Guide
Steps to success

Experiments are an important scientific method to find out new things. An Experiment is handled in a specific order.

With these diagnostic cards you can work step by step through the experiment.

Start now with Card A1!

Otherwise you can also skip sub-steps and go to the step where you need help. Therefore you can find the experiment steps on the back of this card.

Front A0

Front

FaSMEd

SOLUTION A0

Start with card A1 or skip to the sub-step where you need help.

Experiment steps	What's next?
1. Propose a hypothesis	A1
2. What are my experimental approaches?	A2
3. What do I want to observe?	A3
4. Plan an experiment	A4
5. Did I achieve reasonable results?	A5
6. Draw conclusions	A6
7. Create a diagram	A7

Back A0

Back

A1

EXPERIMENT

Can I propose a hypothesis to the given problem?

FaSMEd

Read the story for the given problem.

Propose a presumption for the stated problem (hypothesis). Write it down in experimental protocol.

A1

Front A1

Front A2

A2

EXPERIMENT

What are the experimental approaches?

FaSMEd

After your first scientific presumption you may now design your experiment.

For your first preparations you need two experimental approaches:

- If X is present, then something happens.
- If X is not present, then something different happen

Afterwards the different results after your experiment will show you the effect of this factor.

Which one is your chosen variable in this experiment?

A2

FaSMEd

SOLUTION A1

For this specific problem you can propose the hypothesis in various ways.

(It doesn't matter if your hypothesis turns out to be wrong at the end of the experiment.)

How did you proceed?	What's next?
I didn't know what to find out.	A1.2
I've set up a scientific presumption.	A2
I was unable to propose any scientific presumption.	A1.1

Back A1

Back A2

FaSMEd

SOLUTION A2

The important variables in this experiment are:

- skin available/ not available
- whole apple or apple in pieces
- weight in gram
- temperature
- apple variety
- light
- air flow
- initial weight

Which one is your chosen variable?	What's next?
Light – varied as intense/ not intense	A2.1
Skin- varied as available/ not available	A2.2
Size of the pieces- varied as whole apple/ bite-sized pieces	A3
I've chosen one of the other variables as independent variables.	A2.3

A3

EXPERIMENT
What do I want do observe?

FaSMEd

You now have two experimental approaches. One approach has got the chosen variable, the second doesn't. Now you want to observe for example 8 minutes the effects of these two experimental approaches.

What do you want to observe in your experiment to check your scientific presumption?

A3

Front A3

Front A4

A4

EXPERIMENT
Can I plan an experiment?

FaSMEd

You now have all the necessary information to plan your experiment:

- You know, what has to be present/ not present in the two different experimental approaches.
- You know, what you have to observe to check your scientific presumption.

You should now plan an experiment, where you can check your scientific presumption.

Make notes for your experimental setup and procedure.

A4

FaSMEd

SOLUTION A3

The following aspects can be observed during the experiment:

- skin available/ not available
- whole apple or apple in pieces
- weight in gram
- temperature
- apple variety
- light
- air flow
- initial weight

What are the effects, when the variable is present or not present?

Which one is your independent variable?	**What's next?**
Light – varied as intense/ not intense.	A3.1
Initial weight measured in gram.	A3.2
Weight measured in gram.	A4
I've chosen one of the other variables as dependent variables.	A3.3

Back A3

Back A4

FaSMEd

SOLUTION A4

The **experimental setup** should contain all necessary materials and quantities that you will use in your experiment.

The **experiment procedure** describes the procedure of the experiment in individual steps (What do you do with your materials?). Imagine you are writing a "cooking recipe".

After you listed your ideas for setup and procedure you can continue with A5.

A5

EXPERIMENT

Did I achieve reasonable results?

FaSMEd

Perform the experiment and record your data in a table. Then look at your results.

A5

Front A5

Front A6

A6

EXPERIMENT

Can I draw conclusions from the data?

FaSMEd

Look at your results. Can you confirm the initial hypothesis with these results?

A6

FaSMEd

SOLUTION A5

Compare your results with the given data below from a comparable experiment.

time (in minutes)	**weight** (in gram)	
	unpeeled	Peeled, cut into pieces
0	162	158
1	162	154
2	162	148
3	162	146
4	162	143
5	162	139
6	162	138
7	162	138
8	162	138

What differences can you notice?	**What's next?**
My results do not change or change rapidly.	A5.1
My results have a different arrangement than the given above. They are much higher/lower or the values don't increase evenly.	A5.2
My experimental results are similar to the given above.	A6

Back A5

Back A6

FaSMEd

SOLUTION A6

The determined data from your experiment can now help you to draw conclusions for your hypothesis. Therefore it is important to visualize the data and look for relations between each entry.

For this purpose you create a diagram in the next steps which helps you to represent the collected data clearly and compactly.

Now go to A7.

A7

DIAGRAM
Can I find a suitable diagram type?

FaSMEd

Now you should transfer the measured data into a diagram. Because the connections and changes are visualized, the evaluation of the data gets simplified.

What diagram type is suitable for this situation?

A7

Front A7

Front A8

A8

DIAGRAM
Can I assign the variables to the axes?

FaSMEd

It is important that the experiment variables are correctly assigned so that your classmates can easily read the data vales out your graph.

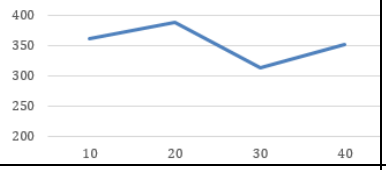
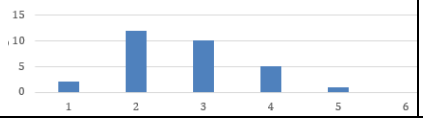
Which axis is assigned with the time, and which one is assigned with the measured effects?

A8

FaSMEd

SOLUTION A7

There are different types of diagrams. Some of them are better to present certain facts and situations charts.

Which diagram type did you choose?	What's next?
line graph 	A7.1/A8
pie chart 	A7.2
column/ bar chart 	A7.3

Back A7

Back A8

FaSMEd

SOLUTION A8

How did you label your axes?	What's next?
I assigned the time to the x-axis.	A8.1
I assigned the time to the y-axis.	A9
I've chosen a different assignment.	A8.1

A9

DIAGRAM
Can I label my axes correctly?

FaSMEd

In order to understand your diagram without any additional information it is important that the axes of the diagram are labeled clearly.

How would you label the axes in your diagram?

A9

Front A9

Front A10

A10

DIAGRAM
Does the diagram has an appropriate scaling?

FaSMEd

A simple diagram should include all necessary information so the reader can read the diagram easily and without additional information.

How should you choose the scaling to provide a clear and structured diagram?

A10

FaSMEd

SOLUTION A9

There are many ways to label the axes. It's important that besides the name the unit is labeled to the axis.

Which label did you choose?	**What's next?**
X: „weight", Y: „time"	A9.1
X: „time" Y: „weight"	A8.1
X: „The weight of the apple", Y: " Depending on time"	A9.1
X: „weight [g]" Y:"time [min]"	A10
I've chosen different labels.	A9.1

↑ Back A9

↓ Back A10

FaSMEd

SOLUTION A10

For a suitable scaling it is important that you clarify what distances are plotted between the individual data points on the graph axes. Also the diagram shouldn't be too small or too large to allow easy reading.

If you drew a suitable scaling on the graph axes go to A11.

A11

DIAGRAM

Can I plot the data in a chart?

FaSMEd

Enter the individual data from your experiment into your previously selected diagram type. Pay attention to the axis labeling and scaling.

A11

Front A11

Front A12

A12

goal

FaSMEd

You are almost done! Finally use your diagram to check if you initial hypothesis was confirmed.

The diagram shows which test approach leads to which result.

Can you explain the differences?

A12

FaSMEd

SOLUTION A11

In this experiment the line graph is the most appropriate diagram type. The questions you have to ask are:
How do I enter my measured points?
How do I connect the individual points together?

How did I solved the problems?	What's next?
My diagram starts at zero.	A11.1
I've created three individual diagrams.	A11.2
I've connected the data points of each individual experimental approaches with each other.	A12
I've interconnected all data points.	A11.3
I didn't connect the data points.	
I was unable to plot the data points into the diagram.	A11.4

Back A11

Back A12

FaSMEd

SOLUTION A12

In this experiment we investigated whether the **bite-sized apple pieces** can cause faster water evaporation.

a) **What did you find out?** Compare the results of the different experimental approaches.

b) Do you have any presumptions?

(Hint: Small cut apple pieces have a larger ("vulnerable") surface)

A1.1 Good to know

FaSMEd

A **hypothesis** is a testable statement, which you want to check in an experiment.
For a hypothesis it is important to check the relation between two factors.

It is common to write a hypothesis like that:

- If X is present, then something happens.
- If X is not present, then something different happens.

Before you examine a relation between the variables in your experiment, you have to set a scientific presumption.

A1.2 Good to know

FaSMEd

example:

Imagine you are getting a cut apple from your mother to school. Unfortunately you forgot to eat it so you find the apple after a week in your schoolbag. The apple pieces are now already shriveled and collapsed. So they also became lighter. This process has already begun on the first day. Sometimes it's difficult to discover these differences in the first few minutes.

By using a balance you can determine the weight repeatedly. Please note that the balance must be set correctly.

A2.1 Good to know

FaSMEd

You can only make conclusions from your observation, if you changed the chosen variable consciously.

Read the situation again. The question is: Which child (Bahri or Sandra) will probably enjoy the juiciest apple in the afternoon? The apples differ in their size: Bahris's apple isn't peeled and Sandra's apple was cut into bite-sized pieces.

The light comes mostly from the sun. This is likely to be the same for all students on their excursion. Keep this in mind for your experiment!

A2.2 Good to know

FaSMEd

Read the task again.

Bahri's apple isn't peeled, Sandra's apple is peeled and was cut into bite-sized pieces.

A2.3 Good to know

FaSMEd

***Variable* X is changed consciously under controlled conditions.**

The apple variety, the initial weight, the temperature and the air flow should be kept constant. Although they impact the experimental process, they don't allow any clear conclusions from the problem situation.

Read the situation again. The question is: Which child will probably enjoy the juiciest apple in the afternoon? The apples differ in their size. Bahri's apple isn't peeled, Sandra's apple is peeled and was cut into bite-sized pieces.

A3.1 Good to know

FaSMEd

You will make observations in your experimental approaches that can be measured.

Hint:

The light comes mostly from the sun. This is likely to be the same for all students on their excursion.

A3.2 Good to know

FaSMEd

You will make observations in your experimental approaches that can be measured.

The weight of the apple will change during the experiment. Only the weight at the beginning is called „initial weight“.

A3.3 Good to know

FaSMEd

You will make observations in your experimental approaches that can be measured.

The apple variety, the initial weight, the temperature and the air flow should be kept constant. Although they impact the experimental process, they don’t allow any clear conclusions from the problem situation.

The variable is the size of the apple pieces.

What happens over the time with the apple pieces and what changes can you measure?

A5.1 Good to know

FaSMEd

Example:

Imagine you are drinking from a water bottle. After each sip you measure the bottle weight in grams. A sip of water weighs about 3g. Because of this the water bottle loses these 3g after each sip. Now compare the exact and the rounded data of this experiment:

	0 sip	**1 sip**	**2 sips**	**3 sips**	**4 sips**	...
exact	500 g	497 g	494 g	491 g	488 g	...
rounded	500 g	500 g	490 g	490 g	490 g	...

As you may notice in the table the rounded values display several times the same values, even though you have been drinking from the water bottle. Therefore it's important to write down the measurements **accurately** to make even **small changes** visible.

A5.2 Good to know

FaSMEd

a) In order to compare the results it's important to record them under the same conditions. For this cause you have to remove the weight of the petri dish from the measured weight to achieve proper results.

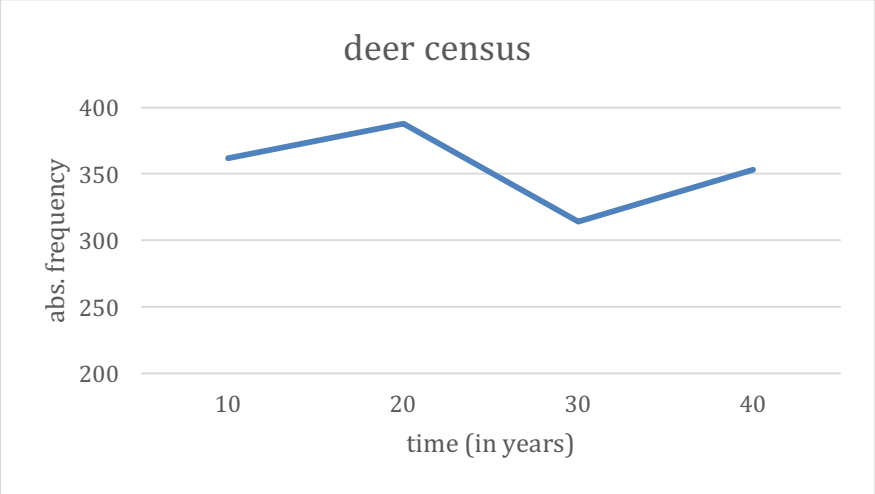
b) For precise and clean working it is important to weigh the apple on a petri dish. It is useful to weigh the petri dish before the experiment and subtract this weight from the determined total weight of each measurement. Thereby you can determine the weight of the apple itself.

A7.1 Good to know

FaSMEd

A line graph illustrates the (time-dependent) course of items. If the measured items are in relation to each other you can connect them to a line.

Example:

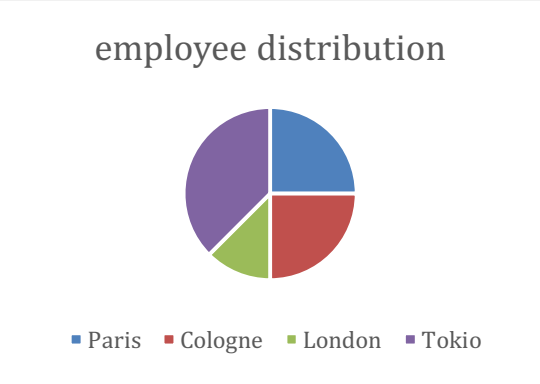


A7.2 Good to know

FaSMEd

A pie chart illustrates the ratio and proportions by representing the ratio of a single value to the total.

Example:



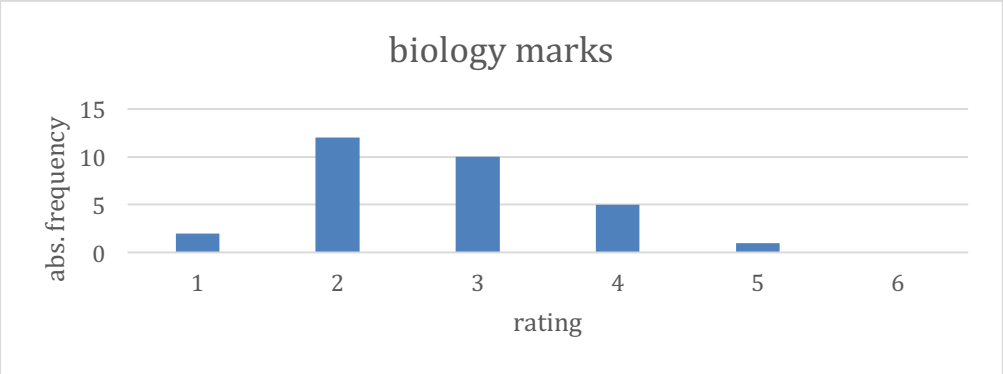
Note: Look at your listed values. They don't describe values or shares. They display the time in correspondence with the weight of the apple pieces.

A7.3 Good to know

FaSMEd

A column chart is used to compare the values among themselves by displaying the quantitative frequency as columns. If you turn the column chart by 90 degrees you get a bar chart.

Example:



Note: A column or bar chart only displays the overall change. In this experiment however it's important to present the progression over time.

A8.1 Good to know

FaSMEd

Remember planning your experiment? You've set up two different experimental approaches: In one approach the variable is present, in the other the variable is not present. Because we summarize both experimental approaches in one chart, we investigate the effects of the time on the weight of the apple.

If you want to investigate the temporal course, you represent it in reading direction. This means: You arrange the time on the horizontal axis (from left to right) and the measured characteristic (for example: weight) on the vertical axis (from bottom to top).

A9.1 Good to know

FaSMEd

In order to interpret it correctly it's important that the labeling is **clear**, **unambiguous** and **complete**.

Please note the following aspects:

- A **clear** diagram should be labeled with short and meaningful words.
  e.g.: Instead of „the achieved height when jumping (in meters)" you should write „jump height [m]"

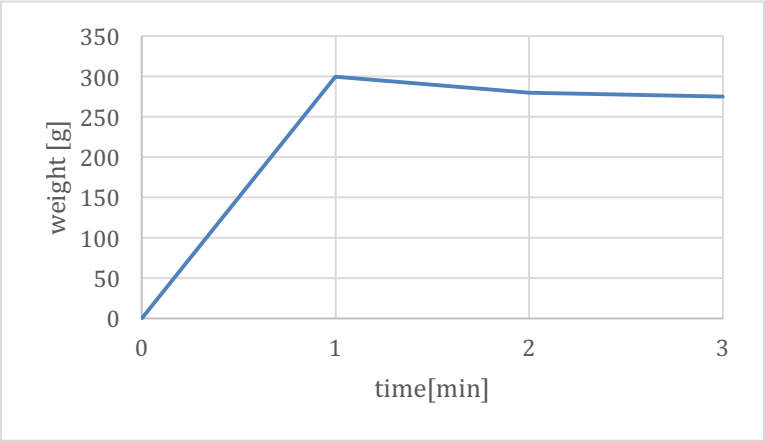
- The reader of the diagram should understand immediately the meaning of the axis labeling. Therefore they should be labeled unambiguous.
  e.g.: the axis label „flower" does not allow any clearly conclusions. Is „diameter", „color", „number" or „size" intended?

- A **complete** description should include the label and the units of the used variables.
  e.g.: Instead of „size" you should write „size [m]" or „size [cm]" in order to make clear in what size units the data were measured.

A11.1 Good to know

FaSMEd

Depending on the obtained data in the experiment, the following line chart can arise:



If the graph starts at zero it means that the apple has a weight of 0g at the beginning. After this the weight increases to the initial weight before it slowly loses weight again.

A11.2 Good to know

FaSMEd

To compare different experimental approaches, we can transfer them in one common diagram under certain conditions.

This requires:

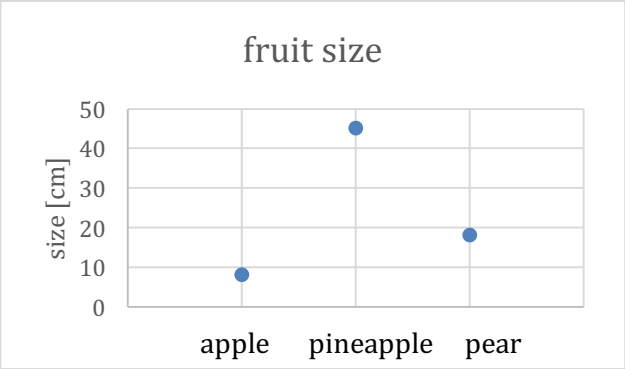
- An appropriate diagram type for the representation of several approaches in one diagram.
- The same initial conditions for each experimental approach.
- The results were obtained in the same units.
- The variables for the experiment and the diagram axes are identical.

A11.3 Good to know

FaSMEd

You can connect the individual data points in a line graph, if the data points are related to each other.

Example:



In this case it's not allowed to connect the points with each other, because the sizes of the different fruits are not interdependent

Note: If you plotted **several experimental approaches** in one diagram, you may only connect the points of **each approach with each other**.

How can I plot the measured data into a line graph?

1) Each data point consists of two values. In this case the values are the time and the measured weight at this time.

Example: If you determined the apple weight of 280 grams one minute after the experimental beginning you get the data point (1 / 280).

2) Now you can use the created axes to find the position in the line graph: The first value specifies the x-axis position, the second value specifies the y-axis position.

Example: The data point (1 / 280) is drawn by „going“ 1 unit in x-axis direction and 280 units in y-axis direction.

Who has the juiciest apple?

The students of the seventh class are doing a school excursion in the mountains. Bahri and Sandra got wrapped apples as supplies from their mothers. Both don't like the bitter skin, so their apples are peeled. Sandras' mother however has cut her the peeled apple in addition into bite-sized pieces.

During the day the temperature rises to 35°C in the shade. Who is going to have the juiciest apple in the afternoon?

Task:

- Formulate a hypothesis for the stated problem.
- Afterwards plan an experiment that verifies your hypothesis.
- Write down your results in your trial protocol and display them there in an appropriate diagram of your choice.
- You may note especially the significance of the size of the apple surface.

Accomplish your goal:
Additional help and instructions can be found on the „Good to know" cards:

First pay attention to the headlines on the front of the cards displaying the individual task steps. The back of the cards show appropriate help and instructions that explain and illustrate associated knowledge. Use the cards only if you are stuck or unsure about how to continue.