# IGCSE BIOLOGY 610 PAPER 6

## PLAN AN INVESTIGATION

## SOME OF THE COMMON TOPICS

**Most Common Investigation Topics**

- Osmosis in potato strips
- Enzyme activity (effect of temperature or pH)
- Photosynthesis rate in pondweed
- Respiration rate (using seeds or insects)
- Food tests (starch, reducing sugar, protein, fat)
- Diffusion (e.g., dye in agar jelly)
- Transpiration in leaves (weight loss, cobalt chloride paper)
- Germination requirements (water, oxygen, temperature)
- Effect of light on seedling growth (phototropism)
- Microscopy (magnification calculation, drawing cells)
- Human gas exchange (breathing rate vs exercise)
- Heart rate changes after exercise
- Testing leaf for starch (chlorophyll, light)
- Testing for carbon dioxide uptake/release

## Germination requirements (water, oxygen, temperature)

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Presence or absence of water, oxygen availability, and different temperature conditions (e.g., optimal, low, high). |
| **Dependent Variable (DV)** | Germination rate or percentage of seeds that successfully germinate (e.g., seed coat break, radicle emergence). |
| **Controlled Variables (CV)** | Same seed type and batch, same light exposure, same seed quantity per container, same soil or germination medium, consistent timing for observations. |
| **Method** | 1. Prepare groups of seeds under different conditions: varying water availability (wet/dry), oxygen availability (normal/airtight), and temperatures (e.g., 5°C, 20°C, 35°C).<br>2. Place seeds on moist cotton or soil as needed.<br>3. Monitor seeds daily for germination (radicle emergence).<br>4. Record germination counts or percentage over a set period (e.g., 7-14 days). |
| **Reliability** | Use multiple seeds per condition (20+), replicate the experiment (2-3 times), keep environmental factors constant across groups except IV, and average results. |
| **Safety** | Handle seeds and soil with clean hands or gloves, use safe containers, avoid mold by not overwatering, dispose of waste properly, maintain good hygiene during handling. |

## Effect of light on seedling growth (phototropism).

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Direction or presence of light (e.g., light source positioned on one side, full light, partial light, or darkness). |
| **Dependent Variable (DV)** | Growth direction and length of seedlings (measured by bending angle towards light and height/length of seedlings). |
| **Controlled Variables (CV)** | Same seed type and age, same soil or growing medium, identical watering schedule, same temperature, same duration of exposure, and consistent distance from light source. |
| **Method** | 1. Plant seeds in pots or petri dishes with cotton/water or soil.<br>2. Allow seeds to germinate.<br>3. Position seedlings under different light conditions (light on one side, darkness, full light).<br>4. Measure seedling height and/or angle of bending daily for about a week.<br>5. Record and compare results. |
| **Reliability** | Use multiple seedlings per condition (minimum 3-10) for repeats, keep environmental factors constant, measure daily, and take average growth values. Run 3 or more trials for consistency. |
| **Safety** | Handle scissors carefully when cutting pots or lids, avoid electrical hazards with grow lights, water carefully to avoid slips or spills, wash hands after handling soil or seeds, and work in well-ventilated space. |

## Testing leaf for starch (chlorophyll, light)

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Presence/absence of light (e.g., covering part of leaf with foil) and presence/absence of chlorophyll (variegated vs. green leaf parts). |
| **Dependent Variable (DV)** | Presence of starch in the leaf detected by blue-black coloration after iodine solution application. |
| **Controlled Variables (CV)** | Same leaf type and size, exposure duration to light, temperature during boiling and ethanol treatment, iodine concentration, time in iodine, and ethanol boiling time. |
| **Method** | 1. De-starch plant by keeping in dark 24 hrs.<br>2. Expose leaf to light with part covered by foil (IV).<br>3. Boil leaf in water to kill cells.<br>4. Boil in ethanol to remove chlorophyll.<br>5. Rinse in cold water.<br>6. Add iodine solution.<br>7. Observe color change for starch presence (DV). |
| **Reliability** | Repeat with multiple leaves/plants, consistent timing and conditions, use white tile for clear observation, full decolorization, and avoid excess iodine. |

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| **Safety** | Handle boiling water/ethanol carefully, boil ethanol in a water bath (flammable), use goggles and gloves, work in ventilated area, use forceps for hot leaf, and dispose chemicals safely. |

## Human gas exchange (breathing rate vs exercise)

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Exercise (e.g., resting vs after set exercise duration like running or jumping for 4 minutes). |
| **Dependent Variable (DV)** | Breathing rate (breaths per minute), measured by counting breaths over a fixed time (usually 15 seconds multiplied by 4). |
| **Controlled Variables (CV)** | Same person or similar participants, time of day, exercise intensity and duration, position during measurements (e.g., sitting), rest time between trials, counting method/time intervals. |
| **Method** | 1. Measure resting breathing rate (count breaths for 15s, multiply by 4).<br>2. Perform exercise for set time (e.g., 4 minutes).<br>3. Immediately measure breathing rate again (same counting method).<br>4. Repeat measurements at intervals (e.g., every minute for 5 mins) after exercise.<br>5. Compare breathing rates before, during, and after exercise. |
| **Reliability** | Repeat measurements multiple times, use more than one participant, standardize exercise intensity and timing, consistent counting intervals, average results across trials. |

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| **Safety** | Ensure participants are healthy and not at risk for intense exercise, warm-up and cool-down periods, do not overexert, measure in safe environment with supervision if needed, stop if discomfort occurs. |

## Heart rate changes after exercise

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Exercise intensity/duration (e.g., set vigorous activity like jumping rope, jogging for 2-4 minutes). |
| **Dependent Variable (DV)** | Heart rate (beats per minute, bpm) during rest, peak exercise, and post-exercise recovery (measured at intervals after exercise). |
| **Controlled Variables (CV)** | Same participant or similar group, same exercise type and duration, time of day, resting position, rest period before and after exercise, consistent heart rate measurement method. |
| **Method** | 1. Measure resting heart rate.<br>2. Participant performs exercise (standardized for time and type).<br>3. Measure heart rate immediately after exercise and at regular intervals (e.g., every 1-2 minutes) during recovery until it returns near resting rate.<br>4. Record recovery time and heart rate drop between intervals. |
| **Reliability** | Repeat measurements multiple times, use several participants, ensure consistent exercise intensity, keep measurement methods constant, average repeated trials. |

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| **Safety** | Ensure participant is healthy for exercise, warm-up and cool-down adequately, monitor for discomfort, stop if adverse symptoms occur, exercise in safe environment with supervision if needed. |

## Testing for carbon dioxide uptake/release

| PLAN | INVESTIGATION |
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| **Independent Variable (IV)** | Light intensity or presence/absence of light (affects rate of photosynthesis), type of plant or leaf area, environmental conditions like temperature. |
| **Dependent Variable (DV)** | Rate of carbon dioxide uptake (decrease in $CO_2$ concentration) or release (increase in $CO_2$ concentration), usually measured in ppm or concentration units. |
| **Controlled Variables (CV)** | Same plant species, same leaf or plant size, consistent temperature, controlled humidity, same measurement duration, airtight conditions in gas chamber. |
| **Method** | 1. Place leaf/plant in sealed chamber connected to $CO_2$ sensor (e.g., IRGA or gas analyzer).<br>2. Allow leaf to photosynthesize under light or be in dark for respiration.<br>3. Measure change in $CO_2$ concentration over time in chamber.<br>4. Compare uptake (photosynthesis) vs release (respiration) rates. |
| **Reliability** | Repeat measurements with multiple plants, calibrate $CO_2$ sensor before experiments, control environmental variables carefully, use same chamber setup, run multiple trials. |

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| **Safety** | Handle equipment carefully, avoid damage to plants during setup, ensure chambers are properly sealed to avoid gas leaks, handle electrical devices with care, work in well-ventilated area if needed. |

## Osmosis in Potato Strips

- **Aim:** Investigate effect of sucrose concentration on potato mass.
- **Variables:** Independent – sucrose concentration; Dependent – change in potato mass/length; Controls – size, type of potato, volume of solution, time.[1]
- **Method:** Cut equal potato strips, blot and weigh. Place in different sucrose concentrations for 30 mins. Remove, blot, reweigh. Calculate percentage change.
- **Reliability:** Repeat for 3 strips per solution. Average results.
- **Safety:** Use clean blades, wear goggles.

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| **Independent Variable (IV)** | Concentration of sucrose solution (varied % sugar solutions). |
| **Dependent Variable (DV)** | Change in mass or length of potato strips after soaking (measured in grams or cm). |
| **Controlled Variables (CV)** | Size and initial mass/length of potato strips, soaking time, temperature, volume of solution, potato type. |
| **Method** | 1. Cut equal-sized potato strips using cork borer and knife.<br>2. Measure initial mass/length.<br>3. Place strips into different sucrose solutions.<br>4. Leave for set time (e.g., 2 hours). |

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| | 5. Remove, blot dry, then measure final mass/length.<br>6. Calculate change in mass/length due to osmosis. |
| **Reliability** | Use multiple strips per solution concentration, repeat the experiment, keep other variables constant, measure accurately, average results. |
| **Safety** | Use sharp tools carefully (knife, cork borer), wear safety goggles, handle solutions carefully, clean workspace, wash hands after. |

## Enzyme Activity (Effect of Temperature)

- **Aim:** Investigate how temperature affects breakdown of starch by amylase.
- **Variables:** Independent – temperature; Dependent – time to no starch (iodine test stays yellow); Controls – amylase and starch concentration/volume, pH, total solution volume, mixing time.[4]
- **Method:** Prepare starch/amylase mix, place in water baths of different temperatures. At intervals, test with iodine. Record time till starch is absent.
- **Reliability:** Repeat 3 times per temperature, average.
- **Safety:** Handle hot water carefully.

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| **Independent Variable (IV)** | Temperature of the environment where enzyme activity occurs (e.g., 0°C, 20°C, 37°C, 60°C, 100°C). |
| **Dependent Variable (DV)** | Rate of enzyme activity measured by either the height of oxygen bubbles (catalase), time taken for starch breakdown (amylase), or amount of product formed. |
| **Controlled Variables (CV)** | Enzyme concentration, substrate concentration, pH (kept constant with buffer), volume of solutions, incubation time, and method of measurement. |
| **Method** | 1. Prepare enzyme and substrate solutions. 2. Place them in test tubes at different temperatures using water baths. 3. Allow temperature to stabilize. 4. Mix enzyme and substrate. 5. Measure enzyme activity (e.g., time for starch to disappear, foam height from catalase). 6. Record data and repeat for different temperatures. |

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| **Reliability** | Use multiple replicates per temperature, keep other variables constant, repeat the experiment, and average results. |
| **Safety** | Handle water baths carefully (hot water), use gloves and goggles, avoid direct contact with enzymes and chemicals, clean spills, and use proper disposal methods for solutions**.** |

## Photosynthesis Rate in Pondweed

- **Aim:** Investigate effect of light intensity on oxygen production.
- **Variables:** Independent – lamp distance; Dependent – bubbles per minute; Controls – pondweed species/size, water volume/temp.[3]
- **Method:** Place pondweed in test tube filled with water. Place lamp at set distances, count bubbles for 1 min at each. Repeat. Plot graph.
- **Reliability:** Average bubble counts for repeats.
- **Safety:** Avoid contact of water with electrical equipment.

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| **Independent Variable (IV)** | Light intensity (varied by changing distance of light source from pondweed). |
| **Dependent Variable (DV)** | Rate of photosynthesis measured by number of oxygen bubbles produced per minute or volume of oxygen collected. |
| **Controlled Variables (CV)** | Same species and size of pondweed, temperature, carbon dioxide concentration (using sodium bicarbonate solution), duration of measurement, light color, water volume. |
| **Method** | 1. Place pondweed in a beaker with sodium hydrogen carbonate solution (providing $CO_2$).<br>2. Position a light source at a set distance.<br>3. Cut the pondweed stem underwater at an angle. |

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| | 4. Allow it to adjust to light for a few minutes.<br><br>5. Count oxygen bubbles from the cut end for one minute or collect gas volume.<br><br>6. Repeat for different light distances.<br><br>7. Record and analyze data. |
| **Reliability** | Repeat each measurement several times, use multiple pondweed samples, maintain constant temperature, control other variables, calculate average bubble rate or gas volume. |
| **Safety** | Handle glassware carefully, avoid electric hazards with lamps near water, cut stems carefully using scissors, avoid direct contact with sodium bicarbonate solution, work in a clean dry area. |

## Food Tests Investigation

- **Aim:** Identify food content in samples using biochemical tests.
- **Variables:** None, different food samples.
- **Method:** Test each food for starch (iodine), reducing sugar (Benedict's), protein (biuret), fat (ethanol).
- **Reliability:** Test multiple samples or repeat same sample.
- **Safety:** Handle chemicals with care.

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| **Independent Variable (IV)** | Type of food sample being tested (e.g., starch-rich, protein-rich, lipid-containing foods). |
| **Dependent Variable (DV)** | Presence or absence of specific nutrients indicated by color change in food tests (e.g., blue-black for starch, purple for protein). |
| **Controlled Variables (CV)** | Volume of reagent added, amount of food sample, temperature during test (especially for Benedict's), time allowed for color change, use of same test tubes/equipment. |
| **Method** | 1. Prepare small amounts of different food samples (liquid or crushed solids).<br>2. Perform specific tests:<br>- Iodine test for starch (add iodine solution, look for blue-black color) |

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| | - Benedict's test for reducing sugars (add Benedict's solution, heat in water bath, color change to brick red indicates positive)<br>- Biuret test for protein (add Biuret solution, purple color indicates positive)<br>- Emulsion or Sudan III test for lipids (mix with ethanol, add water, cloudy emulsion or red layer indicates positive).<br>3. Record color changes. |
| **Reliability** | Use fresh reagents, repeat tests, use control samples (known positive and negative), perform tests under same conditions, use multiple food samples, record observations accurately. |
| **Safety** | Wear safety goggles and gloves, handle chemicals with care (iodine, Benedict's solution, Biuret reagent, Sudan III/ethanol are irritants or flammable), avoid ingestion, dispose waste properly, avoid contact with skin and eyes. |

## Respiration Rate (Seeds/Insects)

- **Aim:** Investigate effect of temperature on rate of respiration.
- **Variables:** Independent – temperature; Dependent – $CO_2$ produced/time; Controls – number/type of organism, mass, flask volume.[6]
- **Method:** Place seeds/insects in respirometer with soda lime. Put in water baths at different temps. Measure rate of movement of indicator liquid.
- **Reliability:** Repeat at each temp, average readings.
- **Safety:** Handle living organisms ethically.

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| **Independent Variable (IV)** | Organism type (germinating seeds or insects), temperature of environment, exercise/activity level of insects (if applicable). |
| **Dependent Variable (DV)** | Rate of respiration measured by oxygen uptake (volume change in respirometer), typically expressed as $cm^3$ $O_2$ consumed per minute. |
| **Controlled Variables (CV)** | Same number and size of seeds or insects, same apparatus, same duration of measurement, fixed $CO_2$ absorption (using KOH), controlled temperature, airtight connections. |
| **Method** | 1. Set up respirometer with living organisms in one tube and control (glass beads) in another.<br>2. Use KOH to absorb $CO_2$, measuring oxygen consumption.<br>3. Measure movement of liquid manometer over a set time. |

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| | 4. Repeat at different temperatures or with different organism states (germinating/non-germinating).<br>5. Calculate respiration rate from volume change (cylinder volume formula). |
| **Reliability** | Multiple replicates per condition, consistent organism preparation, use fresh KOH solution, airtight setup, experiment repeated across temperatures or organism conditions, average results. |
| **Safety** | Handle living organisms with care, avoid contamination, use KOH carefully (skin irritant, corrosive), ensure airtight connections to prevent gas leaks, use protective gloves and goggles, dispose of chemicals safely. |

## Transpiration in Leaves

- **Aim:** Investigate effect of wind on transpiration rate.
- **Variables:** Independent – wind speed; Dependent – time for cobalt chloride paper to turn pink; Controls – leaf surface area, starting humidity/temp, paper placement.[2]
- **Method:** Attach cobalt chloride paper to identical leaves, expose to different wind speeds, record time for colour change.
- **Reliability:** Repeat for more leaves per wind speed, average.
- **Safety:** Avoid inhaling cobalt chloride dust.

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| **Independent Variable (IV)** | Environmental factors affecting transpiration such as light intensity, temperature, humidity, and air flow (wind). |
| **Dependent Variable (DV)** | Rate of transpiration measured by distance moved by air bubble in potometer, volume of water lost, or increase in water vapor. |
| **Controlled Variables (CV)** | Same plant species, size and type of leaf, duration of experiment, volume of water in potometer, airtight setup, same time of day. |
| **Method** | 1. Cut a shoot underwater to prevent air bubbles in xylem.<br>2. Attach the shoot to a potometer filled with water, ensuring airtight seal with vaseline.<br>3. Introduce an air bubble in the capillary tube.<br>4. Place under set environmental conditions. |

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| | 5. Measure distance air bubble moves over set time (e.g., 30-60 minutes).<br>6. Repeat for different IV conditions. |
| **Reliability** | Repeat measurements multiple times, use several shoots, keep other factors constant, calibrate potometer before use, average results. |
| **Safety** | Handle sharp tools carefully (scissors/razor), avoid spills, prevent breakage of glassware, ensure secure airtight setup to avoid water spills, work safely with electrical equipment if using lamps/fans. |