www.scienceinschool.org

Explore enzymes and the science of lactose intolerance using lactase tablets

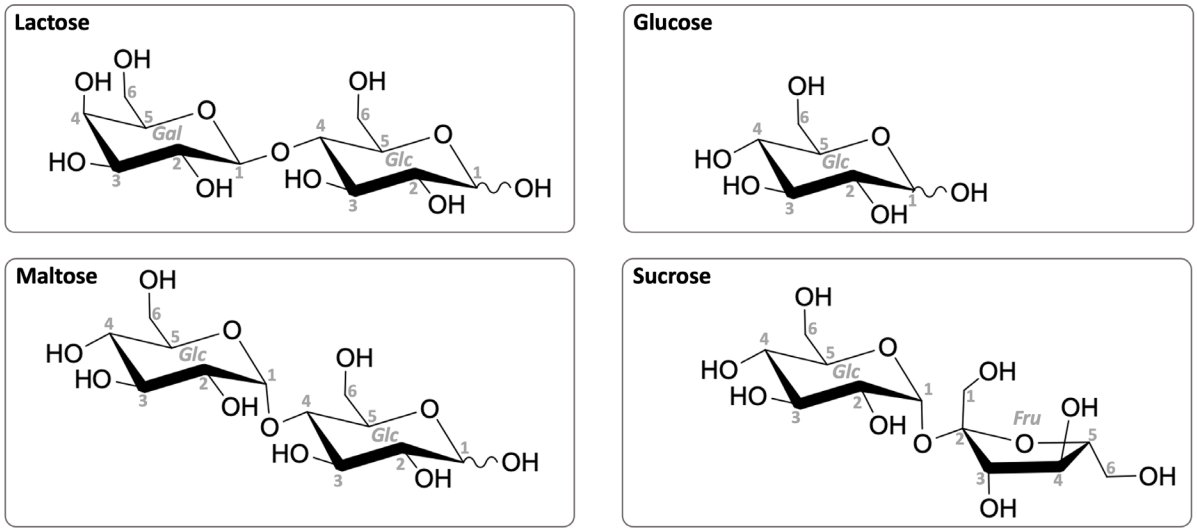
Model answers

Worksheet 1: model answers

1) Perform the experiment 'Detecting different sugars using Fearon's reagent'.
2) Record your observations by completing Table 1, column 2.
3) Study the molecular structures of the sugars depicted in the figure and complete the remaining columns of Table 1.
4) Summarize your results by answering the following questions:
    a) Which colour is observed using Fearon's reagent on monosaccharides like glucose? (Tip: identical results are observed with monosaccharides galactose and fructose.)
    b) Which colour is observed using Fearon's reagent on disaccharides with different glycosidic bonds?
    c) What kinds of saccharides are present in whole milk and oat milk?

Table 1: Results

Sugar/milk	**Colour detected by using Fearon's reagent**	**Monosaccharide or disaccharide (if applicable)**	**Type of glycosidic bond (if present)**
Lactose	red	disaccharide	1,4-linked
Maltose	red	disaccharide	1,4-linked
Glucose	yellow	monosaccharide	(none)
Sucrose	colourless	disaccharide	1,2-linked
Whole milk	red	disaccharide	1,4-linked
Oat milk	red	disaccharide	1,4-linked



Molecular structures of sugars, shown here as chair conformation. Respective monosaccharide units (galactose, Gal; glucose, Glc; fructose, Fru) and carbon-atom numbers are indicated in grey; wavy bonds indicate reductive or ring-opening capabilities.

Image courtesy of the author

Summary: Experimental results show that 1,4-linked disaccharides (lactose, maltose) can be detected using Fearon's reagent by a red colour. One or both of these sugars are present in both whole and oat milk. In addition, glucose (and other reducing monosaccharides) can be detected in solution by the formation of a yellow dye. 1,2-Linked disaccharides can be detected by the solution being colourless.

Worksheet 2: model answers

1) Perform the experiment 'Investigating lactase activity on different sugars, whole milk, and oat milk'.
2) Record your observation by completing Table 1, column 2.
3) Complete Table 1, column 3. (Tip: remember what colours the Fearon test gives with monosaccharides and disaccharides.)
4) Summarize your results in a short text by answering the following questions:
    a) Why is there a colour change in lactose and whole milk but not in maltose and oat milk?
    b) What does this result tell you about the substrate specificity of an enzyme?
    c) Make a guess as to which sugar might be in oat milk.

Table 1: results

Sugarz/milk	**Colour detected by using Fearon's reagent and lactase**	**Are monosaccharides or 1,4-linked disaccharides contained in the sample?**
Lactose	yellow	monosaccharide
Maltose	red	1,4-linked disaccharide
Whole milk	yellow	monosaccharide
Oat milk	red	1,4-linked disaccharide

Summary: A preparatory experiment (= extension activity) demonstrated the presence of 1,4-linked disaccharides in lactose and maltose solutions, whole milk, and oat milk through the formation of a red dye using Fearon's reagent.

However, applying this test to sugar solutions and milk following lactase digestion, as performed in this experiment, gives different results: the absence of said red dye in test tubes 1 (lactose) and 3 (whole milk) indicates the disappearance of 1,4-linked disaccharides from these liquids, while the appearance of a yellow dye points to the presence of glucose, a known product of lactose breakdown. Thus, the results in test tubes 1 (lactose) and 3 (whole milk) demonstrate the presence of lactose in whole milk, as well as the successful breakdown of milk sugar (lactose) into glucose and galactose by the enzyme lactase in both assays.

In contrast, a red dye still forms in test tubes 2 (maltose) and 4 (oat milk) following lactase treatment. Hence, maltose cannot be digested by lactase, demonstrating the substrate specificity of this enzyme. Furthermore, the results indicate the presence of maltose (or a different) 1,4-linked disaccharide in oat milk, which cannot be digested by lactase.

Worksheet 3: model answers

1) Perform the experiment 'Why lactase tablets should not be taken on an empty stomach'.
2) Record your observations by completing Table 1, column 2.
3) Complete Table 1, column 3. (Tip: remember what colours the Fearon test gives with monosaccharides and disaccharides.)
4) Summarize your results in a short text. What effect does stomach acid have on the enzyme lactase?

Table 1: results

Sugar/milk	**Colour detected by using Fearon's reagent and lactase**	**Are monosaccharides or 1,4-linked-disaccharides contained in the sample?**
Lactose	red	1,4-linked disaccharide
Maltose	red	1,4-linked disaccharide
Whole milk	red	1,4-linked disaccharide
Oat milk	red	1,4-linked disaccharide

Summary: Despite the addition of the enzyme lactase, 1,4-linked disaccharides can still be detected in all solutions. We can see that by the red dye. The enzyme is therefore dependent on the pH value and is rendered ineffective by gastric acid.