Feeding a growing world: Observing the synthesis of starch from reducing sugar

Teacher notes

Introduction

The supernatant liquor left over from the main investigation of reducing-sugar content in potatoes can be used for this simple observation of the enzyme-catalysed synthesis of starch from reducing sugar. The enzyme is potato phosphorylase, present in potato tuber cells.

Students may be familiar with the two-stage catabolic digestion of starch to the disaccharide maltose and then to the monosaccharide glucose. For the **anabolic synthesis** of starch, the best substrate is glucose-1-phosphate, a compound found inside cells. Hydrolysis of the glucose-1-phosphate provides the energy needed to synthesise the starch molecules.

There is an initial lag in the release of the phosphate from the hydrolysis of glucose-1-phosphate and the formation of starch. The addition of starch reduces this lag phase and suggests autocatalysis – the product of the reaction increases the catalysis by the enzyme.

Assumed prior learning

- Involvement of enzymes in biological processes.
- Starch as a polymer of glucose.
- Starch test with iodine.
- Starch storage in potato tubers.

Learning objectives

- View and time the enzyme-catalysed synthesis of starch.
- Understand the concept of autocatalysis.

Practical investigation: starch synthesis

Safety

Carry out a risk assessment with the students. Ask what hazards they can predict and how to control them.

Students should wear eye protection and take care when using scalpel blades and when handling microscope slides and coverslips.

Make sure students know how to safely and properly use a centrifuge, including balancing the tubes.

Centrifuges should meet CLEAPSS recommendations in Section 9.6 of the CLEAPSS Handbook, or SSERC guidelines in Scotland, and should have a lock or automatically cut off power to the rotor when

the lid is raised. If the centrifuge does not have a lock, make sure that a notice is clearly visible warning students not to lift the lid until they hear that the rotor has stopped.

The practical investigation is described in the student activity sheet.

Answers to questions

1. Glucose-1-phosphate (substrate) and enzyme (glucose phosphorylase/starch synthase). May also mention a suitable temperature to allow the reaction to proceed at optimum rate, and a suitable pH.
2. Autocatalysis is involved – the product, starch, catalyses the reaction.
3. Colorimetry; use yellow filter; measure absorption or transmission; calibrate first with cuvettes containing known small concentrations of soluble starch with one drop of iodine/KI solution; set up the potato extract and glucose-1-phosphate in test tubes in a water bath at 25 °C. Set up a series of cuvettes containing one drop iodine/KI solution; at one-minute intervals for 20–25 minutes, take out enough of the reactant mixture (shake/stir first) and add to a cuvette and read absorption/transmission. Use calibration curve to find concentration of starch accumulating.
4. Set up investigation as above, but use maltose instead of glucose-1-phosphate.
5. Osmotically inert; takes up less space than equivalent number of monosaccharide molecules.
6. As energy source (starch is energy store) for respiration/ATP production.
7. When potato tubers are sprouting (in spring) to provide respiratory substrate for ATP synthesis for anabolic reactions (e.g. mitosis, protein synthesis, DNA replication) necessary to make new plants/leaves.
8. Sinks: During summer and autumn when leaves are photosynthesising and sugar is translocated to underground stem tubers for storage as starch over winter.

   Sources: During spring when potato tubers are germinating/sprouting and developing into new potato plants, starch is hydrolysed to sugar for respiration.