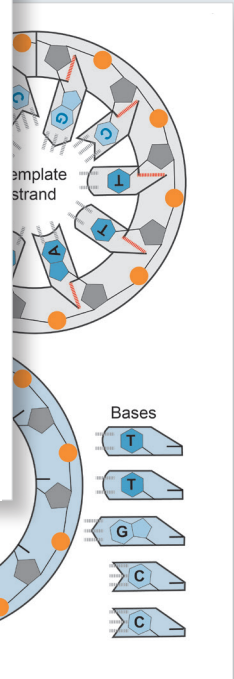
3. Return any living organisms back to the aquarium and dispose of any waste materials.

4. What variable did you change in your bottle ecosystems? Write a hypothesis for how the change will affect the stability of your ecosystem: Did your observations allow you to see any differences between your two bottle ecosystems, and if so did they support your hypothesis?

5. Return any living organisms back to the aquarium and dispose of any waste materials.

6. What variable did you change in your bottle ecosystems? Write a hypothesis for how the change will affect the stability of your ecosystem: Did your observations allow you to see any differences between your two bottle ecosystems, and if so did they support your hypothesis?

7. Were your systems stable? Explain why (or why not):



**Appendix: Equipment List**

**2: Unity and diversity: Cells**

**INVESTIGATION 2.1** Modelling protein structure

Per group:

- Light microscope
- Ornithionin leaf
- Glass microscope slides
- Coverlips
- Scalpel or razor
- Soak salt
- Filter paper/tissue paper

**3: Unity and diversity: Organisms**

**INVESTIGATION 3.1** Develop a dichotomous key

Per student:

- Leaves of various local plants or photos of local animals.

**7: Form and function: Organisms**

**INVESTIGATION 7.1** Measuring lung volumes

Per student:

- Balloon
- Large measuring container

**INVESTIGATION 7.2** Comparing stomatal density

Per group:

- Light microscope
- Dicot plants (e.g. buttercup, buffberry)
- Monocot plant (e.g. maize or corn)
- Glass microscope slides
- Coverlips
- Scalpel or razor
- Access to a computer or device with internet connection

**INVESTIGATION 7.3** Investigating effect of exercise on heart rate

Per group:

- Stopwatch

**INVESTIGATION 7.4** Investigating vascular tissue

Per group:

- Light microscope
- Dicot plants (e.g. buttercup, buffberry)
- Monocot plant (e.g. maize or corn)
- Glass microscope slides
- Coverlips
- Scalpel or razor
- Access to a computer or device with internet connection

**INVESTIGATION 7.5** Investigating motion in a shoulder joint

Per group:

- Goniometer or a similar device to measure angles.

**8: Form and function: Ecosystems**

**INVESTIGATION 8.1** Correlating abiotic factors and population distribution

Per student:

- Quadrats
- Tape measure
- Devices for measuring abiotic factors (e.g. thermometer, lux meter, anemometer)

**9: Interaction and interdependence: Molecules**

**INVESTIGATION 9.1** Investigating peroxidase activity

Per group:

- 13 x boiling tubes
- 42 mL distilled water
- 18 mL 0.1%  $H_2O_2$  solution
- 1.2 mL prepared guaiacol solution
- Paraffin oil
- 6 mL of each pH buffered solution (pH 3, 5, 6, 7, 8, 10)
- 18 mL 10% peroxidase solution
- Text tube rack
- Timer

**INVESTIGATION 9.2** Measuring respiration in germinating seeds

Per group:

- 3 x boiling tubes
- Meiser pen
- 8 x cotton balls
- 10% KOH solution
- 2 x eye dropper or plastic pipette
- 3 x glucose pieces
- Germinated bean seeds (enough to fill one quarter of the boiling tube)
- Ungerminated bean seeds (enough to fill one quarter of the boiling tube)
- Glass beads (enough to fill one quarter of the boiling tube)
- 3 x 2-hole stoppers
- 3 x bent glass tubes or pipettes
- 3 x tubes (must be able to be clamped shut)
- 3 x 4cm clips
- A few drops of colored liquid
- 3 x syringes (must fit tube with screw clamp attached)
- 3 x clamp stands or rack
- Water bath (25°C)
- Baler
- Timer

**INVESTIGATION 9.3** Investigating yeast fermentation

Per group:

- 1 x 100 mL beaker
- 10 g of active yeast
- 50 mL tap water at 24°C
- 20 g substrate (glucose, maltose, sucrose, or lactose)
- 1 x glass stirring rod
- 1 x conical flask (to hold 275 mL)
- Paraffin oil
- Single hole stopper
- Tubing
- 1 x 100 mL measuring cylinder
- 1 x small basin to hold inverted cylinder
- Stopwatch

**INVESTIGATION 9.4** Separating photosynthetic pigments

Per group:

- Leaves of silverbeet or spinach
- Hotstick
- Boiling tube or test tube
- Filter paper or chromatography paper
- Pen
- Ethanol
- Clingwrap or paraffin
- Mortar and pestle
- Sand
- Scissors

**INVESTIGATION 9.5** Investigating the effect of light intensity on photosynthetic rate

Per group:

- 10 g *Columba aquatica*
- Balance
- Water
- 1 x large beaker (large enough to hold the glass funnel)
- 1 x glass funnel
- 1.2 mol/L sodium hydrogen carbonate solution (enough to cover the plant)
- 1 x test tube
- 1 x lamp with a 60W bulb
- Lux meter
- Timer
- 1 x ruler or tape measure

No kits are required for the investigations.

The investigations have been designed using everyday materials and equipment found in most high school laboratories.

A list of the equipment and reagents required for each investigation is provided in the back of the worktext.



# Support for the Scientific Investigation

The IB syllabus requires students to demonstrate the application of skills necessary to carry out insightful and ethical investigations (Assessment Objective AO4). In this assessment, students carry out a scientific investigation to answer a research question of their own. To help students prepare for this assessment, we have included a dedicated chapter (Scientific Investigation) to provide guidance on how to plan, carry out, and report on the scientific investigation. Use this information, along with your own resources, to help students succeed in this assessment task.

In addition, the practical investigations provided in the *IB Biology* worktext give students experience in planning, setting up, and running a scientific investigation. There are also opportunities to collate, present, and analyse data before communicating the findings. While carrying out the investigations, students develop many of the skills required to be successful in their own investigation. These include:

- ▶ Observation.
- ▶ Critical analysis and problem solving.
- ▶ Mathematics and numeracy practise.
- ▶ Data collection and analysis.
- ▶ Maintaining accurate records.
- ▶ Opportunities to work independently or collaboratively.
- ▶ Communication and reporting.

## 373 Planning Scientific Investigation

**Key Idea** Four components of a scientific investigation are research design, data analysis, drawing a conclusion and evaluating the experiment.

**Planning your scientific investigation**

- Once you have decided on a research question or hypothesis for investigation you need to decide what data is needed to support your investigation. You may need to consider the following:
  - Relevant evidence to test a hypothesis is central to a scientific investigation. For a practical investigation, you need to ensure that the method used to gather and analyse data is:
    - a. ethically acceptable
    - b. ethically sound
    - c. ethically safe
    - d. ethically sound
    - e. ethically safe

**Identifying variables**

An independent variable is a variable or attribute that is varied or changed in an experiment. Investigations often look at the effect of changing one variable on another. The independent variable is the variable that is being changed or manipulated. The dependent variable is the variable that is being measured or observed. The dependent variable is the variable that is being measured or observed. The dependent variable is the variable that is being measured or observed.

**Controlled variables**

- Factors that are held the same throughout the experiment.
- Used to ensure that any change in the dependent variable is due to the independent variable.

**Dependent variable**

- Measured during the investigation.
- Recorded on the y-axis of the graph.

**Independent variable**

- Set by the experimenter.
- Recorded on the x-axis of the graph.

**Controlled variables**

- Factors that are held the same throughout the experiment.
- Used to ensure that any change in the dependent variable is due to the independent variable.

**Experimental controls**

An experimental control is a variable or attribute that is held constant in an experiment. It is used to ensure that any change in the dependent variable is due to the independent variable.

**How good was the investigation design? Was it a test?**

The experimenter plans the effect of a certain factor on biological growth. All the agar plates are prepared in the same way, but the control plate does not have the nutrient applied.

Each plate is inoculated from the same stock. The inoculation is done under the same conditions, and each plate is incubated in the same place. The control plate has the same nutrient as the other plates.

The control plate is attributed to the nutrient.

## Method, data collection, and results

**Your report should include:**

1. Introduction: Introduce your investigation. This may include background information, your aim and your hypothesis.
2. Methods: Describe how you carried out your study including any equipment you used.
3. Results or presentation: Present your data in an appropriate format along with an explanation of it.
4. Conclusions and evaluation: Write a clear conclusion based on the results of the investigation. Identify limitations to the method and suggest improvements based on how the investigation proceeded.
5. Acknowledgements/References: Include a section listing your sources of information. This helps validate your arguments.

**Methods**

The methods section of a report should include enough detail to enable the study to be repeated. It should include the following:
 

- 1. A list of materials and equipment used.
- 2. A list of the steps followed.
- 3. A list of the safety precautions taken.
- 4. A list of the ethical considerations.
- 5. A list of the ethical considerations.

**Study site & organisms**

Study site & organisms:
 

- Why that site was chosen.
- Species involved.

**Specialised equipment**

Specialised equipment:
 

- pip and eugen meters.
- Thermometer.
- Nets and traps.

**Data collection**

Data collection:
 

- Aim and timing of observations/measurements.
- Time of day or year.
- Sample size and size of the sampling unit.
- Language of the sampling unit.
- Method of sample preservation or storage.
- Method of counting.
- Method of sampling.
- Method of recording.

**Results**

The results section is arguably the most important part of any research report. It is the place where you can bring together your data and carefully consider the appropriate analysis. A portion of the results section from a scientific paper on the topic of photosynthesis is shown below. The results section should describe the results clearly and show that the data are statistically significant. Use a table to present information clearly, even if your results are relatively lengthy. Use a table to present information clearly, even if your results are relatively lengthy.

**Table 1** Characteristics of sites with and without rainfall

| Site    | Mean CI   | Mean CI   | Mean CI    | Mean CI    |
|---------|-----------|-----------|------------|------------|
| Site 1  | 2.1 ± 0.1 | 2.2 ± 0.2 | 2.4 ± 0.05 | 2.6 ± 0.05 |
| Site 2  | 2.0 ± 0.1 | 2.1 ± 0.1 | 2.2 ± 0.1  | 2.3 ± 0.1  |
| Site 3  | 1.9 ± 0.1 | 2.0 ± 0.1 | 2.1 ± 0.1  | 2.2 ± 0.1  |
| Site 4  | 1.8 ± 0.1 | 1.9 ± 0.1 | 2.0 ± 0.1  | 2.1 ± 0.1  |
| Site 5  | 1.7 ± 0.1 | 1.8 ± 0.1 | 1.9 ± 0.1  | 2.0 ± 0.1  |
| Site 6  | 1.6 ± 0.1 | 1.7 ± 0.1 | 1.8 ± 0.1  | 1.9 ± 0.1  |
| Site 7  | 1.5 ± 0.1 | 1.6 ± 0.1 | 1.7 ± 0.1  | 1.8 ± 0.1  |
| Site 8  | 1.4 ± 0.1 | 1.5 ± 0.1 | 1.6 ± 0.1  | 1.7 ± 0.1  |
| Site 9  | 1.3 ± 0.1 | 1.4 ± 0.1 | 1.5 ± 0.1  | 1.6 ± 0.1  |
| Site 10 | 1.2 ± 0.1 | 1.3 ± 0.1 | 1.4 ± 0.1  | 1.5 ± 0.1  |

**Figure 2** Catch rates in shaded area

**Table 2** Mean CI and standard deviation (SD) for each site

| Site    | Mean CI | SD  |
|---------|---------|-----|
| Site 1  | 2.1     | 0.1 |
| Site 2  | 2.0     | 0.1 |
| Site 3  | 1.9     | 0.1 |
| Site 4  | 1.8     | 0.1 |
| Site 5  | 1.7     | 0.1 |
| Site 6  | 1.6     | 0.1 |
| Site 7  | 1.5     | 0.1 |
| Site 8  | 1.4     | 0.1 |
| Site 9  | 1.3     | 0.1 |
| Site 10 | 1.2     | 0.1 |

**Table 3** Mean CI and standard deviation (SD) for each site

| Site    | Mean CI | SD  |
|---------|---------|-----|
| Site 1  | 2.1     | 0.1 |
| Site 2  | 2.0     | 0.1 |
| Site 3  | 1.9     | 0.1 |
| Site 4  | 1.8     | 0.1 |
| Site 5  | 1.7     | 0.1 |
| Site 6  | 1.6     | 0.1 |
| Site 7  | 1.5     | 0.1 |
| Site 8  | 1.4     | 0.1 |
| Site 9  | 1.3     | 0.1 |
| Site 10 | 1.2     | 0.1 |

**Table 4** Mean CI and standard deviation (SD) for each site

| Site    | Mean CI | SD  |
|---------|---------|-----|
| Site 1  | 2.1     | 0.1 |
| Site 2  | 2.0     | 0.1 |
| Site 3  | 1.9     | 0.1 |
| Site 4  | 1.8     | 0.1 |
| Site 5  | 1.7     | 0.1 |
| Site 6  | 1.6     | 0.1 |
| Site 7  | 1.5     | 0.1 |
| Site 8  | 1.4     | 0.1 |
| Site 9  | 1.3     | 0.1 |
| Site 10 | 1.2     | 0.1 |

## Reviewing and presenting data

**Review your initial data**

1. Check your data to see if it makes sense. Do the results make sense? Do they answer your question? Do you need to do anything else to improve your data? Do you need to do anything else to improve your data?
2. You may discover that you need to collect your data differently from the first time you did. Do you need to do anything else to improve your data? Do you need to do anything else to improve your data?
3. You may discover that you need to collect your data differently from the first time you did. Do you need to do anything else to improve your data? Do you need to do anything else to improve your data?
4. You may discover that you need to collect your data differently from the first time you did. Do you need to do anything else to improve your data? Do you need to do anything else to improve your data?

**How do I analyse my data?**

Check your data to see if it makes sense. Do the results make sense? Do they answer your question? Do you need to do anything else to improve your data? Do you need to do anything else to improve your data?

**Presenting data in graphs**

Graphs are a good way to show trends, patterns, and relationships visually without having to list too much data. Complete data sets tend to be presented as graphs rather than tables, although the raw data can sometimes be included as an appendix.

**Guidelines for bar charts**

- 1. The y-axis is the dependent variable and the x-axis is the independent variable.
- 2. The bars are separated by equal gaps.
- 3. The bars are labeled with the category names.
- 4. The bars are labeled with the category names.

**Guidelines for line graphs**

- 1. The y-axis is the dependent variable and the x-axis is the independent variable.
- 2. The line is labeled with the dependent variable.
- 3. The line is labeled with the dependent variable.

**Guidelines for scatter graphs**

- 1. The y-axis is the dependent variable and the x-axis is the independent variable.
- 2. The points are labeled with the category names.
- 3. The points are labeled with the category names.

## Summarizing findings and references

**Conclusions and evaluation**

In this section of your report, you must interpret your results in the context of the specific questions/hypothesis you set out to answer and test the investigation. You should also place your conclusions in the context of your broader, relevant issues. If your results contradict what you expected, then your conclusions and evaluation will be based on the results of the investigation. You should discuss your findings and evaluate any problems with your study design.

**Support your conclusions**

Support your conclusions with evidence from your investigation. This evidence should be presented in a clear and concise manner. This evidence should be presented in a clear and concise manner.

**References**

Proper referencing of sources of information is an important aspect of report writing. It shows that you have explored the topic, and it allows others to find the sources you used. It also shows that you have done your research and that you are confident in your findings. It also shows that you have done your research and that you are confident in your findings.

**Example of a reference list**

Lee, M. (2019). *The science of the future*. London: Penguin.

Cooper, G.M. (1997). *The cell: a molecular approach* (2nd ed.). Washington D.C.: ASM Press.

Davis, P. (1986). *Cellular function*. New Scientist 2037. Inside science supplement.

Hodge, B. (2001). *Chemical digestion and absorption*. *Biological Sciences Review*, 7(2), 1-10.

Hodge, B. (2001). *Experimental. Biological Sciences Review*, 14(2), 11-13.

King, A. (2000). *Biological Sciences Review*. New Scientist, 242: Inside science supplement.

Internet sites change often so the URL is not included in the reference list. However, the URL is included in the reference list.

# Evaluating Student Performance

*IB Biology* provides assessment tasks which you can use to test student understanding of the IB syllabus. Opportunities for formative and summative assessment are provided in the form of chapter assessments and theme assessments (see below and next page).

While most activities require students to record a response, we do not recommend that every question is graded. In most instances, student answers form an individual record of work, allowing students to review their answer within the context of the activity at any time. We recommend teachers are selective about activities, or questions they choose to review or grade to avoid assessment fatigue. We highly recommend that chapter and theme assessments are graded.

## Chapter assessments

Chapters 1-16 each conclude with a *Did you Get It?* assessment task. These have been designed to test student understanding of the chapter content, and can be used to help identify any gaps or misconceptions which still need to be addressed before moving on. AHL questions are clearly identified for easy differentiation of question setting. Students undertaking the standard level course should complete the questions *without the AHL tag*. Students undertaking the higher level course should answer all questions.

**76 Did You Get It?** 121

1. The structure on the right represents a phospholipid bilayer.

(a) What does label A represent? \_\_\_\_\_

(b) What does label B represent? \_\_\_\_\_

(c) Explain how the properties of the phospholipid molecule result in the bilayer structure of membranes:

\_\_\_\_\_

\_\_\_\_\_

2. The organic molecule on the right is haemoglobin.

(a) What class of organic molecules does it belong to? Explain how you decided.

(b) What factors could cause this molecule to lose its shape?

(c) What would a loss of shape do to the functionality of this molecule?

(d) **AHL:** Which order of structure does the haemoglobin molecule represent?

3. (a) What general reaction combines two molecules to form a larger molecule?

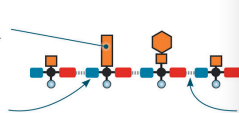
(b) What general reaction cleaves a larger molecule by the addition of water?

(c) Describe what happens to water in each of the reactions described above

4. In the polypeptide chain below identify (a), (b), and (c):

(a) \_\_\_\_\_

(b) \_\_\_\_\_



5. **AHL:** Is the protein shown on the right a conjugated or non-conjugated protein? Explain your answer:

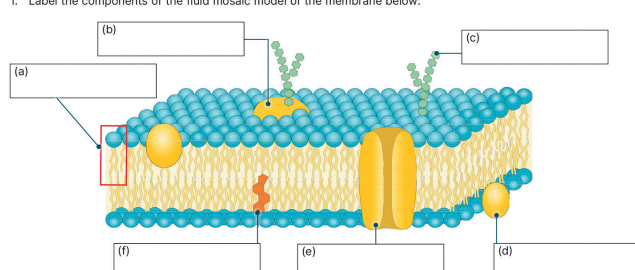
\_\_\_\_\_

\_\_\_\_\_

©2024 BIOZONE International  
ISBN: 978-1-99-101410-8  
Photocopying prohibited

**97 Did You Get It?** 155

1. Label the components of the fluid mosaic model of the membrane below:



(a) \_\_\_\_\_ (b) \_\_\_\_\_ (c) \_\_\_\_\_

(d) \_\_\_\_\_ (e) \_\_\_\_\_ (f) \_\_\_\_\_

2. What function does structure (e) above have in the cell?

\_\_\_\_\_

3. **AHL:** Why is membrane fluidity important, and how is it maintained in changing environmental conditions?

\_\_\_\_\_

4. Compare differences in location and differentiation ability between totipotent, pluripotent, and multipotent stem cells:

\_\_\_\_\_

5. What is the purpose of compartmentalization in cells?

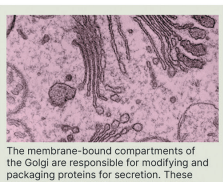
\_\_\_\_\_

6. How can eukaryotic cells efficiently obtain the raw materials they need for metabolism, even as they become larger?

\_\_\_\_\_

7. **AHL:** Describe the process secretion in vesicles from the Golgi apparatus:

\_\_\_\_\_



8. **AHL:** Why are so \_\_\_\_\_ give an example in your answer:

\_\_\_\_\_

**Questions for students doing higher level are identified with the AHL prefix.**

©2024 BIOZONE International  
ISBN: 978-1-99-101410-8  
Photocopying prohibited

## Theme assessments

Longer, summative assessment tasks conclude each theme section. There are four in total. The questions allow students to demonstrate their understanding through a variety of question types including multiple choice, short answer, and longer answer responses. The questions allow students to demonstrate understanding and application of their acquired knowledge, and to analyse, evaluate, and synthesize information. These assessments can be used to help prepare students for the formal assessment requirements of the syllabus (Assessment Objectives AO1-AO3).

AHL questions are clearly identified for easy differentiation of question setting. Students undertaking the standard level course should complete the questions *without the AHL tag*. Students undertaking the higher level course should answer all questions.

236

### 150 Summary Assessment

- Which type of bond involves sharing of electron pairs between atoms:
  - Hydrophobic bond
  - Hydrogen bond
  - Ionic bond
  - Covalent bond
- Which element is not found in a carbohydrate?
  - Carbon
  - Hydrogen
  - Nitrogen
  - Oxygen
- The primary barrier to the passage of ions and polar molecules through the plasma membrane is the:
  - Boundary layer of carbohydrates
  - Hydrophobic nature of the proteins in the plasma membrane
  - Hydrophobic nature of the lipid bilayer
  - The thickness of the plasma membrane
- What is the main purpose of arteries?
  - Carry blood to the body tissues
  - Carry blood towards the heart
  - Allow diffusion of oxygen and nutrients to the body tissues
  - Pump blood to the body

Mean annual temperature (°C)

- Which of the following adaptations is likely to be found in a xerophytic plant?
  - Stomata placed in sunken pits
  - Trichomes
  - Reduced leaf size
  - All of the above

Question 6 refers to the graph below

Percentage saturation of haemoglobin

PO<sub>2</sub> (oxygen tension) (kPa)

- Which biome?
  - Temperate
  - Tropical
  - Grassland
  - Tundra

Species tolerant of large environmental ranges are widespread than organisms with narrow ranges. The blue crab (left) is widespread from Scotia to Argentina. Adults range from almost fresh to almost old and eats anything, from shellfish to other crabs.

- Suggest an advantage to a wide range of environmental tolerance.

237

- AHL:** People with iron-deficient anaemia lack haemoglobin in the blood. The graph right shows the oxygen-haemoglobin dissociation curves for a person with iron deficient anaemia compared to a person with normal haemoglobin levels.
  - What does an oxygen-haemoglobin dissociation curve show?
 

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_
  - What has happened to the oxygen-haemoglobin dissociation curve in the anaemic person and why?
 

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_
- Transpiration in a hydrangea shoot was investigated using a potometer (measures water loss). The experiment was set up and the plant left to stabilize (environmental conditions: still air, light shade, 20°C). The plant was then placed in different environmental conditions and the water loss was measured each hour. Finally, the plant was returned to original conditions, allowed to stabilize and transpiration rate measured again. The results are presented below:
 

| Experimental conditions                      | Temperature (°C) | Humidity (%) | Transpiration rate (g/h) |
|--|------------------|--------------|--------------------------|
| (a) Still air, light shade, room temperature | 20               | 70           | 1.20                     |
| (b) Moving air, light shade                  | 20               | 70           | 1.60                     |
| (c) Still air, bright sunlight               | 23               | 70           | 3.75                     |
| (d) Still air and dark, moist chamber        | 19.5             | 100          | 0.05                     |

  - Describe the three processes in which water is transported from the roots to the leaves:
 

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_
  - What conditions acted as the control in this experiment? \_\_\_\_\_
  - Which factors increased transpiration rate and why? \_\_\_\_\_
  - Why did the plant have such a low transpiration rate in humid, dark conditions? \_\_\_\_\_
- How can an organisms be both saprotrophic and heterotrophic at the same time? \_\_\_\_\_

Questions for students doing higher level are identified with the AHL prefix.

©2024 BIOZONE International  
 ISBN: 978-1-99-101410-8  
 Photocopying prohibited

# Identifying SL and HL Content

The IB Biology syllabus is taught at two levels, standard level (SL) and higher level (HL). While there is content common to both levels, students undertaking the HL course are required to complete additional material. This allows HL students to study selected topics in greater detail and expands on the breadth and depth of the material covered and discovered in the SL course, preparing students for study at university level.

The IB Biology syllabus divides content into SL and HL (to be covered by students doing both the SL and HL courses) and additional higher level (AHL). *Material marked as AHL content should only be taught to HL students.* We have tagged AHL material so teachers can easily identify the differentiated content. The identification strategies are described below.

The image shows a portion of the IB Biology syllabus table of contents. It lists chapters from 1 to 11, with sub-chapters and specific topics. Orange text is used to highlight AHL content. For example, in Chapter 1, 'Molecules', 'AHL: Explain the significance of water as a medium for cellular processes...' is highlighted. In Chapter 2, 'Cells', 'AHL: Explain how the structure of the nucleus enables it to function as a medium for genetic material...' is highlighted. The table continues with chapters on Organelles, Ecosystems, and Interactions and Interdependence.

This image shows the introduction to Chapter 1: Molecules. It includes learning outcomes and a 'Did You Get It?' section. An orange box highlights the text 'AHL: Explain the significance of water as a medium for cellular processes...' and a yellow shaded box highlights the text 'AHL: Explain the significance of water as a medium for cellular processes...'. The page number 128 is visible in the top right corner.

**Content pages:** Activities written in orange text indicate AHL only material. This allows you to easily identify AHL material and assign it to students taking the HL course. The legend underneath the contents tells students orange text denotes AHL content.

**Chapter introductions:** An orange AHL tag and a yellow shaded box identify AHL statements. This material should only be assigned to students doing the HL course.

This image shows a page from the IB Biology syllabus (page 343) discussing Darwin's theory of evolution by natural selection. It includes text, diagrams of beetles, and graphs. A blue activity tab with the number 343 is present. An orange activity tab with the number 352 is also present. Assessment tags 'AHL' and 'D4.1' are visible at the bottom right of the page. A legend at the bottom right shows 'AHL' in an orange box and 'D4.1' in a blue box.

This image shows a page from the IB Biology syllabus (page 128) titled 'Did You Get It?'. It contains several questions related to gas exchange and transport. A blue activity tab with the number 128 is present. An orange activity tab with the number 15 is also present. Assessment tags 'AHL' and 'D4.1' are visible at the bottom right of the page. A legend at the bottom right shows 'AHL' in an orange box and 'D4.1' in a blue box.

**Activity tabs:** Activity numbers are contained in either a blue or orange box. Blue boxes indicate the activity should be assigned to SL and HL students. An orange activity box indicates the material should only be assigned to HL students. An AHL tab is also present on the bottom of the page (inset, above).

**Assessment tags:** Chapter and theme assessments contain both SL and HL content. HL content is identified with an **AHL prefix** at the start of the question.

# Identifying AOS and NOS Components

## Application of Skills

Application of skills (AOS) are directed tasks requiring students to connect a specific understanding with a skill. This is usually achieved through an action. For example, use banding patterns, length, and position of the centromere to classify chromosomes. These skills are often, but not always, associated with a practical activity. In order to help with planning and checking off required skills, activities with an AOS component have been identified in the contents, chapter introduction, and through the tab system on an activity page.

**AOS material has a green tag** for easy identification.

## Nature of Science

The nature of science (NOS) is an overarching theme that enhances students' understandings of science concepts. It is broader than simply understanding science concepts. The NOS encompasses the purpose, features, and impact of scientific knowledge, enabling students to make informed decisions about scientifically-based personal and social issues. NOS is an important component in IB Biology, and is integral within the understandings. In order to help with planning and checking off required skills, activities with a NOS component have been identified in the contents, chapter introduction, and through the tab system on an activity page.

**NOS material has a red tag** for easy identification.

Green and red coloured dots in the contents.

**Contents**

Using This Workbook ..... vii  
Using BIOZONE's Resource Hub ..... x  
Themes in IB Diploma Biology ..... xi

**Theme A: Unity and Diversity**

**Chapter 1: A1 - Molecules**

**Chapter 3: A3 - Organisms**

**Chapter 4: A4 - Ecosystems**

**Chapter 6: B2 - Cells**

**Chapter 7: B3 - Homeostasis**

**Chapter 8: B4 - Plant Structure and Function**

**Chapter 9: B5 - Plant Reproduction**

**Chapter 10: B6 - Animal Reproduction**

**Chapter 11: B7 - Animal Structure and Function**

**Chapter 12: B8 - Animal Reproduction**

**Chapter 13: B9 - Animal Reproduction**

**Chapter 14: B10 - Animal Reproduction**

**Chapter 15: B11 - Animal Reproduction**

**Chapter 16: B12 - Animal Reproduction**

**Chapter 17: B13 - Animal Reproduction**

**Chapter 18: B14 - Animal Reproduction**

**Chapter 19: B15 - Animal Reproduction**

**Chapter 20: B16 - Animal Reproduction**

**Chapter 21: B17 - Animal Reproduction**

**Chapter 22: B18 - Animal Reproduction**

**Chapter 23: B19 - Animal Reproduction**

**Chapter 24: B20 - Animal Reproduction**

**Chapter 25: B21 - Animal Reproduction**

**Chapter 26: B22 - Animal Reproduction**

**Chapter 27: B23 - Animal Reproduction**

**Chapter 28: B24 - Animal Reproduction**

**Chapter 29: B25 - Animal Reproduction**

**Chapter 30: B26 - Animal Reproduction**

**Chapter 31: B27 - Animal Reproduction**

**Chapter 32: B28 - Animal Reproduction**

**Chapter 33: B29 - Animal Reproduction**

**Chapter 34: B30 - Animal Reproduction**

**Chapter 35: B31 - Animal Reproduction**

**Chapter 36: B32 - Animal Reproduction**

**Chapter 37: B33 - Animal Reproduction**

**Chapter 38: B34 - Animal Reproduction**

**Chapter 39: B35 - Animal Reproduction**

**Chapter 40: B36 - Animal Reproduction**

**Chapter 41: B37 - Animal Reproduction**

**Chapter 42: B38 - Animal Reproduction**

**Chapter 43: B39 - Animal Reproduction**

**Chapter 44: B40 - Animal Reproduction**

**Chapter 45: B41 - Animal Reproduction**

**Chapter 46: B42 - Animal Reproduction**

**Chapter 47: B43 - Animal Reproduction**

**Chapter 48: B44 - Animal Reproduction**

**Chapter 49: B45 - Animal Reproduction**

**Chapter 50: B46 - Animal Reproduction**

**Chapter 51: B47 - Animal Reproduction**

**Chapter 52: B48 - Animal Reproduction**

**Chapter 53: B49 - Animal Reproduction**

**Chapter 54: B50 - Animal Reproduction**

**Chapter 55: B51 - Animal Reproduction**

**Chapter 56: B52 - Animal Reproduction**

**Chapter 57: B53 - Animal Reproduction**

**Chapter 58: B54 - Animal Reproduction**

**Chapter 59: B55 - Animal Reproduction**

**Chapter 60: B56 - Animal Reproduction**

**Chapter 61: B57 - Animal Reproduction**

**Chapter 62: B58 - Animal Reproduction**

**Chapter 63: B59 - Animal Reproduction**

**Chapter 64: B60 - Animal Reproduction**

**Chapter 65: B61 - Animal Reproduction**

**Chapter 66: B62 - Animal Reproduction**

**Chapter 67: B63 - Animal Reproduction**

**Chapter 68: B64 - Animal Reproduction**

**Chapter 69: B65 - Animal Reproduction**

**Chapter 70: B66 - Animal Reproduction**

**Chapter 71: B67 - Animal Reproduction**

**Chapter 72: B68 - Animal Reproduction**

**Chapter 73: B69 - Animal Reproduction**

**Chapter 74: B70 - Animal Reproduction**

**Chapter 75: B71 - Animal Reproduction**

**Chapter 76: B72 - Animal Reproduction**

**Chapter 77: B73 - Animal Reproduction**

**Chapter 78: B74 - Animal Reproduction**

**Chapter 79: B75 - Animal Reproduction**

**Chapter 80: B76 - Animal Reproduction**

**Chapter 81: B77 - Animal Reproduction**

**Chapter 82: B78 - Animal Reproduction**

**Chapter 83: B79 - Animal Reproduction**

**Chapter 84: B80 - Animal Reproduction**

**Chapter 85: B81 - Animal Reproduction**

**Chapter 86: B82 - Animal Reproduction**

**Chapter 87: B83 - Animal Reproduction**

**Chapter 88: B84 - Animal Reproduction**

**Chapter 89: B85 - Animal Reproduction**

**Chapter 90: B86 - Animal Reproduction**

**Chapter 91: B87 - Animal Reproduction**

**Chapter 92: B88 - Animal Reproduction**

**Chapter 93: B89 - Animal Reproduction**

**Chapter 94: B90 - Animal Reproduction**

**Chapter 95: B91 - Animal Reproduction**

**Chapter 96: B92 - Animal Reproduction**

**Chapter 97: B93 - Animal Reproduction**

**Chapter 98: B94 - Animal Reproduction**

**Chapter 99: B95 - Animal Reproduction**

**Chapter 100: B96 - Animal Reproduction**

**Chapter 3: Unity and Diversity**

## Organisms

**A3.1 Diversity of organisms**

**Guiding Questions:** How do we define a species? What patterns in genomes are evident within and between species?

**Learning Outcomes:**

- 1 Connect classification and taxonomy to the variation seen in all organisms. **30**
- 2 Use Linnaeus' original definition of a species as a group with shared traits. **30**
- 3 Use the system of binomial nomenclature to name organisms. **30**
- 4 Define 'species' using the biological species concept and compare to other competing species definitions. **31**
- 5 Distinguish between the terms population and species, acknowledging that speciation can result in an arbitrary decision. **31**
- 6 Examine examples of chromosome number diversity in different species using humans and chimpanzees as an example. **33-35, 38**
- 7 **AOS:** Identify features seen in a human karyotype to classify chromosomes specifically as evidence for a testable hypothesis on common ancestry with a primate ancestor. **33-35**  
**NOS:** Distinguish between testable hypotheses and non-testable statements.
- 8 Explain how variations such as single-nucleotide polymorphisms result in the genetic diversity of organisms. **36, 37**
- 9 Compare the relative eukaryote genomic diversity between species and within a population of a species. **37, 38**
- 10 Gather information from a digital database to compare the genomic size of different taxonomic groups with their varying complexity. **37**
- 11 Investigate a range of current and potential future uses of whole genome sequencing. **39**
- 12 **AHL:** Identify the constraints of applying the biological species concept to asexually reproducing species. **32**

**Learning Outcomes:**

- 1 **AHL:** Discuss the importance of taxonomic classification. **43**
- 2 **AHL:** Describe the constraints of traditional Linnaean taxonomy and therefore why there has been a theoretical paradigm shift to using cladistics for classification. **43**

**Learning Outcomes:**

- 7 **AOS:** Identify features seen in a human karyotype to classify chromosomes specifically as evidence for a testable hypothesis on common ancestry with a primate ancestor. **33-35**  
**NOS:** Distinguish between testable hypotheses and non-testable statements.
- 8 Explain how variations such as single-nucleotide polymorphisms result in the genetic diversity of organisms. **36, 37**
- 9 Compare the relative eukaryote genomic diversity between species and within a population of a species. **37, 38**

Green AOS tags and red NOS tags in the chapter introduction.

## 33 Karyotypes

**Key Idea:** The karyotype is the number and appearance of chromosomes in the nucleus of a eukaryotic cell. The karyotype can be pictured in a standard format, called a karyogram, in which the chromosomes are ordered by size. Different species of organisms have different numbers or structures of chromosomes. This is called the karyotype. The karyotype is displayed as a karyogram, a standardized layout of the chromosomes. Karyograms are able to show if

a cell is diploid (2n) (having pairs of chromosomes), triploid (3n) or aneuploid (2n + 1) and allow comparison between species. The number of chromosomes a species can range from two to dozens. In humans, the male karyotype has 44 autosomes (non-sex chromosomes), and an X and Y chromosome (44 + XY). The female karyotype has 44 autosomes and two X chromosomes (44 + XX). Karyograms can be prepared from cells in the metaphase stage of mitosis.

**Preparing a karyotype**

- 1 The sample is centrifuged and the lymphocytes (a type of white blood cell) are removed and induced to divide (mitosis).
- 2 They are grown for several days in culture and then treated to halt the cycle at the metaphase stage.
- 3 A sample of cells is taken from the person of interest. This may be from the amniotic fluid surrounding a foetus or from a blood sample from an adult or child.
- 4 A drop of the cell suspension in preservative is spread on a microscope slide, dried and stained with a dye that causes a banding pattern to appear on each chromosome.
- 5 The chromosomes are viewed under a microscope and photographed. Newer techniques use fluorescent probes to colour-code chromosomes and provide a spectral karyogram.
- 6 The photograph is cut up (manually or by computer) so that each chromosome is separate from the others. The chromosomes are then arranged into homologous pairs according to size, shape, and banding pattern.
- 7 Close up reveals two chromatids.

**Spectral karyogram (female): 44 + XX**

**Rock melon**

Green AOS tabs and red NOS tab on the activity page.

**Activity Page Tabs:**

- NOS** (Red)
- AOS** (Green)
- A3.1** (Purple)
- 6, 7** (Blue)

**Activity Page:**

**Rock melon**

**Learning Outcomes:**

- 7 **AOS:** Identify features seen in a human karyotype to classify chromosomes specifically as evidence for a testable hypothesis on common ancestry with a primate ancestor. **33-35**  
**NOS:** Distinguish between testable hypotheses and non-testable statements.
- 8 Explain how variations such as single-nucleotide polymorphisms result in the genetic diversity of organisms. **36, 37**
- 9 Compare the relative eukaryote genomic diversity between species and within a population of a species. **37, 38**

# Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's worktexts and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for differential instruction.

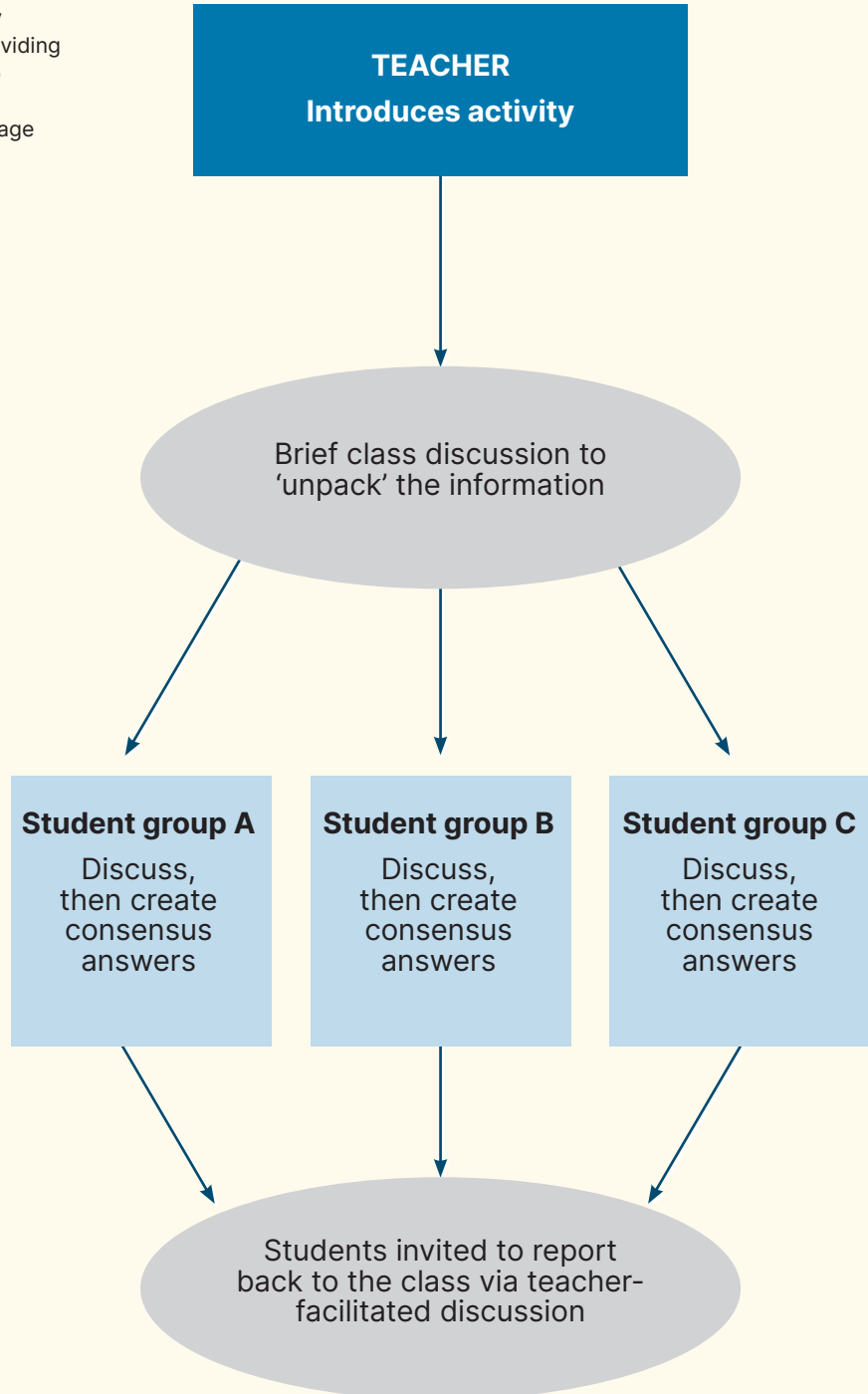
## Making a start

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. For collaborative work, the teacher can then divide the class into appropriate groups, each with a balance of able and less able students. Depending on the activity, the class may regroup at the end of the lesson for discussion or to present their findings.

The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.

Students work in small groups so that everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer (or not), not just sharing ideas.

At the end of the session, students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting consists primarily of providing answers to questions, but may involve presenting a report, model, or slide show, or contributing to a debate.



## Using collaboration to maximize learning outcomes

- The structure of *IB Biology* allows for a flexible approach to unpacking the content with your students.
- The content can be delivered in a way to support collaboration, where students work in small groups to share ideas and information to answer and gain a better understanding of a topic, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners and developing their English and scientific vocabularies.
- Use a short, informal, collaborative learning session to encourage students to exchange ideas about the answer to a question.
- A collaboration icon (right) indicates where there is an opportunity for students to work together.



## Peer to peer collaboration and support

- Peer-to-peer learning is emphasized throughout the worktext, and is particularly valuable for more challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to solve a problem.
- Stronger students can assist their peers and both groups benefit from verbalizing their ideas. Students for whom English is an additional language can ask their classmates to explain unfamiliar terms and this benefits the understanding of both parties.
- *IB Biology* provides a range of activities. These include encouraging students to think about and share what they already know and then build on this knowledge by exploring and explaining content in a more formal role that lasts for a longer period of time, e.g. assign groups to work together for a practical activity, to research questions, or design a solution to a problem.



**Student A** is capable. He helps to lead the discussion and records the discussion in a structured way.

**Students B and C** are also capable but less willing to lead discussion. They will add ideas to the discussion but need a little direction from A to do so.

**Student D** is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.

## Reviewing work and providing answers

Our worktext approach encourages students to demonstrate their understanding of the content by inputting their answers on the activity page, either by writing it into the printed book or typing answers onto the digital version in BIOZONE WORLD. This approach makes it easy for students to record and share their answer and ideas with other students. They can also review their own work or peer-review the work of others. Teachers can easily review an individual's work and see how they are progressing through the content. Model answers are provided for each activity and these can be shared with students at the teacher's discretion. Self reported grading is a powerful tool for accelerating learning (CG4) and should be encouraged where possible. Students should also be encouraged to refine their answers (if needed) and deepen their level of understanding. This enhances the learning moment.



### Peer feedback

Dividing students into small groups allows them to share their answers and ideas and receive immediate peer feedback. Sharing ideas and discussing alternative perspectives and solutions can broaden each student's understanding or perspective. Students may or may not come to a consensus answer through this process. Some students may wish to refine their original answer after the discussion.



### Class discussion to review answers

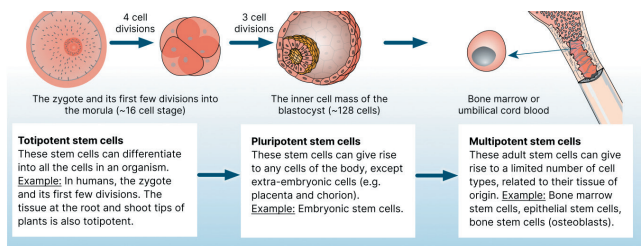
Small groups can partake in collaborative summarizing when brought together as a larger group or class. Students can share ideas and answers through structured discussion, either as a class or within larger groups. The class benefits from hearing a range of ideas, and teachers can guide the discussion to ensure efficient use of time. At the end of the discussion, the teacher may wish to share the model answer with the class.



### Review answers in class via BIOZONE WORLD

The teacher view in BIOZONE WORLD has model answers which can be toggled on and off using the show/hide buttons on an activity page. View activities in BIOZONE WORLD on a shared screen and reveal the answers as required. This is ideal for:

- Providing a concise model answer after a group or class discussion.
- Self marking by students. Students can amend their answer if necessary, providing a powerful secondary learning moment.
- Providing a quick review of answers if time is short.



1. Describe the two defining features of stem cells:

- (a) Potency - ability to differentiate into other cell types.
- (b) Self renewal - ability to maintain an unspecialized state.

2. Describe the potency of stem cells and where they are found:

- (a) Totipotency: The ability to differentiate into any cell in the organism. Found in the zygote in animals and meristems in plants.
- (b) Pluripotency: The ability to differentiate into any cell except extra-embryonic cells e.g. the placenta. Found in the embryo.
- (c) Multipotency: Ability to differentiate into a limited number of cells related to the tissue of origin (e.g.

### Teacher review of student work

Students using the print version of *IB Biology* each have their own worktext and write their answers directly into the space provided. Teachers can revise student responses as required.

Students using the digital version of *IB Biology* input and submit their answers via the digital platform, BIOZONE WORLD. Teachers can revise each activity as required.