IA Problem Questions by Topic click to view more:

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ARE YOU A STUDENT AT GHA SCHOOL? CAUTION!!! *You are responsible for coming up with your own research question that is relevant and interesting to you. Do not simply copy ideas that other students are doing. Ethics and integrity matter.*

This is a list of past IB Internal Assessment research questions that students have completed in IB Biology at Green Hills Academy. It can serve as inspiration for generating your own idea!
Authentic cites

As you are planning your problem question, keep in mind the following:

1. You'll need to analyze data. You can't just report about data other people have collected.
2. If you're doing a controlled experiment - you'll need at least 5 levels of your manipulated variable and 5 trials at each of those levels. If possible, 10 trials is better.
3. If you're doing a correlation study - you'll need at least 30-100 data points (depending on how easy data is to collect) in order to draw a conclusion.
4. Everyone who is going to investigate human subjects… Consider yourself warned… These historically do not score well by the IB because there are so many limitations and uncontrolled variables. You MUST get informed consent and have large (like 100) samples or lots (like, LOTS) of repeated measures. So, CAUTION!
5. People doing database analysis - be sure you are analyzing and manipulating the data in some way. You can not simply report on what data is available and/or has been collected by someone else. You will have to have data tables, graphs and statistics of your own - but you are getting the data from a database. So, CAUTION!

1.1: Introduction to Cells

- Cell density in different plant tissues
- Comparing cell sizes in different animal tissues using prepared/purchased slides
- Comparing cell sizes in different plant tissues using prepared/purchased slides
- Analysis of movement in single celled organisms

1.2: Ultrastructure of Cells

- Effect of force on cell wall structure
- Rate of cell division in lactobacillus (stain yogurt samples over time)
- Comparing plastid size in different plant cell types
- Garlic allicin released from vacuoles with crushing
- Quantifying strength of plant cell wall in different ages of leaves (relates to herbivory)

1.3: Membrane Structure

1.4: Membrane Transport

- Rate of active transport in yeast cells
- Quantifying plasmolysis in plant cells
- Estimating osmolarity of plant tissues
- Measuring osmosis in red blood cells
- Diffusion
    - MV: solution concentration
    - MV: temperature
    - MV: surface area to volume ratio
    - MV: tissue type (i.e. different root vegetables)
    - RV: Beetroot solution color using calorimeter
    - RV: Change in mass of a sample (root veggies, de-shelled eggs)
    - RV: Rate of diffusion

1.5: Origin of Cells

- Percentage homology in DNA sequence of genes found in bacteria, mtDNA and cDNA
- Replicating Pasteur's experiments

1.6 Cell Division

- Mitotic index in prepared microscope slides samples
- Database analysis of cancer and a variable (using CDC databases)
- Comparing Length of time of different cell cycle phases
    - Using prepared slides (alium or whitefish)
    - Using Allen cell images

FOR BACTERIA STUDIES:

- Only culture known, non-pathogenic strains of microbes. For example, do not culture from hands or swabs of door handles.(the school will purchase lab safe bacteria for you)
- Do not test for antibiotic resistance. There are enough antibiotic resistant strains circulating in the environment without more being selected for.
- Apply strict rules of hygiene and aseptic techniques.
- Do not culture microbes at 37°C. Incubation should be carried out below 30°C.
- Always label cultured plates so they can be clearly identified and never open them for inspection.
- Tape the lids on but do not tape all the way round a Petri dish. Taping all around the dish encourages anaerobic conditions that are best avoided.
- Never assume that what is growing in the culture is the strain that was inoculated, even if nonpathogenic strains have been used.
- Always sterilise used cultures and dispose of the cultures using local health and safety regulations.

2.1: Molecules to Metabolism

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2.2: Water

- Surface tension of water with different mass of modeled water glider
- Sweating rate vs. exercise intensity

2.3: Carbs and Lipids

- Comparison of energy released by different fat types using calorimetry
- Using iodine titration to determine degree of lipid saturation and comparing to expected values
- Comparing actual fat to food label fat per serving
- Comparing viscosity of fats with different saturations

2.4: Proteins

- Protein denaturation
    - MV: temperature
    - MV: salinity
    - MV: drops of acid solution
    - RV: viscosity of egg yoke (albumin)
    - RV: mass of clumped milk (casein)
    - RVL colorimeter (albumin)

2.5: Enzymes

- Enzyme reaction experiments
    - MV: amount of enzyme
    - MV: amount of substrate
    - MV: temperate
    - MV: pH
    - MV: inhibitor concentration
    - MV: type of (related) substrates
    - RV: rate of reaction by measuring change in product mass/volume/area/concentration
    - RV: rate of reaction by measuring change in substrate mass/volume/area/concentration
    - Example enzymes: lactase, amylase, lipase (with pH indicator), pectinase, catalase, peptidase, maltase, protease (with jello)

2.6: DNA and RNA

- Manipulating various aspects of the DNA extraction procedure to test impact on amount of DNA extracted from strawberries

2.7: DNA Replication, transcription and translation

2.8: Cell Respiration

- Fermentation in yeast. Possible variables:
    - MV: sugar type
    - MV: sugar amount
    - MV: Incubation temperature
    - MV: Amount of yeast starter added
    - MV: Incubation time
    - RV: CO_2 volume
    - RV: CO_2 bubble counts/volume
    - RV: pressure
- Fermentation and the production of yogurt. Possible variables:
    - MV: Fat content of milk
    - MV: Incubation temperature
    - MV: Amount of starter added
    - MV: Incubation time

    - RV: Acidity
- Measuring respiration rates in germinating seeds
    - MV: seed type
    - MV: Incubation temperature
    - MV: time since germination
    - RV: CO_2 volume
    - RV: CO_2 bubble counts

2.9: Photosynthesis

- Pigments present in the same plant species in different seasons (chromatography)
- Photosynthesis rate experiments
    - MV: area of plant (using tissue discs)
    - MV. amount of CO_2 in system
    - MV: light intensity
    - MV: light wavelength / color (action spectrum)
    - MV: light time
    - MV: temperature
    - MV: leaf color (same tree in the fall)
    - RV: O_2 (bubbles) produced
    - RV: [CO_2]
    - RV: leaf disc assay
    - RV: change in biomass (growth)
    - RV: leaf starch test

3.1: Genes

- Comparing allele frequencies in different populations using the ALFRED database
- Comparing gene sequence differences between different species

3.2: Chromosomes

- Correlating dry mass of DNA extracted and number of chromosomes in a fruit type

3.3: Meiosis

3.4: Inheritance

- Comparing observed vs. expected phenotype frequencies in fast plants over multiple generations
- Effect of UV radiation time on yeast reproduction rates
- Effect of sunscreen SPF on reproduction rates of yeast exposed to UV radiation

3.5: Biotechnology

- Buffer concentration effect on DNA electrophoresis rate
- Voltage effect on DNA electrophoresis rate
- Gel density on electrophoresis rate
- Manipulating various aspects of the pGLO transformation procedure to test impact on transformation efficiency
- Factors affecting rooting of stem cuttings
    - Cut site relative to node
    - Number of leaves
    - Exposure time to air for callus formation

    - Concentration of hormone rooting powder
    - Medium the cutting is placed in
    - Temperature

4.1: Species, Communities and Ecosystems

- Abiotic factor and species abundance
    - MV: amount of light
    - MV: soil moisture
    - MV: distance from water
    - MV: soil density
    - MV: distance from human disturbance (i.e. trail or road)
- Association between two species in a habitat
- Monitoring plant growth in mesocosms with different levels of an abiotic factor

4.2: Energy flow

4.3: Carbon cycling

- Data logging of CO_2 and pH in an aquarium over repeated day-night cycles
- Quantifying CO_2 released by the combustion of various forms of biomass

4.4: Climate Change

- Acidity of solution and rate of $CaCO_2$ dissolving in shells (change in mass)
- Database analysis of CO_2 emissions and another variable
- Database analysis of ocean acidity and CO_2 emissions
- Database analysis of water temperature and coral growth rates
- Modeling greenhouse effect using bottles filled with different amounts of CO_2

5.1: Evidence for Evolution

- Comparing average femur length in different breeds of domestic dogs
- Quantifying change in allele frequency using a simulation of industrial melanism
- Artificial selection of a trait over generations using Wisconsin fast plants

5.2: Natural Selection

- Quantifying and comparing variation in a trait between related species of plants (i.e. comparing variation in needle length in different conifer tree species)

5.3: Classification and biodiversity

5.4: Cladistics

- Creating cladograms based on percentage homology in DNA sequence of genes between different species
- Creating cladograms based on percentage homology in amino acids sequence in proteins between different species

CAUTION! For topic 6 Anatomy and Physiology…. *Don't say I didn't warn you…*

Straight from the IB "The weaker submissions tended to be from candidates who investigated a topic in which causal relationships are difficult to confirm and a large number of controls are missing. For example, human physiology studies with limited data sets and poorly controlled variables."

6.1: Digestion and Absorption

- Using dialysis tubing to model starch digestion in the small intestine

6.2: The Blood System -

- Modeling rate of blood flow in modeled vessels of different diameters
- Age of person and capillary refill rate
- Heart rate recovery time after different exercise intensity
- Change in heart rate with exercise intensity
- Measuring blood pressure with different body positions

6.3: Defense against infectious disease

6.4: Gas Exchange

- Correlation between lung capacity and 5K times
- Body position and lung capacity
- Ventilation rate with different exercise intensities
- Correlating lung capacity and height
- Change in solution pH with exhaling after different exercise intensities (pH probe or BTB indicator)

6.5 Neurons and synapses

6.6: Hormones, homeostasis and reproduction

7.1 DNA structure and replication

7.2 Transcription and Gene Expression

7.3 Translation

8.1: Metabolism

- Enzyme reaction experiments with different inhibitor concentration

8.2: Cell respiration

8.3: Photosynthesis

9.1: Transport in Xylem

- Stomata counts (using impressions)
    - MV: plant location
    - MV: time of day
    - MV: amount of light provided
    - MV: humidity
    - MV: type of plant

- Transpiration experiments
    - MV: humidity
    - MV: temperature
    - MV: wind
    - MV: light
    - RV: change in mass whole system
    - RV: potometer
    - RV: pressure
- Comparing xylem and phloem cell sizes in prepare microscopic slides

9.2: Transport in phloem

9.3: Growth in Plants

- Angle of seed planting and degree of gravitropism
- Angle of plant to light source and degree of phototropism
- Amount of meristem cut and rate/amount of growth
- Auxin concentration and rate of growth in roots
- Auxin concentration and rate of growth in shoots
- Micropropagation efficiency in different concentrations of auxin and/or cytokinin

9.4: Reproduction in Plants

- Effect of day/night length on flowering in fast plants
- Germination experiments
    - MV: amount of water
    - MV: temperature
    - MV: physically roughing seed/scarification
    - MV: light intensity
    - MV: light color
    - MV: gibberellin concentration
    - MV: seed UV exposure
- Using a sucrose refractometer to measure fruit ripeness over time
- Using a sucrose refractometer to compare amount of sugar in different fruit types
- Correlating flower size to fruit size in angiospermatophyta
- Comparing average time different types of insect pollinators spend at flowers

10.1 Meiosis

10.2: Inheritance

- Modeling dihybrid crosses predicted vs actual chi-square with penny probabilities
- Comparing actual vs theoretically predicted phenotypic results of dihybrid crosses of Wisconsin fast plants
- Quantifying variation in polygenic human traits

10.3: Gene Pools and Speciation

- Modeling change in allele frequencies in populations - with and without selective pressures

11.1: Antibody Production and Vaccination

- Database analysis of vaccination rates and disease rates in different countries

11.2: Movement

- Rate of muscle fatigue dominant vs non-dominant hands

11.3: Kidney and osmoregulation

11.4: Sexual reproduction

A.1: Neural development

A.2: The human brain

A.3: Perception of Stimuli

- Reaction rates at different times of the day
- Age of perception of sound frequency
- Comparing two-point discrimination difference in different parts of the body
- Comparing minimum scent concentration
- Variation in distinguishing temperature changes by age

A.4: Innate and Learned Behavior - be sure to avoid writing a psychology IA -- this in biology :-)

A.5: Neuropharmacology

A.6: Ethology

- Analysis of behaviors of ducks in different habitats

B.1: Microbiology in industry

- Comparing production of biogas using different feedstocks in a small scale fermentor
- Zone of inhibition in bacteria grown the the presence of various household chemicals as a measure of bactericide effectiveness

B.2: Biotech in agriculture

B.3: Environmental protection

B.4: Medicine

B.5: Bioinformatics

C.1: Species and communities

- Use of a transect to correlate distribution of a plant species with an abiotic variable
    - Light
    - Soil moisture
    - Temperature
- Quantifying succession in habitats
    - Species diversity
    - Stem density
    - Leaf area

C.2: Communities and ecosystem

- Comparing diversity index of water samples taken from different watersheds
- Diversity of aquatic macroinvertebrates in different areas of a stream

C.3: Impacts of humans on ecosystems

C.4: Conservation of biodiversity

C.5: Population ecology

- Tracking duckweed (Lemna) population growth rates over time

C.6: Nitrogen and phosphorus cycles

- Comparing nitrogen and phosphorous in different habitats (soil or water)

D.1: Human Nutrition -

- Type of citrus fruit and amount of vitamin C
- Comparing home calorimetry results with published nutrition information for foods

D.2: Digestion

D.3: Liver

D.4: Heart

- Comparing heart rate in different temperatures

D.5: Hormones and Metabolism

D.6 Respiratory Gases

Other investigations

https://docs.google.com/document/d/1uO1KVi3CAf4Rt7rUlvJSNj7uD6psHGoo73Dt50tQhX4/edit?usp=sharing

Using immobilised beads of algae to investigate the rate of photosynthesis.

This is a neat idea to immobilise algae in alginate beads and use them to investigate photosynthesis rate. The concentration of carbon dioxide in the solution can be measured using a data logger or an indicator like bicarbonate indicator can be used. This will work best if used in conjunction with a colorimeter. A range of factors could be

tested including temperature, light intensity,frequency of light. Steps must be taken to control variables or to monitor variables which are impossible to control.

Antibacterial properties of a food or food ingredient.

There are many possible investigations here, from mint to chili. controlling the conditions of growth of the bacteria and ensuring save sterile technique are some of the problems. Actually measuring zones of inhibition is quite easy but preparation of a range of concentrations of the food ingredient may prove difficult to organise. If it was possible to quantify and identify the active ingredient then there is more chance of success. Finding a mechanism of action is another desirable outcome, but a study which simply identifies a correlation or a lack of one, without a mechanism, will also be acceptable for an IA.

The affect of temperature on non-enzyme controlled reactions or processes.

This is an interesting twist on an classic enzyme reaction. What is the effect of temperature on the absorbance of light by photosynthetic pigments? Is there a difference in the stretchiness of a ring of artery at different temperatures. Of course the control of all the other variables which may affect the reaction will be important and may not be easy. You have to collect sufficient data and repeats of each value a,d it would be good to be able to suggest a possible biological mechanism, although this isn't essential.

Ripeness of fruit and vitamin C content.

Does ascorbic acid get converted to sugar as part of the ripening process of a fruit. The challenge of this IA would be to accurately, or quantitatively estimate the ripeness of the fruit. This could be helped if the fruit can actually be collected as it falls off the tree. Perhaps the colour of the fruit can suggest ripeness, and remember that many plant parts contain vitamin C, not just oranges. DCPIP will be useful as an indicator of the concentration of vit C but a calibration curve might be useful.

Effects of light on vitamin C.

This investigation is interesting as it relates to the shelf life of food and also the quality of food after the processing. If a bottle of juice is stored in direct sunlight does the vitamin C get damaged. Using DCPIP and a simple titration an experiment can be planned to estimate the concentration of vitamin C in a juice drink after a range of different light treatments. Artificial bulbs or sunlight screens could be used to get a range of the independent variable, and of course it will be important to control other variables.

[There are many possible variations on this experiment: such as looking at storage temperature, or interactions with other chemicals, preservatives, colourings, or perhaps even other fruit juices which may cause oxidation or decomposition of Vitamin C., Even simple contact with the air may have an effect. It might also be possible to compare the stability of different sources of vitamin C at different temperatures. Why limit yourself to vitamin C, any

nutrient which can be tested would lend itself to this type of study. It would be possible to estimate the concentration of enzymes like catalase in samples of fruit, for example.]

Photosynthesis and light colours.

This study as an IA could attempt to answer the following type of research questions, "Given that the absorption spectrum of chlorophyll has peaks at blue and red, can a while light be replaced by a blue and red light and still give the same amount of photosynthesis?" Of course there are many alternatives, but by trying to answer a precise question like this the planning can be a little simpler. Having said that of course it is important the the background of the exploration section includes appropriate reference to biology theory. There are many ways to measure the rate of photosynthesis, using data logging probes, little clips of spinach leaves, Elodea, and more. This can make for a wide range of choices in the planning of the experiment. Every experiment will need careful consideration of the controlled variables too.

Methods of preventing decay in vegetables

This is an applied study of inhibition of enzyme reactions, or the prevention of the growth of spoiling bacteria. It is vital to decide which one of these is the focus of the research question, at the beginning. The way in which bacteria might spoil food could be influenced by the origins of the food, it's cultivation, organic or not, and any treatment after harvesting, or during transport. Controlling these factors will be a challenge but might be possible by washing in diluted antiseptic solution. Of cause all the normal problems of control of temperature and other factors during the experiment will be important too. There are lots of possible research questions, and using a single type of vegetable will be more focused than comparing several.

If enzyme reactions are thought to cause the decay this will make for another research pathway. Of course reactions will happen more slowly at cold temperatures, but there may be inhibitors or catalysts in the environment such as plant hormones, acids or oxygen. Perhaps the enzymes of one fruit (like bananas) will have an effect on another, we all know that storage of bananas and unripe Kiwis can speed up ripening but do they speed up spoiling?

The role of stomata in controlling transpiration rates - using a

microscope

Why not use a microscope to investigate a biological process like transpiration? Of course factors which influence the rate of transpiration such as temperature and humidity will need to be controlled if the rate of transpiration is the

dependent variable and stomata 'openness' or 'size' is the independent variable but there are other possibilities. It might be possible to sample leaves in different parts of a plant, so the independent variable is the position on the plant. Leaves in sunshine, or shade, leaves on a plant which is gradually experiencing more water stress, leaves in rapidly moving air (like on a windy day) compared to slower moving air. Painting nail varnish onto the leaves may be a good solution, but there are clip on telephone microscopes which could snap a photo in which stomata would be visible.

The effects of playing the flute on asthma, studied using a peak flow meter.

Miller and Goss (in 2013) published an interesting paper which explored physiological responses to playing the American flute. In their methods they show that listening to the music has little effect, but in the conclusions they suggest that beneficial effects of playing a wind instrument are worthy of further study. This would be a very nice starting point for an individual investigation, especially for a student who plays a wind instrument. One suggestion is that playing the flute may help people with asthma and it is quite easy to measure peak flow in the lab using a spirometer or a simple peak flow meter.

Testing enzyme activity in the presence of a suspected inhibitor.

This is a simple twist on a standard enzyme experiment. Students should be able to design an experiment to collect data testing the idea that X inhibitor (eg. a heavy metal or ethanol) either does or doesn't inhibit an enzyme. If the experiment is designed carefully it may be possible to decide whether the inhibition is reversible or not, and / or if the inhibitor is competitive or non-competitive. Of course the usual controls of the other variables which affect enzymes will be needed. It would also be helpful to test if the indicator is affected by the suspected enzyme inhibitor, if there is one.

Investigation of a factor which might affect skin temperature.

This seems like an easy investigation but it certainly has challenges. Careful organise for the collection of meaningful data and controlling variables other than the IV will be required. Consent forms for participants are essential and some biological reasoning for the possibility of a correlation will be important. Possible specific research questions could address temperatures of different parts of the skin, related to hair, or muscle, or blood circulation. alternatively differences between different people, some have cold hands and feet for example.

Data based investigation of animal diseases

In many countries the occurrence of diseases in farm animals or fisheries is recorded by a national agricultural service. At the same time there are possible causes of the spread of disease, or animal susceptibility to infections. For example, migratory birds could spread disease to free range chicken farms, rainfall could affect the spread of a disease, perhaps the location of the farmers market, or other factors affecting contact between cattle. Climate data, or geographical location of different farms could be used to test for correlations. In this type of study it is important to be selective about the data and to try to control other variables, for example the size of farms, the breed of animals, etc.

The effect of an abiotic factor on a single feature of leaf structure

This is an interesting opportunity to investigate form and function in the leaves of plants. There are several features of plant leaves which are easy to see with the naked eye, such as shape and colour. Other features require some kind of measuring tool, for example a colorimeter for pigment composition, or for measuring thickness. There are also features which may be interesting to study with a microscope for example, stomata density, the shape of pallisade mesophyll cells, the presence or absence of hairs, or the density of hairs on different parts of the leaf might be interesting. Abiotic factors could be identified and the sites of leaf sampling could be carefully chosen to incorporate control of variables. While this might be difficult there is a lot which can be considered such as amount of water in the soil, light levels, wind speed, etc.

The effect of aphids on a single aspect of plant structure.

Beans and roses grown in a garden often suffer from the presence of aphids. In my garden the aphids are sometimes actually cultivated by ants. Does this herbivory affect any structures on the plant leaves. Do the leaves respond to the presence of the aphids? For example could there be an increase in the thickness of epithelial cells in the leaf, could there be an increase in the density of hairs on the veins of the leaf, alternatively could the presence of leaf hairs on the veins affect the distribution of aphids on the leaves? There are plenty of options in this kind of study but it could only be carried out during the summer / autumn season when leaves have had time to respond.

The effects of aquatic plants on the nitrate content of water.

We know that plants take up nitrates from their roots by diffusion or active transport and that ecological swimming pools can be constructed using plants and gravel instead of filters. However, in high nitrate water the algae can bloom and cause eutrophication. Would other plants cause eutrophication at high nitrate levels, or is it the fact the algae reduce light penetration in the water and thus lead to the death of some of the algae and the growth of bacteria which causes eutrophication? This topic is a rich source of research questions and it is quite easy to test the nitrate (and other ion) content of water. What about experimenting with lettuce plants in a hydroponics system or in a school aquarium?

Other microscope ideas -

leaf structure, relative depth of palisade cells, or number of layers of palisade cells in ivy from different locations,

petals insect navigation and pollination,

human skin suppleness and wrinkles,

root hair distribution in germinating seeds, or garlic roots,

ecological changes in microscopic organisms in a hay infusion,

cytoplasmic streaming in *Elodea* chloroplasts under different light intensities.

Note: I must look at some of the microscope sites for more ideas.