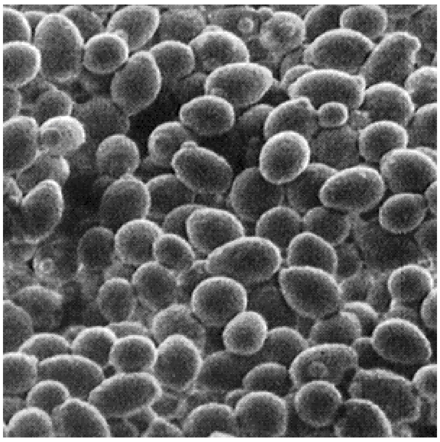
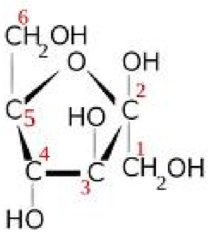
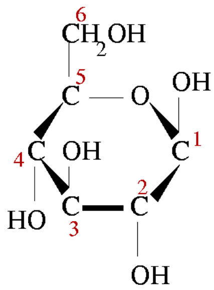


Fermentation : Teacher Guide

D-glucose





D-fructose

Ontwikkeld voor scholen binnen Bètapartners

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Klas: 5 vwo

Vak: Scheikunde

1. Teacher Guide: Fermentation

Teaching guide for six lessons. Study time for the students: 10 – 20 hrs

Below you find a time schedule for the inquiry project, 'Fermentation'. The first three parts (1-3) are integrated in the chemistry lessons and the others (4-8) will be done outside the chemistry lessons. The students' first task is to become familiar with the inquiry. Therefore you will give a demonstration and the students will do a guide experiment. After this the students will analyse and judge the research done by Slaa, Gnode & Else (2009). These three researchers investigated the optimal temperature to produce bio-ethanol in the fermentation process of D-glucose by yeast cells. Some questions arise. How 'fair' and accurate is their research? Are their research results trustworthy? Are their conclusions valid? These are questions that the students will answer by critically analysing the article written by these three researchers. Doing this we expect the students – in a team of two – to perform a better inquiry. As a team they will write a first report on their inquiry. You need to publish the first reports on a website/*elo*. In this way the students can discuss their results with peers, giving and receiving suggestions. They have to use these suggestions to improve their report, when writing their final article. All articles will compete for a research award.

Schedule for the procedure of the 'Fermentation' inquiry project (10-20 hours):

Procedure	Part of the project
Start with the task	1. *Understand aim and nature of the inquiry project* 2. *Understand the research of Slaa, Gnode &Else:* • Predict, observe, explain • Conduct guide experiment • Judge accuracy, reliability and validity
Conduct research	3. *Own inquiry in teams*
Write report	4. *Report*
Send first report	5. *Report* to: <u>teacher</u> All reports on a website/*elo*
Peer discussion	6. *Peer discussion* The peer discussion on: • Accuracy in the inquiry plan • Accuracy in performing the inquiry • Reliability of the results • Validity of the conclusions
Process comments	7. *Teamwork*: Processing the comments received, improve report
Send final article	8. *Report* to: <u>teacher</u>
Receive prize	All final articles on a website/*elo* Jury selects the best inquiry

Before the six lessons

1. An introduction in class of approximately 15 minutes, with:
   A. The aims of the inquiry task
   The students:
   - Gain knowledge on the process of fermentation
   - Gain knowledge on the method of measuring mass of carbon dioxide gas
   - Judge accuracy and reliability in a research
   - Design a 'fair' inquiry, measure accurately, determine whether measurements are reliable and lead to valid conclusions
   - Are part of a *simulated research community* and gain knowledge on peer review in an Internet symposium

   How to achieve these aims?
   1. Do the inquiry task guided by the questions in the workbook
   2. Predict, observe and explain in the demonstration: sugar and baker's yeast
   3. Conduct the guide experiment: how much carbon dioxide?
   4. Analyse/judge the Slaa, Gnode & Else (2009) article: "Yeast and fermentation"
   5. Formulate own inquiry question and plan the experiments to answer this question
   6. Conduct planned experiments
   7. Write a report about this inquiry and submit the report
   8. Discuss results with peers in an Internet Fermentation symposium
   9. Rewrite report into a final version or article
   10. Submit final article to an independent jury, e.g. other science colleagues or experts from outside; they select the best inquiry and award a prize

   B. The nature of the inquiry task
   - A scientific inquiry with measuring accurately

   Why is accurate and reliable research so important?
   - To acquire knowledge
   - An inquiry should be accurate, reliable and repeatable in order to convince other researchers of the (tentative) reliability of the results

   Why is the inquiry interesting?
   The students can, in teams:
   - Acquire chemical knowledge and knowledge about empirical evidence
   - Critically discuss empirical evidence in their peers' inquiry
   - Win a research award
   - Publish their results on the Internet/*elo* or in the school magazine

   What should be handed in for a mark?
   - The filled student workbook
   - The inquiry plan
   - The participation in the peer discussion
   - The final article
2. Distribute the printed student materials (workbook) and the article of Slaa, Gnode & Else, 2009.
3. Focus the students' attention on the 'Study Guide' (workbook p. 25) and the planning of the project (workbook p. 5)
4. Ask the students to make teams of two or three

Lesson 1: Understand what Slaa, Gnode & Else (2009) investigated

Introduction

1. Introduce the workbook and the 'Planning', see Student **workbook p. 5**.
   Introduce what the students have to do in the first lesson. Refer to the workbook 'Study guide', **p. 25**.
2. Let the students read the introduction in the **workbook**, **p.3**.
   Refer to the list of concepts on **p. 26.** The students can fill out this list bit by bit as the project proceeds.

Demonstration: sugar and baker's yeast

3. Let the students *individually* predict and write down what they expect to happen when baker's yeast cells (*Saccharomyces cerevisiae*) are mixed with a sugar solution.
   Ask them to answer the questions in **2.1, workbook p. 6**.
4. Discuss the predictions (what they expect) and explanations (why they expect this).

Materials needed for the demonstration:	*Procedure:*
- A 0.5 L Erlenmeyer flask - Lukewarm distilled water - 36 g Sugar - A package of dried yeast cells - Calcium hydroxide solution	- Fill the Erlenmeyer with 200 mL lukewarm distilled water. Add the sugar and mix until it is dissolved. Add a package of dried baker's yeast and mix. - Detect the carbon dioxide gas by bubbling it through a calcium hydroxide solution.
Safety and remarks: N.B: no eating allowed in the lab	

5. Follow the procedure for the demonstration and ask the students – in their teams – to write down their observations, conclusion and explanation in **2.2., workbook p. 6 and 7**.
6. Discuss the observation that the bubbling indicates that a reaction occurred in which a gas is produced.
   Discuss the observation that the bubbles turn the calcium hydroxide solution cloudy concerning the detection of the gas being carbon dioxide.
   Discuss what reaction has occurred and relate it to the growth of yeast cells in an oxygen free environment

Homework

7. Ask the students to browse the Internet for information on fermentation of glucose. Ask them to write down their findings.
8. **Students should read the article of Slaa et al. (2009) on "Yeast and fermentation: the optimal temperature"**

Lesson 2 and 3: Thought experiment and judgement of Slaa, Gnode & Else's research

Introduction

1. Introduce what the students need to do in these lessons. Refer to **workbook "Study guide" p. 25**.

Thought experiment: how much carbon dioxide?

2. In teams the students discuss their expectation on the amount of carbon dioxide released **(3.1, workbook p. 8**).

3. Follow the procedure for the thought experiment and ask the students – in their teams – to write down their calculation of the maximum amount of carbon dioxide gas (in grams) that can be produced when yeast cells grow in a 18% D-glucose solution; **3.3. (i), workbook p. 8**

   Let them compare their calculation with the findings of Slaa et al. and discuss possible reasons for the difference; **3.3. (ii) and (iii), workbook p. 5**

   To support the thought experiment students can use the information they found on the Internet about D-glucose and fermentation.

Judging the research of Slaa, Gnode & Else, 2009

4. Let the students work (in teams) on the questions in **4.1. (i), (ii) and (iii), workbook p. 9-10.** After that ***discuss accurate measurement* [4.1. (i)]**, depends on e.g.:
   - Use of the same amount of L sugar solutions
   - Use of the same amount of mass of dried yeast cells
   - Use of the same concentration of the sugar solutions
   - Type of the thermometer
   - Use of the same thermometer before and after the experiment

   ***Discuss what to do to find out if a measurement is reliable* [4.1. (ii)]**:
   - Repeat the experiment
   - How many times to repeat, depends on the deviation between the measurements.

   ***Discuss reliability of a series of measurements* [4.1. (iii)]**, depends on:
   - The experiment should be set-up in a 'fair' way
   - All experiments should be conducted in exactly the same way
   - The deviation between measurements should not exceed 0.5%

5. Let the students (in teams) work out the rest of the questions in **chapter 4**; **p. 10 - 18**. Be sure that they get to know and understand the meaning of accuracy, reliability and validity in an inquiry.

Lesson 4: Students' own inquiry project: question and plan

Introduction:

1. Introduce what the students need to do: formulate inquiry question and design an inquiry plan (see workbook **"Study guide" p. 25**). As indicated on **p. 18** in the workbook the students are free to choose a certain inquiry, as long as it is related to fermentation.

   NB: possible inquiry projects are:
   -repeat the experiment
   -the effect of the acidity on the amount of carbon dioxide / ethanol produced,
   -fermentation of molasse, starch, corn, rice, soft drinks
   -fermentation of fructose, sucrose or other sugars
   -fermentation with different Fungi
   -fermentation in an environment with oxygen

Inquiry in teams:

2. Let the students work out the "inquiry in teams" (**workbook p. 18-21**)
   The students' inquiry questions should be:
   a. Unambiguous: contains one problem
   b. Relevant: related to the topic 'fermentation'
   c. Concrete: the question should contain the dependent variable and independent variable
   The student's inquiry plan should be handed in and checked on:

d. Is it related to the inquiry question?
e. Are the experiments not dangerous?
f. Is it too time consuming?
g. Students can vary a lot e.g. use different sources of 'sugar', change the acidity instead of the temperature, use different concentrations of sugar solutions, repeat the experiment of Slaa et al. (2009), etc.

3. Give the students feedback on their inquiry plans and a go!
4. Remind the students to keep a record of the inquiry (**workbook p. 22**).

Lesson 5 and 6: Conduction of the planned inquiry

Introduction:

1. Introduce what the students need to do:
   -discuss the teacher's comments on their plans,
   -execute the experiments, and
   -write down their observations.

Conduction of the experiments:

2. Let the students discuss the comments on their inquiry plan
3. Let the students execute their experiments
4. When the teams conduct their experiments, walk around and pay attention to:
   (i) Do they always measure in the same way?
   (ii) Do they accurately read the measurements?
   (iii) Do they repeat measurements?
   (iv) Do they write down their observations and measurements?

Further approach in the project

5. Discuss with the students the part in the project "Outside the chemistry lessons", so that all students know what still needs to be done

Outside the chemistry lessons

Check, now and then, whether the teams do the following:

1. Write a first version of their report with the following guidelines (**workbook p. 23**):
   - **Snappy** but relevant title
   - Names of the authors and submission date
   - **Summary** of the inquiry
   - **Introduction** with the reason of or problem in the inquiry guided by theory on the problem, with the **inquiry question** and with a **hypothesis** and the **theoretical assumptions** concerning the answer on the inquiry question.
   - **Experimental design** with a description of the method of investigation, of the way of handling the different **variables** and of the way of handling the **accuracy** in the experimental set-up and the measuring itself.
   - **Results** with a description of the **relevant observations**/ **measurements** that are correctly put into **tables and graphs**.
   - **Discussion and conclusion** with a critical interpretation of your results and with a valid answer to your inquiry question.
   - **Evaluation** with a critical description of the experimental set-up, with suggestions for improvements and further inquiry questions.
   - **Bibliography** with relevant resources like textbooks, websites, magazines, articles.

Further guidelines:

- Use correct **English** and use a layout in **2 columns**.
- Enclose a **picture** or **drawing** of the experimental set-up (max. **100 kb**).
- The report should not exceed **1500 words** (max. **500 kb**).
- **Label** your document with **teamnumber_first name_first name**.
- Add **separately the email addresses of all team members.**

2. **Submit** the **first version** of the report on a website / elo

3. **Discuss** the published report of at least another team in the Internet 'Fermentation' symposium
   Use the following questions (**workbook p. 24**):

- Are the dependent and independent variable visible in their inquiry question?
- Are their assumptions and theory about their hypothesis relevant?
- Did they manage the control variables well?
- Did they measure accurately?
- Are their results well presented?
- Did they track the reliability of their results?
- Can you approve of their discussion and conclusions?
- Did they write a critical evaluation?
- Did they come up with a relevant bibliography?

4. **Use comments from the peer discussion to improve their first report**

5. **Rewrite their report into a final version: article**
   Again use the guidelines on **p. 23** of the workbook

6. **Submit their final version**.

7. Ask the jury to find the best inquiry.