Internal Assessment Ideas for the International Baccaleaureate

Introduction

This is a document briefly outlining Internal Assessment (IA) ideas for students pursuing Higher and Standard Level Biology in the IBDP programme. IAs are a crucial opportunity in the students' academic journey to acquire skills useful for university and external work, develop soft scientific skills, and become inspired in specific research areas. The current IBDP Biology syllabus has limited coverage of biotechnology and synthetic biology topics. Therefore, this document seeks to inspire students to pursue these scientific areas in their IAs, opening new research and knowledge apprehension opportunities for them at school level. The proposed ideas are dependent on certain laboratory equipment and may not be possible to implement for all IBDP schools. Where possible, the ideas are designed to overlap with the current syllabus.

N.B. Since molecular biology and biotechnology is somewhat of an uncharted area in the IBDP, students must be warned of potential risks in choosing to pursue a project in one of these fields. Students must be prepared for limited results and many deviations from expected trends. An IA in this topic should particularly be pursued by students interested in a biochemistry-related higher education and career; students should consider the risk of having lower IA grades, albeit experimental success is not necessary to achieve the best grades.

Safety/Regulatory note

Transformation creates genetically modified organisms, which in the UK is contained-use work regulated under the Genetically Modified Organisms (Contained Use) Regulations 2014. Premises must be notified to the HSE and a risk assessment is required, so students should confirm their school's arrangements well before starting. Consult CLEAPSS for additional safety guidance.

IA Ideas

1. Transformation efficiency tests.

Transformation is a critical step in biochemistry and engineering biology workflows. At high schools, transformation with genetic constructs could be performed using ampicillin as a selectable marker, for competent cells induced in-house. Ampicillin does not require a deliberate recovery stage for the bacterial culture before plating, making it a perfect candidate for school-based experiments.

Possible independent variables: recovery time, heat shock duration, construct size, bacterial strain, duration of $CaCl_2$ treatment
Possible dependent variables: colony count

2. Cell viability haemocytometry assays.

Trypan blue is a very straightforward marker of cell death; this dye passes through the compromised plasma membranes of dead cells. A haemocytometer, compatible with a simple light microscope, can be used to count the proportion of dead and live cells in the sample. Yeast are the typical organism for such experiments, however, algae such as *Chlorella vulgaris* along with other organisms are also possible to study.

Possible independent variables: osmolyte concentration, cytotoxin/therapeutic concentration, pollutant concentration, treatment with other stress factors, such as pH, temperature, and UV light.

Possible dependent variables: cell viability (percentage of live cells from total cells), cell density (trypan blue-independent).

3. Mitotic index as a model of mutagenicity or cell cycle arrest.

Particularly relevant for plant cell microscopy. Treatment with UV or another mutagen may perturb the cell cycle, leading to uncontrolled division or other cell cycle aberrance. Mitotic index can be measured as a ratio of cells undergoing mitosis to the total cell number. Other conditions can affect mitotic index, promoting cell division, such as optimal environmental conditions.

Possible independent variables: Mutagen exposure, nutrient concentration, light intensity
Possible dependent variables: Mitotic index

4. Biofuel production by cellulosic breakdown.

Cellulose is the most abundant biopolymer on Earth, and releasing its glucose is the central problem in second-generation biofuel production. Cellulases hydrolyse the β-1,4 bonds in cellulose to cellobiose, which β-glucosidase then converts to glucose. Lignocellulose valorisation and biofuel production are currently some of the most prominent topics in biotechnology. The Imperial iGEM 2026 project, reGELerate, closely explores the applications of these enzymes.

Glucose concentration can be measured quantitatively with an affordable handheld glucometer with strips or qualitatively, using Benedict's solution. Standard curve construction is recommended, if using a glucometer, which is usually calibrated for blood readings. Alternatively, cellulose breakdown can be modelled as a fall in the viscosity of a carboxymethylcellulose solution using an inexpensive Ostwald viscometer.

> **Possible independent variables:** temperature; pH; enzyme concentration; substrate type (filter paper, cotton wool, carboxymethylcellulose, shredded newspaper, grass); substrate pre-treatment (grinding, freezing, soaking in dilute alkali); incubation time; free versus immobilised enzyme; number of reuse cycles; presence of inhibitors such as added glucose or metal ions.

Possible dependent variables: glucose concentration; percentage mass loss of the cellulose substrate; viscosity of a carboxymethylcellulose solution over time.

5. Quorum sensing.

Quorum sensing is a common switch in synthetic biology genetic circuits. *Vibrio fischeri* is a classic and purchase-available microorganism exhibiting this phenomenon. At specific conditions and sufficient density, the bacterial culture luminesces. Light output then rises steeply with further growth before levelling off.

Possible independent variables: cell density, salinity, temperature, nutrient concentration, addition of spent culture medium containing signalling molecules.
Possible dependent variables: luminescence quantified from long-exposure photographs in ImageJ; time to visible light after subculture (i.e. time between culture dilution and reappearance of quorum sensing-induced light signal).