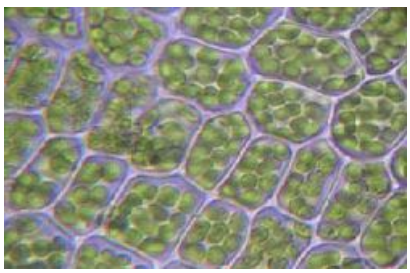
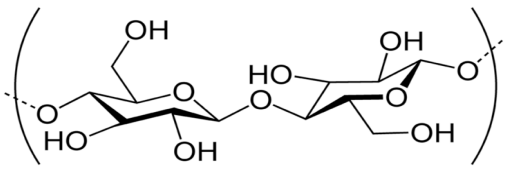
Gastronomy

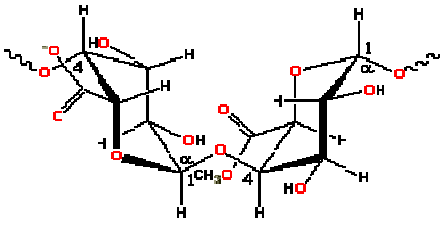
Plant cells separated by cell walls



Cell wall consists of:

Cellulose: a polymer of β-D glucose and Pectin containing substances





Ontwikkeld voor scholen binnen Bètapartners

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Klas: 5 vwo
Vak: Scheikunde

Explanation of the used icons:

 Observation

 Inquiry Question

 Theory formation

 Experiment

 Execution

 Conclusion

Name:

Cooperated with:

Mark:

Content

1. Introduction

Nowadays chemistry forms an integral part of daily life. Whether it is clothes, food, body care, cars, computers or drugs, everything people produce involves chemistry. Without inventions and chemical research the world would be very different. Chemists conduct research to acquire directly applicable knowledge, but sometimes also to understand things better. Most of the time they build on research done by other chemists. Building on knowledge of others can be advantageous because you do not need to examine things yourself. On the other hand previous research causes problems of its own. When results are not reliable, invalid conclusions may be drawn. Other research can be distorted by invalid information and this may have serious consequences. That's why accurate and reliable research is important.

One of the aims of this inquiry project is to understand how to measure **'fair'** and **accurate** in your inquiry. This accuracy is necessary to get **reliable results** in your inquiry. The only way to draw **valid conclusions** is to get reliable results.

Only when 'fair' and accurate measurements are taken, research results will be reliable and valid conclusions can be drawn. Research should also be designed in such a way that other researchers can repeat it. This does not mean, however, that knowledge based on research results in itself is justified. Further investigations or other research can yield results that are slightly different or even undermine acquired knowledge. Researchers communicate about their research methods and their conclusions in professional magazines, journals and on the Internet. Another way of informing the public and politicians is by means of papers and television.

The researchers Fels, Egnod & Bu (2008) investigated what amount of NaCl is leached out of plant cells when heated at different temperatures in a common salt solution. We take their article as a starting point in your inquiry project. How 'fair' and accurate is their research? Do you think their research results are trustworthy? Are their conclusions valid? These are questions that you will answer by critically analysing the article written by the three researchers. Following this we expect you – in a team of two – to perform a better inquiry. As a team you will write a first report on your inquiry. You mail this first report to your teacher. All of the first reports will be published on a website or elo. In this way you can discuss your results with peers in your class, giving and receiving suggestions. You have to use these suggestions to improve your report, when you write your final article.

A professional jury will judge all incoming final articles and will select the best inquiry. Those students whose inquiry is considered the best will win a *chemistry inquiry award*.

Below you find a time schedule for the inquiry project, 'Gastronomy'. The first three parts (1-3) are integrated in the chemistry lessons and the others (4-8) will be done outside the chemistry lessons. Your first task is to become familiar with the inquiry. Therefore your teacher will give you a demonstration and you will do a guide experiment. After this you will analyse and judge research done by Fels, Egnod & Bu (2008). Then you can start with your own inquiry.

Schedule for the procedure of the 'Gastronomy' 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 Fels, Egnod & Bu:* • 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: teacher 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: teacher All final articles on a website/*elo*
Receive prize	Jury selects the best inquiry

2. Demonstration: fresh and cooked green beans

Two portions of fresh green beans were differently treated. One portion was just kept at room temperature and the other portion was cooked for 5 minutes in a 0.1 mol/L NaCl solution. A solution with an amount of cooking salt or NaCl (s) that resembles the amount that usually is used for cooking.

2.1. Prediction

What do you expect about the texture of the uncooked and cooked green beans?

(i) For the texture of uncooked green beans I expect that …….

Why?

(ii) For the texture of the cooked green beans I expect that …….

Why?

2.2. Write down your observations, conclusion and explanation.

Now compare the texture of the uncooked beans with the texture of the cooked beans.

Observations

Conclusion

Explanation

(i) Do you still agree with your expectations as written under "prediction" [2.1. (i) and (ii)]? Yes / No, because

(ii) What causes the change in texture?

(iii) What is your explanation on this change in texture?

2.3. Browse the Internet for information on cooking vegetables.

Write down your findings

3. Guide experiment: how much NaCL?

Fresh green beans were cooked in a 0.1 mol NaCl/L.
What do you expect about the amount of NaCl in the recovered cooking water?

3.1. Prediction

I expect that …….

Why?

Now titrate once 10.00 mL of the recovered cooking water with 0.05 mol/L silver nitrate solution. **!!Silver nitrate solution is dangerous to the eyes and blackens the skin!!** Use ten drops of the **(!!toxic!!)** potassium chromate (yellow) as an indicator. Write down your observations and compare the titre (mL) of silver nitrate needed in the titration with the titres that are found by the other teams. Find the best titre.

3.2. Observations

3.3. Results, conclusion and discussion

(i) Calculate the amount of NaCl (s) gram/L in the recovered cooking water.

(ii) What is the conclusion about this amount compared to the solution of 0.1 mol NaCl/L in which the green beans were cooked?

(iii) How would you explain your findings?

4. Judging the research of Fels, Egnod & Bu

'Sodium chloride and Vegetables'

Before analyzing Fels, Egnod & Bu's research on 'fairness', accuracy, reliability and validity you will first answer some questions concerning accurate and reliable measurements.

4.1. Orientation on accurate and reliable measurements

Suppose that you would like to compare the amounts of NaCl in the recovered water when fresh green beans are cooked in a 0.1 mol/L NaCl solution at four different temperatures.

(i) What would you do to measure as accurately as possible? Explain

Assume that the recorded titre in a titration of 10.00 mL recovered cooking water with silver nitrate solution is 22.02 mL

(ii) What would you do to find out if this measurement is reliable? Explain.

(iii) When is a series of measurements reliable?

4.2. The research of Fels, Egnod & Bu: accuracy, reliability, validity

The research question of Fels, Egnod & Bu (2008) was: *'what amount of NaCl is leached out of plant cells when heated at different temperatures in a common salt solution?'*

From the demonstration and guide experiment you have learned that NaCl is leached out of plant cells in the cooking process. In paragraph 4.1 you have thought about reliability of measurements. In order to be capable of measuring accurately, experiments need to be designed in a 'fair' way. You need accurate measurements to come to reliable results. Only when results are reliable can one draw the most valid conclusions. So the question is how to design your experiments as 'fair' as possible to measure most accurately.

To achieve accurate measurements researchers have to follow certain procedures. You will practice this procedure using the article of Fels et al.(2008):

How 'fair' is the design of the research of Fels et al.?
How accurate are the measurements of Fels et al.?
How reliable are the measurements or results of Fels et al.?
How valid is the conclusion drawn by Fels et al.?

By practicing these steps you will be able to critically judge other research and be capable of doing an accurate inquiry yourself.

A. How 'fair' is the design of the research of Fels et al.?

To judge a research design, you need to identify all of the variables that play a

role in the experiment. To take accurate measurements researchers want to know which variable they will measure. Variables are quantities (e.g. temperature), which can be measured as a number. Usually variables also have a unit (e.g. degree Celsius). Researchers should also carefully take into account other factors (e.g. when measuring the height of a person the floor on which the person stands should be straight), which can interfere with the variable to be measured. When taking variables into account:

1 **List** all of the variables;
2 Choose **one** of the variables
3 **Change** this variable;
4 **Measure the effect** of this change; and at the same time
5 Keep all other variables and factors **constant**.

Researchers distinguish three types of variables:
Independent variable: This is the variable to be **changed**
Dependent variable: This is the variable to be **measured**
Control variables: These are the variables to be kept **constant**

By using distinct variables it is easier for researchers (and other interested people) to understand the research and follow its progress. 'Fair' handling of variables is a difficult aspect of research design. For researchers it is difficult both to recognize 'all' of the variables and to exclude those variables and factors that they do not want to measure or to change. In other words: to keep all interfering variables and factors constant.
Now it's up to you (in groups) to recognize the different variables in the experimental procedure of the research of Fels et al. (2008) and to find out whether they handled the variables carefully.

B. Recognizing variables in the research of Fels et al. (2008)

Use the part on 'Experimental procedure' in the article of Fels et al. (2008); page b.
List all variables and factors that influence the measurements in the experiment

as done by Fels et al. (2008).

(i) Variables:

(ii) Factors:

(iii) What is the independent variable in the experiment done by Fels et al.?

(iv) What is the dependent variable in the experiment done by Fels et al.?

(v) What are the control variables in the experiment done by Fels et al.?

(vi) Did Fels et al. (2008) forget any control variables?
If yes, which one(s)?

(vii) Compare your answers to these of the other groups in your class.

C. How accurately did Fels et al. measure?

When the variables – related to the question under research – are known, the next step is to think about the design and set-up of the experiments. It is

important to decide carefully, in advance how to conduct the actual experiment, both the set-up and the measurements. Fels et al. had to make decisions about:

i. How much fresh beans to use?
ii. How many different temperatures to use?
iii. How much NaCl solution to use?
iv. How long should the beans be heated in the solution?
v. How often should every titration be repeated?
vi. What instrument should be used to measure?
vii. To what significant figure can the measuring instrument be read off?

With a well-developed research you will be less likely to encounter unpleasant surprises while the experiment is being conducted.
To find out whether Fels et al. (2008) did collect accurate measurements, you judge the decisions made by them in their experimental procedure, see article of Fels et al. (2008) page b.

Discuss and answer in your group the following questions.

C. 1. Decisions regarding the experimental set-up

(i) Did Fels et al. choose the correct amounts of green beans? Explain.

(ii) Did Fels et al. choose appropriate temperatures to be able to measure the released amount of NaCl by plant cells? Explain.

C.2. Decisions regarding the measuring instrument

(i) Is the measuring instrument used in the silver nitrate titration by Fels et al. accurate enough? Explain.

(ii) Did they read the titres to a correct significant figure? Explain.

C.3. Decisions regarding the number of measurements

Fels et al. repeated the measurement of the titres three times.
Was this enough times, according to you? Explain.

D. How reliable are the measurements or results of the research of Slaa et al.?

Before collecting measurements researchers think about how to collect their observations and data, how to present and analyze their results. Collected measurements are presented in tables and graphs. Furthermore, researchers always need to check whether their results are reliable. When measurements show too much deviation, they need to be repeated. Repetition of measurements

enhances the reliability.

You are now to judge whether Fels et al. presented their measurements in a correct manner and whether their measurements are reliable.

D.1. Presentation of measurements

Fels et al. presented the averaged $AgNO_3$ titres in mL in the three titrations of 10.00 mL of the recovered solutions S_1-S_4 in Table 2 as:

Solution: averaged (mL)	Averaged titres of $AgNO_3$ (mL)
S_1: 10.00	22.20 ± 0.02
S_2: 10.00	22.33 ± 0.06
S_3: 10.00	22.59 ± 0.02
S_4: 10.00	22.72 ± 0.03

Table 2: Averaged $AgNO_3$ titres in mL in the three titrations of 10.00 mL of the recovered solutions S_1-S_4.

(a) Did they present the measurements in a correct manner? Explain.

Fels et al. used a graph (see Figure 4) to find the relation between averaged titre (mL) and the temperature (^oC).

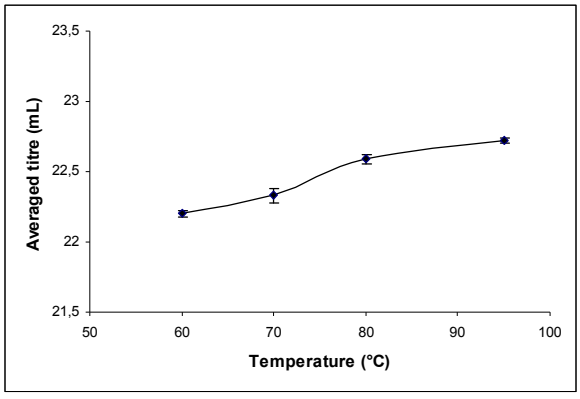

Figure 4: Averaged measured titres (mL) against temperature (^oC).

(b) Did they use the correct variables on the x-axis and y-axis? Explain.

(c) Is the graph in Figure 4 a good representation of the measurements as shown in Table 2? Explain.

D.2. Reliability of measurements

Fels et al. (2008) presented their measurements in Table 2 as:

Solution: averaged (mL)	Averaged titres of $AgNO_3$ (mL)
S_1: 10.00	22.20 ± 0.02
S_2: 10.00	22.33 ± 0.06
S_3: 10.00	22.59 ± 0.02
S_4: 10.00	22.72 ± 0.03

Table 2: Averaged $AgNO_3$ titres in mL in the three titrations of 10.00 mL of the recovered solutions S_1-S_4.

When looking at a series of measurements, e.g. S_1 we see:

Solution: averaged (mL)	Averaged titres of $AgNO_3$ (mL)
S_1: 10.00	22.20 ± 0.02

With 22.20 $\pm$ 0.02 Fels et al. state that the measured titre values lie between 22.22 and 22.18 mL

Their measurements deviate 0.02 from the average titre which is 22.20 mL.

Suppose that the titre values are allowed to deviate **<u>within</u>** 0.1% of the average result.

Which of the values in Table 2 are accurate enough to be reliable?

(i) Encircle them.

What possible causes of inaccuracy in Fels et al. measurements occur:

(1) Low significance of the titre values. Yes / No Explain.

(2) Low number of measurements. Yes / No Explain.

(3) Lack of keeping control variables and factors constant. Yes / No Explain.

(4) Other causes. Yes / No Explain.

E. How valid is the conclusion of Fels et al.?

A conclusion can be considered as valid when experiments are accurately designed and carefully executed. Of course, experiments should be designed in such a way that answering the research question is possible. Fels et al. (2008) research question is: *'what amount of NaCl is leached out of plant cells when heated at different temperatures in a common salt solution?'*. To answer this question first four portions of 130 g fresh beans where heated at four different temperature in a 0.1 mol/L NaCl solutions and kept at that temperature for 5 minutes. Then the averaged titres of the titration of 10.00 mL of the four recovered salt solution with a 0,05 mol/L silver nitrate solution were determined and plotted in a – averaged titre (mL) against temperature (T in ^{o}C) – graph. The results were presented in Table 3 and Figure 4. From the results as

presented Table 3 (page b) Fels et al. concluded that *'the amount of grams of NaCl in all solutions (S_1-S_4) compared to the S_0 solution has increased'*. And from the graph in Figure 4 Fels et al. concluded '*… is temperature dependent and probably has a S-shaped dependency.'*

(i) Do you agree with the conclusions Fels et al. (2008)? Yes / No Explain.

(ii) Is the experimental design of Fels et al. suitable or valid to find an answer on the research question as stated in their article? Yes / No. Explain.

5. Inquiry in teams

The research question of Fels et al. (2008) was *'what amount of NaCl is leached out of plant cells when heated at different temperatures in a common salt solution?'* and they concluded that *'the amount of grams of NaCl in all solutions (S_1-S_4) compared to the S_0 solution has increased'* and '*… is temperature dependent and probably has a S-shaped dependency.'* Out of their discussion further questions arise e.g.:

"Further inquiry is needed to find the nature of the relation between the temperature and the amount of Na^+ and Cl^- ions leaching out of plant cells … During the cooking process this magnesium ion can in acidic conditions be replaced by two H^+ ions to give a compound called phenophytin (6). This compound is responsible for the brown colour of cooked vegetables. There appears to be no good reason why addition of cooking salt or NaCl (s) would affect the colour of vegetables during cooking. This needs further inquiry. Some top cooks add sodium hydrogen carbonate to keep the cooking water alkaline. Alkaline conditions minimize the replacement of Mg^{2+} ions and therefore the change in colour. But alkaline conditions in cooking probably affect the amount of vitamin C. This as well needs further inquiry. Moreover, what would happen to the colour of cooked vegetables when other salt solutions like $CaCl_2$ (aq) are used?".

To answer one of these questions, or your own question, you design and conduct your own inquiry. You will do an inquiry and write a report in a 'fair', accurate, reliable and a step-by-step manner.
It is all up to you! Before starting your own inquiry answer the following questions. Before starting your own inquiry answer the part in 5.1.

5.1. Formulate your own inquiry question

An inquiry question can be investigated when this question has an independent (what are you going to change?) and a dependent (what are you going to measure?) variable.
Write down:

(i) inquiry question:

(ii) our hypothesis:

(iii) based on which theory:

Now write your own inquiry plan as a team.

5.2. Inquiry plan

5.2.1 Variables

Dependent variable

What variable are you going to measure? Explain why.

Independent variable

What variable are you going to change? Explain why.

Control variables

Which variables and factors do you need to control - keep constant - in your experiment? Explain why.

5.2.2. Decisions on the experiment, the experimental set-up and the measurements

How to make accurate measurements?

(i) What instrument for measurement are you going to use? Explain.

(ii) What is the accuracy of the instrument?

(iii) Up to what significant figure can you read the instrument?

(iv) Are repeated measurements needed? Explain.

(v) Which materials do you need? List these materials below.

(vi) Make a drawing of your experimental set-up.

(vii) What results do you expect? Explain why.

(viii) Check whether your inquiry plan is really answering your inquiry question. If not, change your question into a question that fits to your plan.

Discuss your plan with your teacher. If she / he agrees, you can start your experiments.
Good luck!

5.3 Keep a record of the inquiry

Inquiry dairy

Date	Work done	Remarks / Observations

6. First and final report, peer discussion: guidelines

This booklet needs to be handed in to the teacher. As a team you will get a mark for your inquiry plan, your final article and for your participation in the peer discussion.

6.1 Writing a report: guidelines

The layout of a report depends on the journal you are writing for. A report will be published when it satisfies criteria posed by the journal. This will also be the case for your article. After publishing the reports on the website/*elo* the peer discussion starts. You can use the comments to improve your first report as you write a final article. These articles will also be published on the website/*elo*. Then a professional jury will compare all articles and nominate the best research for Chemistry inquiry award.

Take Fels et al.'s article as an example. Your report should contain the following:

- **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.**

6.2. The peer discussion in the Gastronomy symposium

To have a meaningful and fruitful discussion with another inquiry team in your class, you first need to read their report. Then judge their inquiry report by using the following questions:

- 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 relevant bibliography?

Halfway the discussion you will be checked to see how well you have participated in the symposium. This will be part of the jury's judgement.

7. Study guide

- Read the planning
- Choose your inquiry partner

Lesson 1. Understand what Fels, Egnod & Bu (2008) investigated:

- Read the introduction
- Follow the demonstration: Predict, observe and explain
- Find information on the Internet

Homework:

- Read the article of Fels, Egnod & Bu (2008)

Lesson 2. Judge the research of Fels, Egnod & Bu:

- Conduct the mind experiment: how much carbon dioxide?
- Orientation on accurate and reliable measurements
- Read about variables
- Judge Fels, Egnod & Bu's article on handling variables
- Judge Fels, Egnod & Bu's article on accuracy

Lesson 3. Judge the accuracy and reliability in Fels et al. 's research:

- Judge Fels, Egnod & Bu's experimental set-up
- Judge the reliability of Fels, Egnod & Bu's measurements
- Judge the presentation of Fels, Egnod & Bu's results
- Judge the validity of Fels, Egnod & Bu's conclusion

Lesson 4. Your own inquiry project: question and plan:

- Formulate an inquiry question
- Design an inquiry plan
- Hand in your inquiry plan to the teacher

Lesson 5-6. Your own inquiry project:

- Conduct your planned experiments and collect measurements
- Write a first report as a team (see **Planning**)
- Send your first report **with the right code** to your teacher
- Discuss the report of another team in the Fermentation symposium
- Improve your report and write a final report
- Send your final report **with the right code** to your teacher

The jury only **judges final reports of teams that participated in the peer discussion**.

8. List of concepts

Complete the list of concepts. Work gradually on this list as the project proceeds.

Write the definition of:

DISSOLVING

CONCENTRATION

TITRATION

INDICATOR

CHLOROPHYLL

INDEPENDENT VARIABLE

DEPENDENT VARIABLE

CONTROL VARIABLES

ACCURACY

RELIABILITY

VALIDITY

9. Some words explained

accuracy	nauwkeurigheid
amount	hoeveelheid
average	gemiddelde
control variables	controlevariabelen
dependent	afhankelijk
dependent variable	afhankelijke variabele
to dissolve	oplossen
increase	toename
independent variable	onafhankelijke variabele
inquiry	onderzoek
indigestible	onverteerbaar
nature	aard
permeable	doorlaatbaar
reliable	betrouwbaar
reliability	betrouwbaarheid
snappy	pakkend
to shrivel	ineenschrompelen
starch	zetmeel
to submit	insturen
texture	textuur
tissue	weefsel
validity	geldigheid
vegetables	groenten
to wither	verwelken