**Developed as part of the project:**
*Fascinating and safe world around us – increasing the effectiveness of education of future chemistry and biology teachers and deepening the knowledge and skills of humanities students about safety of conducting experiments and dealing with substances present in everyday life –* financed from the Didactic Innovation Fund of the University of Warsaw for years 2019-2020.

**Substantive editing**
Marcin M. Chrzanowski, PhD and Agnieszka Siporska, PhD

**Authors**
Piotr Bębas PhD DSc, University of Warsaw, Faculty of Biology, Department of Animal Physiology
(Subchapters 1.1, 1.2, 3.1, 3.2, 3.3, 3.4, 5.4, 5.5);
Marcin M. Chrzanowski PhD, University of Warsaw, Faculty of Biology, Biology Teaching Laboratory
(Subchapters 1.1, 1.2, 1.3, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4, 4.3, 5.4, 5.5, 6.1, 6.4, 7.1, 7.2);
Joanna Lilpop MSc, University of Warsaw, Faculty of Biology, Biology Teaching Laboratory
(Subchapter 1.2);
Agnieszka Siporska PhD, University of Warsaw, Faculty of Chemistry, Chemistry Teaching Laboratory
(Subchapters 1.1, 2.1, 2.3, 2.4, 2.5, 3.4, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 5.6, 6.2, 6.3, 7.3);
Maria Zachwatowicz PhD, University of Warsaw, Faculty of Biology, Biology Teaching Laboratory
(Subchapter 1.2).

**Substantive review**
Maciej Chotkowski, PhD DSc, University of Warsaw, Faculty of Chemistry;
Takao Ishikawa, PhD, University of Warsaw, Faculty of Biology.

**Language review**
Dominika Romańska, – Business English coach, trainer, psychologist,
owner of 2B (www.2b.edu.pl)

**Cover design**
Marcin M. Chrzanowski

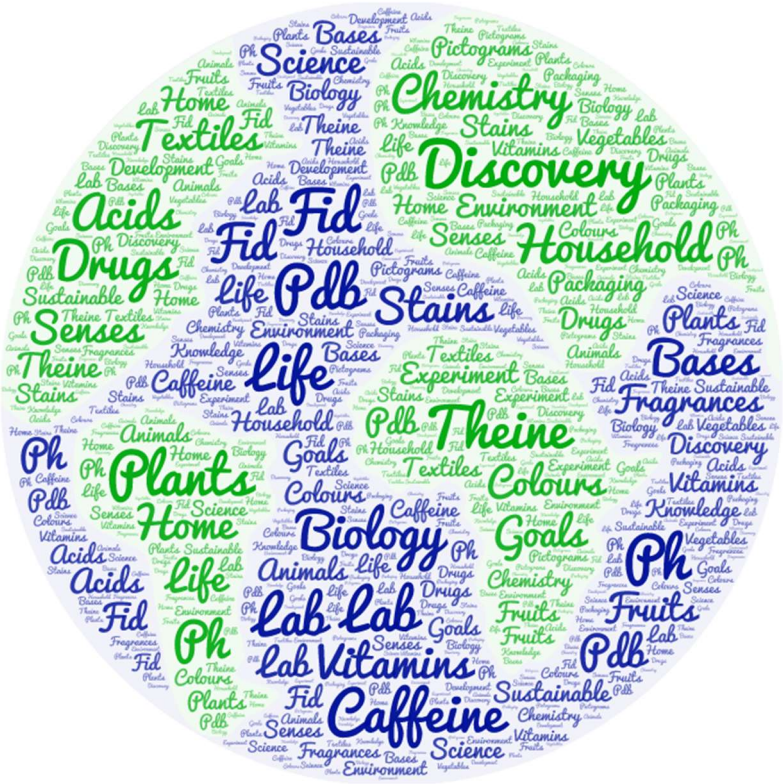
# ABOUT THE PROJECT

## IN QUESTIONS AND ANSWERS – INTERVIEW WITH EDITORS

*by Daiwa Maksimowicz, Press Office, University of Warsaw*

**What is innovative about the project in the context of the university's teaching offer?**

Its biggest innovation is the joint participation in laboratory classes of science and humanities students who usually have the opportunity to experiment in a real chemical laboratory for the first time. Classes will be implemented in large part by the CLIL (Content and Language Integrated Learning) method, which is integrated teaching of a subject and a foreign language – in this case English.




**What are the assumptions and goals of the project? What is its subject?**

The planned innovation will increase the efficiency of education of future chemistry and biology teachers. Their simultaneous joint participation in classes with humanists will become a simulation of school lessons during which the teacher's task is to strengthen students' interest in the subject, and then to maintain, and develop this interest.

**What measurable benefits for students and academic staff of the University of Warsaw does the project implementation imply?**

During the course, students will increase their knowledge of substances present in the household, as well as shape practical skills related to their safe use. They will develop their knowledge and skills regarding the application of health and safety principles in the laboratory, identifying hazards on the basis of pictograms present on packaging, including packaging of substances used on a daily basis. During the course, elements of the scientific method (including *IBSE – Inquiry Based Science Education*) will be implemented, i.e. formulating research problems, making hypotheses, planning ways of solving, documenting, analyzing, drawing conclusions, and finally verifying hypotheses and, if necessary, making new ones. The implementation of the *CLIL* method will allow participants to learn the basic chemical nomenclature (names of selected elements and chemical

compounds, laboratory glass names), which will facilitate the identification of substances on labels, names of which are often written in English.

An important element of the classes, in particular dedicated to non-natural science students, will be a module on critical thinking and the subject of contemporary scientific myths and biochemical misconceptions in various aspect of everyday life (anti-vaccine movements, miracle diets, alternative medicine, dietary supplements).

**What was the inspiration for your project?**

One of the most important tasks of school education is to shape students' motivation to learn. This motivation will be the basis for further self-education of the student. The level of teacher motivation is greatly influenced by the teaching style of the teacher. Chemistry and biology are experimental sciences. In the education of natural sciences, experimenting and practical indication of the use of natural knowledge is an extremely important element. As the results of research conducted by specialists from the Natural Sciences Laboratory of the Educational Research Institute show[1], experience in science classes at school is not common: in the case of chemistry, the percentage of classes with experiment demonstration exceeded 40%, while for biology it reached only 25%. Other data provided in the report indicates that the most common method of conducting biology and chemistry classes is the delivery method. One of the important reasons why teachers do not conduct experiments in class is fear of failure[2]. The aim of the innovative classes that are the subject of this publication is to familiarize students - future chemistry and biology teachers - with the methodology of experimenting in an interesting context - everyday context close to every student. You do not need to have advanced laboratory facilities to perform fascinating experiments.

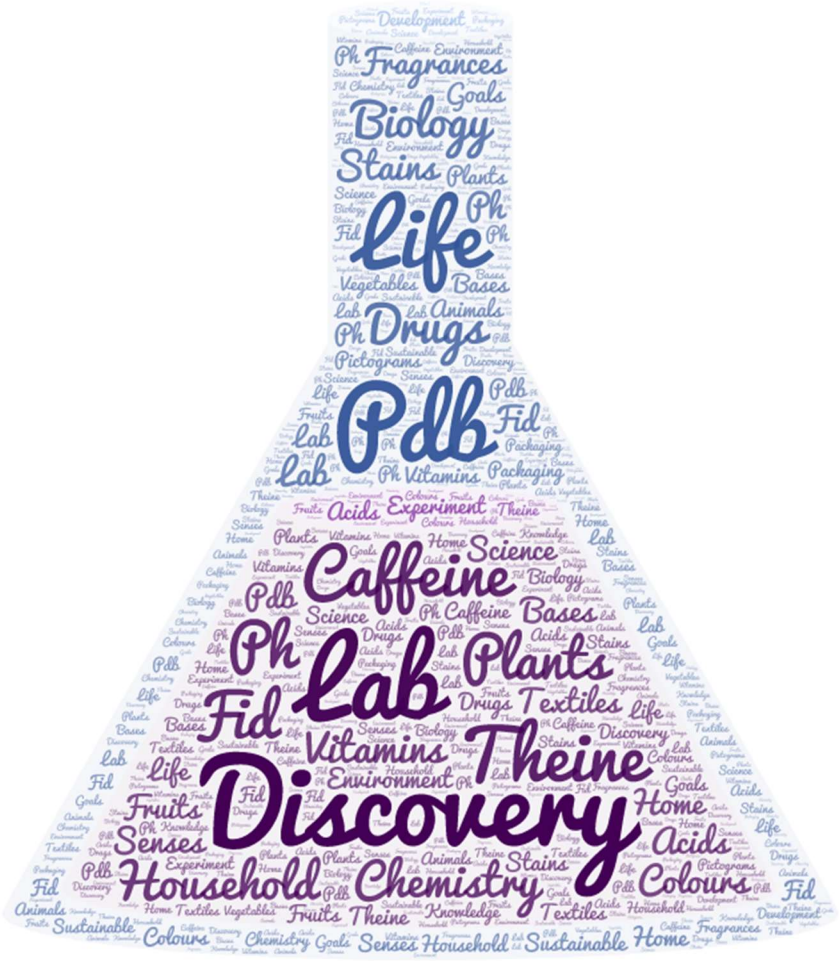
**What FID project has already been implemented jointly by the Biology Teaching Laboratory and the Chemistry Teaching Laboratory?**

In 2016-2017, the Laboratory of Didactics of Biology and the Laboratory of Didactics of Chemistry jointly implemented a project in English: *The modern science subjects teaching in English - programs and strategies for students-prospective teachers.* This project concerned teaching bilingual science subjects and, in schools, providing education for international baccalaureate (International Baccalaureate, IB) students. As part of it, classes were held for students of the Faculty of Biology and Chemistry entitled Didactics Of Science Subjects In International Curricula, conducted in English by 10 specialists representing mathematics and all natural science fields. Among them were also school teachers with extensive experience in teaching science subjects in schools offering IB programs. Participation in classes was a unique opportunity for students to get acquainted with the programs taught in Poland as an alternative to those prepared in accordance with the General Education Core Curriculum (Journal of Laws of 2012 item 977 of 27 August 2012). The accompanying publication/script (in English) was very well received in both academic and school environments. It is currently used not only by science teachers, but also English language teachers from the Foreign Language School of the University of Warsaw.

*Editors*

[1] Report: *Laboratorium myślenia. Diagnoza nauczania przedmiotów przyrodniczych w Polsce 2011–2014*;

[2] M. Jędrzejczyk, *Motywacja w procesie edukacyjnym*, Centrum Kształcenia Praktycznego w Radomsku, J. Madalińska-Michalak, *Pasja w pracy nauczycieli osiągających sukcesy zawodowe a potrzeba rozwijania ich kompetencji emocjonalnych*, ROZPRAWY, Studia z Teorii Wychowania, VII: 2016 4(17).




**Development of the project timetable**
Marcin M. Chrzanowski, PhD and Agnieszka Siporska, PhD

**Script plan development**
Agnieszka Siporska, PhD and Marcin M. Chrzanowski, PhD

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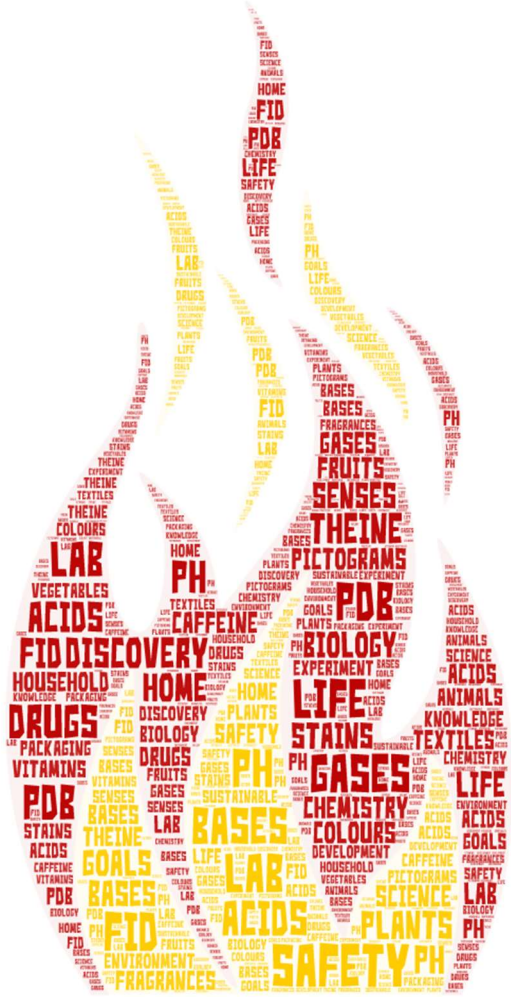
# LAB SAFETY RULES[3]




1. Always treat unknown substances as poisons.
2. Do not eat or drink in the laboratory.
3. If something is flammable, keep it away from flames, from sparking devices and away from other things that could catch fire.
4. If you use fire, look around in advance in order to identify what can be used to extinguish the flame if necessary.
5. Remember that any mixture of flammable gas and air can cause a strong explosion.
6. If something is corrosive, wear suitable gloves and eye protection.


7. If you spill any hazardous liquid on yourself or burn yourself (or if something splashes into your eyes), rinse for a long time (even several minutes) with plenty of cold water.
8. When you smell something, don't put your nose into the bottle, but get acquainted with the substance by smelling the air from above the outlet and moving your hand towards yourself.
9. Always pour acid into the water (not the other way around).
10. If you have long hair, tie it so that it does not fall on your shoulders.

[3] W. Mizerski, ABC ucznia. *Matematyka, fizyka, chemia,* Warszawa: Adamantan 2008.

# GHS Hazard Pictograms

**explosive**

**flammable**

**oxidizing**

**compressed gas**

**harmful / irritant**

**dangerous for the environment**

**health hazard**

**corrosive**

**toxic**

# CHEMICALS

| substance |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| 2,6-dimethylpyrazine | x | | x | | | x | |
| acetic acid | x | | | | | x | |
| acetone | x | | x | | | | |
| activated charcoal | | | | | | | |
| aluminium chloride | | | | | | x | |
| aluminum | x | | | x | | | |
| ammonium carbonate | | | x | | | | |
| amyl acetate | x | | | | | | |
| amyl butyrate | | | | | | | |
| amyl formate | x | | x | | | | |
| ascorbic acid | | | | | | | |
| aspartame | | | | | | | |
| benzaldehyde | | | x | | | | |
| benzyl acetate | | | | x | | | |
| boric acid | | | | | x | | |
| butyl laurate | | | | | | | |
| calcium chloride | | | x | | | | |
| chlorophorm | | | x | | | | x |
| chromium(III) chloride | | | x | x | | x | |
| cinnamaldehyde | | | x | | | | |
| citral | | | x | | | | |
| citric acid | | | x | | | | |
| cobalt(II) chloride | | | x | x | x | x | |
| copper(II) chloride | | | x | x | | x | |
| copper(II) sulphate | | | x | x | | | |
| cumarin | | | | | | | x |
| curcumin | | | | | | | |
| dimethyl trisulfide | | x | x | | | | |
| ethanol | x | | | | | | |
| ethyl acetate | x | | x | | | | |
| ethyl butyrate | x | | | | | | |
| ethyl formate | x | | x | | | | |
| ethyl salicylate | | | x | | | | |
| ethyl vaniline | | | x | | | | |
| eugenol | | | x | | | | |
| geranial | | | x | | | | |
| geraniol | | | x | | | x | |
| glucose | | | | | | | |
| glycerol | | | | | | | |
| hydrochloric acid | | | x | | | x | |
| iodine | | | x | x | x | | |
| iron(III) chloride | | | x | | | x | |

| substance |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| isovaleraldehyde | x | | x | x | | | |
| isoamyl isovalerate | | | x | | | | |
| lactitol | | | | | | | |
| nickel(II) chloride | | | | x | x | | x |
| nitric acid | | x | | | | x | x |
| phosphoric acid | | | | | | x | |
| polyethylene | | | | | | | |
| potassium hydroxide | | | x | | | x | |
| potassium permanganate | | x | x | x | | x | |
| salicylic acid | | | x | | | x | |
| sodium bicarbonate | | | | | | | |
| sodium hydroxide | | | | | | x | |
| sodium silicate | | | x | | | x | |
| sodium sulphite | | | | | | | |
| sodium sulphide | x | | | x | | x | x |
| sorbitol | | | | | | | |
| starch | | | | | | | |
| sucrose (sugar) | | | | | | | |
| sulfur | x | | x | | | | |
| thymol | | | x | x | | x | |
| vaniline | | | x | | | | |
| xylitol | | | | | | | |
| zinc | | | | | | | |
| α-pinene | x | | x | | | | |
| β-ionone | | | x | | | | |

# CHAPTER 1. WE ARE ALL SCIENTISTS

## 1.1. OBSERVATIONS

### ARE YOU A GOOD OBSERVER? SCIENCE AND VEGETABLES. SCIENCE AND FRUIT.

Understanding the shape and structure of an object can tell you something about how it functions. Do you know the plane sections? We may cut different objects in different ways. Some special names have been given to different types of sections to enable scientists to communicate with one another (Fig. 1.1).

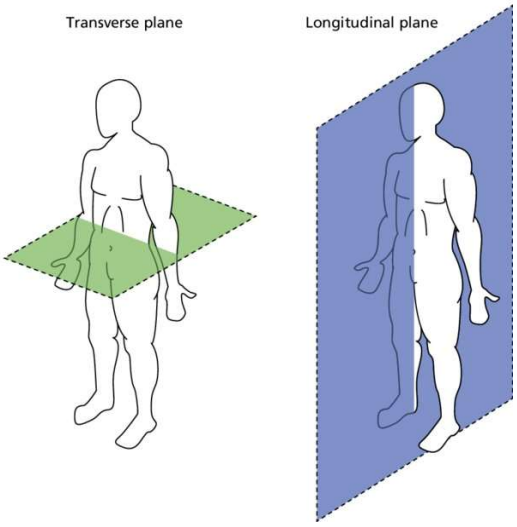



Fig. 1.1. Exemplary body sections and planes[4].

**Ex. 1.1.** **AN APPLE**

Think what the apple looks like and make two drawings of an apple - transverse cross-section and longitudinal cross-section.

| an apple | |
|---|---|
| transverse | longitudinal |
| | |

[4] G. Kiru, C. Bicknell, E. Falaschetti, J. Powell, N. Poulter, *An evaluation of the effect of an angiotensin-converting enzyme inhibitor on the growth rate of small abdominal aortic aneurysms: a randomised placebo-controlled trial (AARDVARK),* Health Technology Assessment, 20, 59 2016.

It was rather an easy task. Now think what the tomato looks like and make two drawings of it: transverse cross-section and longitudinal cross-section.

| **a tomato** | |
|---|---|
| transverse | longitudinal |
| | |

Write down your reflections. Was it an easy or rather hard task for you? Why?

……

……

……

**EX. 1.2. CUBES**

*The foods we eat come in all shapes and sizes, but something beautiful happens if you cut it all down to size — literally. Design studio Lernert & Sander did just that to make the remarkable piece of art below* (Fig. 1.2)*, which was commissioned by Dutch newspaper De Volkskrant last year for a feature on the nation's eating habits. The very act of cutting each food from corn and salmon to cauliflower and kiwi into 2.5-centimeter cubes shows just how unique the nature can be. By attempting to force the nature to conform, the differences between each fruit, vegetable, and slab of meat becomes even more apparent (and beautiful)*[5].

Fig. 1.2. A design made by Lernert & Sander studio[6].

[5] D. D'Orazio *Cubes of fruits, vegetables, and meats will make you see food in a new light*, The VERGE, May 16, 2015miz;
[6] Figure source: followthecolours.com.br/wp-content/uploads/2015/05/follow-the-colours-cubos-alimentos-Lernert-Sander-01.jpg).

Write down how many cubes are there in the figure. Do not count them, just try to estimate.

……

Now count them and write the exact number……..…
Do you think that observation skills are something important to science? If yes – where might they be used?

……

……

……

……

Now look one more time at the figure with cubes. For each of 8 chosen rows, try to write at least three names of substances the cubes are made of.

1st row: ……..……

……

2nd row: ...……..……

……

3rd row: ...……..……

……

4th row: ...……...……

……

5th row: ...……...……

……

6th row: ...……...……

……

7th row: ...……...……

……

8th row: ...……...……

……

What do you think about your observation skills?

……

……

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……

……

……

## Ex. 1.3. Various fruits and vegetables

Write down the names of all the 18 fruits and vegetables transverse plane sections of which are shown in the figure 1.3.

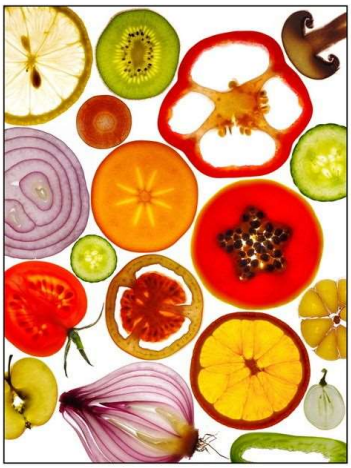

Fig.1.3. Transverse plane sections of different fruits and vegetables[7].

……

……

……

## Ex. 1.4. A tangerine[8]

MATERIALS

- ✓ a basket of tangerines,
- ✓ a sheet of paper,
- ✓ pencils and crayons.

PROCEDURE

1. Take one of the tangerines from the basket.
2. You have two minutes to draw your tangerine.

3. Put the tangerine into the basket. Jumble the tangerines up.
4. Now use your drawing to find the tangerine you have just drawn.

[7] Figure source: https://66.media.tumblr.com/74c6cdebade475b67f105de5c30d139a/tumblr_mp0dalWV8H1qzs7m3o1_500.jpg;

[8] Based on: Jack Guichard: *Observer pour la comprendre: les sciences de la vie et de la terre*, Paris: Hachette, 1998.

5. Now you have two minutes to make a drawing of another tangerine in a way that will make it possible to recognize your tangerine among others.

7. Put the tangerine into the basket and jumble all the tangerines up.
8. Now use your second drawing to find the tangerine you have just drawn.
9. Exchange your drawings and try to find particular tangerines using drawings made by another student.
10. Now you have one minute to upgrade the second drawing of your tangerine to help another student to find it.

11. Now try to find the tangerine again using the upgraded drawing made by another student.

<u>What do you think about your observation skills after the exercises?</u>

……

……

……

……

<u>What could you do to make your observation skills better?</u>

……

……

……

……

## LAB. 1.1. MINERALS AND ROCKS

You have five numbered samples of rocks and minerals. Look at them carefully and describe them.

| number of sample | description |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

Take each of the samples in your hand and try to arrange them in order of mass, starting from the smallest. Insert the appropriate sample numbers into the gaps.

**…… < ……. < ……. < ……. < …….**

Use the scale and weigh the samples tested. Enter the results into the table below.

| number of sample | mass |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

Now arrange the samples again in order of mass, starting from the smallest.

**…… < ……. < ……. < ……. < …….**

Have the weighing results confirmed your prediction? Why do you think that happened?

……

……

## LAB. 1.2. COLORS

Prepare the following materials and chemicals:

MATERIALS AND CHEMICALS

- ✓ four glasses,
- ✓ four plastic tea spoons,
- ✓ water,
- ✓ granules for pipe unblocking (available at the supermarket),
- ✓ potassium permanganate (available at the pharmacy),
- ✓ sugar (sucrose, available at the supermarket),
- ✓ glucose (available at the pharmacy).

PROCEDURE

1. Put on safety goggles and gloves.
2. Pour water into the glass to about ¼ of its volume.
3. Add ¼ teaspoon of granules for pipe unblocking.
4. Mix the contents of the glass.
5. Add a few crystals of potassium permanganate and mix.
6. Pour water to about one quarter of its volume into the other glass.
7. Put a teaspoon of sugar and mix.
8. Mix the contents of both glasses with each other - pour the contents of one glass into another.

Write down the names of all the colors you have just seen in the order they appeared.

……

……

Now you are prepared for the second part of the experiment. Follow the steps above. Use glucose instead of sugar.
Write the names of all the colors you have just seen in the order they appeared.

……

……

Was it an easy task to find all the colors? Why?

……

……

## 1.2. SCIENTIFIC METHOD

### HOW TO DESIGN AN EXPERIMENT?

Science is a way of getting to know the world. Science is not magic, it is characterized by a rational approach to reality, and scientific knowledge is not constant – claims are considered true until there is strong evidence showing a different state of affairs. We say that scientific claims are verifiable, i.e. they can be tested, which means that at least in theory there is a way to show that they are true or false. Researchers must therefore be skeptical about claims – they hold their judgment until they collect enough evidence and arguments to communicate the truth or falseness of the claim. The thesis, which cannot be checked, is not the subject of science.

Data for building scientific knowledge is usually obtained as a result of conducting planned observations or experiments (Fig. 1.4).

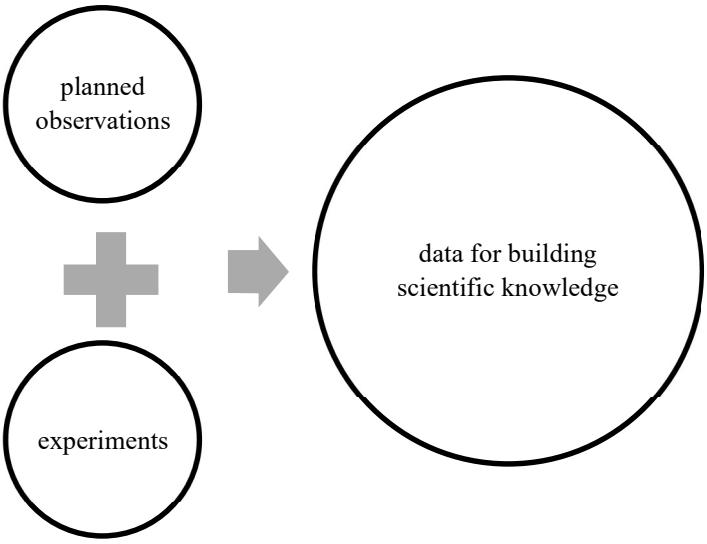


Fig. 1.4. Two main sources of data for scientific knowledge.

The **observational method** is one of the oldest methods of cognition and relies on a purposeful, targeted and systematic description of the studied subject, process or phenomenon. In the course of scientific observation, the researcher does not manipulate variables to determine their impact on the course of the process. It focuses on the collection and analysis of data. Observation can be of qualitative or quantitative nature. In the process of collecting of the data, leads to recognition and interpretation of phenomena, understanding their causes and consequences or identifying interdependencies and relationships. Most natural sciences use observation to collect data and derive scientific evidence.

**The experimental method (experiment)** consists in the purposeful induction of a specific phenomenon by introducing the so-called independent variable and systematic analysis of changes taking place. Thanks to this, it is possible to collect data that allows detection of interdependencies and causal relationships between phenomena. Conducting the experiment the scientist intervenes in nature, manipulates variables and analyzes the effects of this interference. The experiments can be conducted in natural conditions or in artificial conditions (in the laboratory). In both cases, all relevant factors should be controlled and the significance of variables unrelated to the test system is minimized or closely monitored.

Evidence, collected through observations and experiments, serves to formulate theories, laws and generalizations. These, in turn, serve to set further hypotheses that can be tested. In this way, the hypotheses can be confirmed with further evidence or refuted and changed. Therefore, the scientific process is not a linear sequence of events, but rather a cyclic process.

The basis for exploring the world is the curiosity that characterizes all people. Careful observation of reality leads to the formulation of questions and arises the desire to deepen knowledge about a given phenomenon. Add to this a pinch of imagination and intuition, sometimes a coincidence of cases, and a scientific discovery is ready!

**Ex. 1.5.** **Let's formulate a question and answer IT – Fortune Teller Fish**

The object that you hold in your hands is the *Fortune Teller Fish.* Place it on the inside of your hand and observe its behavior. Now read information on the packaging to find out what the different fish movement patterns mean?

Formulate an adequate question regarding to the fish behavior.

……

……

Formulate two different answers to the question sated above.

……

……

Now discuss with another student and try to figure out how to set up an experiment to check if the answers you proposed are correct. Perform the experiment. Write down the steps you have taken to answer the question.

……

……

……

The process of scientific cognition begins with curiosity, leading to the formulation of a research problem – putting a specific research question and formulating a hypothesis. The next step is to design the experimental setup that allows us to test the hypotheses that have been put forward, followed by the inference and critical evaluation of the process. The scheme of the research method is cyclical, and solving one research problem opens the field for further research and new research questions (Figure 1.5 and 1.6).

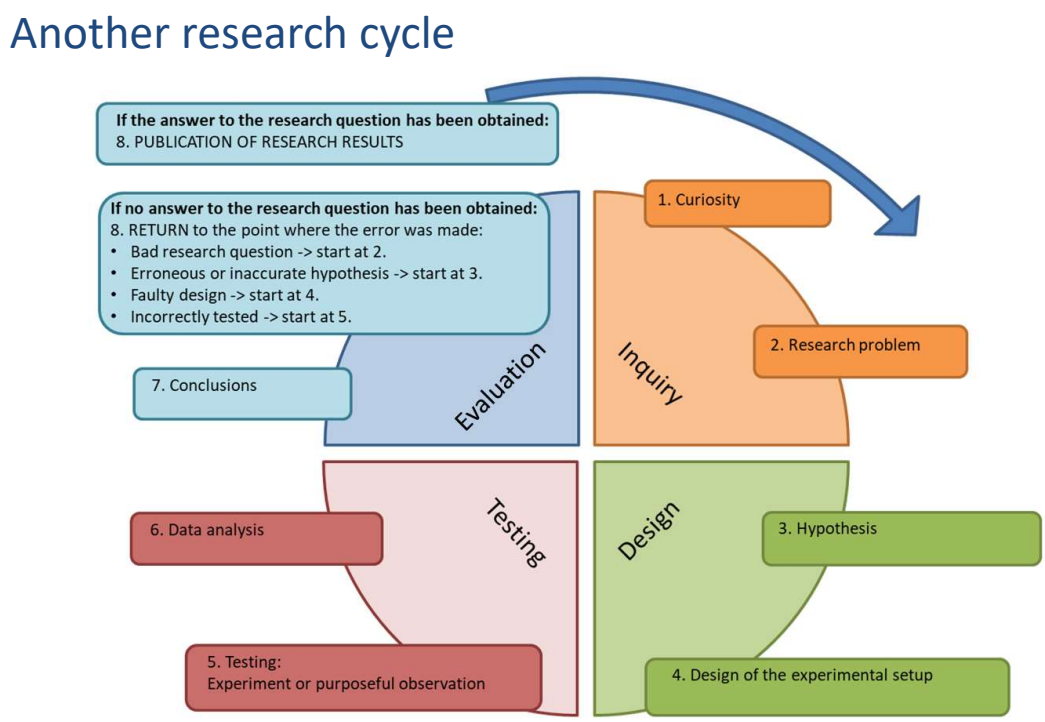


Fig. 1.5. The general scheme of the research cycle. The colors refer to four main processes occurring during each research cycle - inquiry, design, testing and evaluation of tests[9].

[9] J. Lilpop, M. Zachwatowicz, Ł. Banasiak, M. Chrzanowski, P. Bębas, *Jak przygotować pracę badawczą na Olimpiadę Biologiczną? Poradnik*, Edukacja Biologiczna i Środowiskowa, 2 2017, 79-102.

Activities related to the initial stage of the research cycle can be called *inquiry*. It consists of the ability to observe the surrounding reality, perceptiveness and the desire to deepen the message. An effective researcher is characterized by cognitive curiosity. Before the final formulation of a research problem, one should learn as much as possible about the object of research and recognize the current scientific achievements in a given area – a review of the literature serves this purpose.

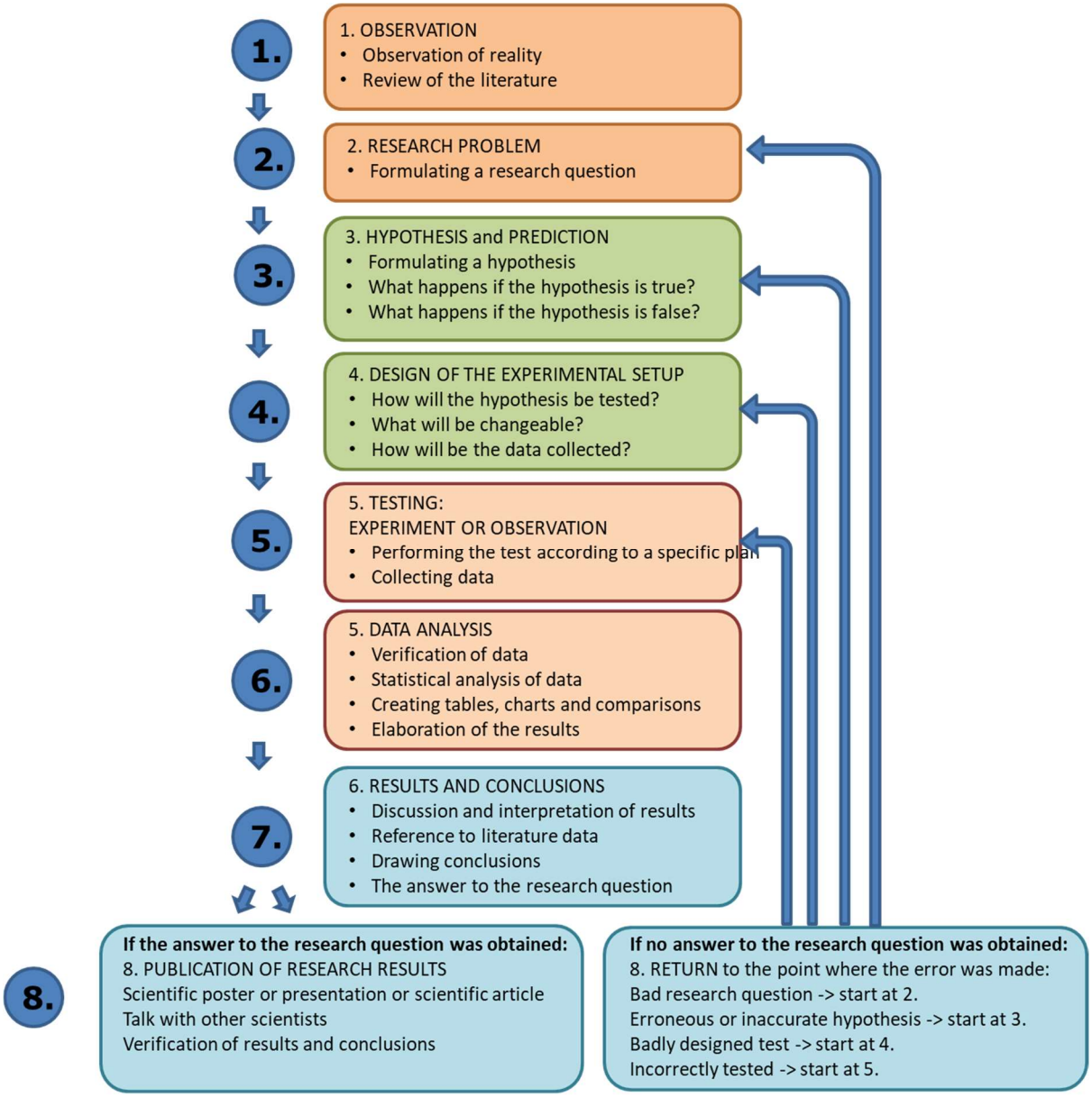


Fig. 1.6. Detailed diagram of the research cycle.
The colors of the rectangles correspond to the next stages of the cycle:
orange is the stage of inquiry, green - design, pink - testing,
and blue is the stage of evaluation of the research[10].

[10] Joanna Lilpop, Maria Zachwatowicz, Łukasz Banasiak, Marcin Chrzanowski, Piotr Bębas, *Jak przygotować pracę badawczą na Olimpiadę Biologiczną? Poradnik*, Edukacja Biologiczna i Środowiskowa, 2 2017, 79-102.

### HOW TO SET UP A RESEARCH QUESTION? WHAT IS THE HYPOTHESIS

*Hypothesis – a guess about the occurrence of certain phenomena or dependencies between them, which allows to explain some inexplicable complex of facts being a problem*[11].

Questions that are not answered, despite the recognition of the current state of knowledge, form the basis for the formulation of the **research problem**. Research questions must be topical and unambiguous. A good research question makes it possible to determine the research process and basically defines the purpose of the research. It also takes into account potential limitations of available research methods and tools as well as time available. When formulating research questions, it is worth considering what probable results can be predicted based on the existing laws and theories and the current state of knowledge on a given topic.

The **hypothesis is a scientific supposition, a probable explanation of the studied phenomenon or the definition of dependence that should be tested while conducting the research**. It can be said that the hypothesis is a proposition for answering a research question – a response that needs to be checked and empirically verified. Based on hypotheses, it is possible to formulate predictions – for example, you can predict the effects that will change a single factor affecting the studied phenomenon. The characteristics of the correct scientific hypothesis can be summarized as follows:

- It is precisely formulated and internally consistent.
- Applies to previously undiscovered aspects of a given field of knowledge.
- It is testable, i.e. there is a method and there are criteria that can be used to check the hypothesis.
- Can be used to make predictions.
- Is the affirmative, and usually contains information about the relationship or the absence of it between an independent and dependent variable.

### Ex. 1.6. A RESEARCH PROBLEM AND A HYPOTHESIS

Formulate a research problem (question) in your area of study. Try to choose as simple problem as possible.

……

……

……

……

Formulate two different hypotheses to the research problem sated above.

……

……

……

……

Discuss with another student your research question and hypotheses you stated.

### SELECTION OF VARIABLES OR FEATURES TO BE TESTED

Choosing the object and subject of research, asking research questions and formulating hypotheses makes it possible to move on to the creation of a research plan, that is a course of action aimed at answering research questions and checking hypotheses.

---

[11] T. Kotarbiński. Dzieła wszystkie. *Elementy teorii poznania, logiki formalnej i metodologii nauk*. Kraków: Ossolineum 1990.

**Selection of variables in the experimental research work**

Designing the experiment should start with determining the so-called **variables**. Variables **are parameters that we measure or control during testing**. Therefore, when planning a hypothesis-testing experiment, it is crucial to determine all variables existing in a given test system. There are three types of variables:

- **Independent variable** – this is a **factor that we consciously manipulate** in our experiment. The test group and the control group differ from each other in the value of the independent variable.
- **Dependent variable –** this is a **parameter that changes under the influence of the examined factor**, in other words, this variable *depends on the independent variable*, which is why it is called dependent. The difference in the value of the dependent variable between the control group and the test group is the measure of the effect that the factor tested in the experiment causes.
- **Controlled variables** are **all other parameters and conditions in which the test runs and which should not change while the experiment is conducted**. Parameters of controlled variables should be monitored during the course of the study *to ensure that the recorded changes of dependent variables are the result of the influence of the studied factor (independent variable), not the change of other factors*. The test group and control group in the experiment should have the same conditions – the values of controlled variables.

All types of variables can be quantitative (for example: growth, temperature, light intensity, etc.) or qualitative with two or more levels (for example: presence or absence of a predator in an aquarium, color of a light filter, etc.).

Usually, among the many values of an independent variable, the reference value of this variable will also be taken into account – *which is the reference point for the remaining variants tested*. We call it the **control sample**. It allows you to draw conclusions by comparing the results obtained in the test sample. In the case of an experimental set-up with two or more levels of an independent variable, usually only one of the samples is treated as a reference point for the others – it is a control sample.

If we would like to answer the question: *Will the fertilization of cultivated plants increase the yield?*, the natural control group would be cultivation without fertilizer. If we reverse the research question: *Will the discontinuation of fertilization cause a decrease in the yield*?, then the control test will be in the same experimental system with the fertilizer. This example shows that an indication of a control and research sample is impossible without a precise research question and that the control cannot be simply defined as where the test factor does not work – in this case it is fertilization.

**The experimental research system has to contain at least one independent variable** (there may be more of them, but it should be remembered that each additional independent variable increases the complexity of the system and may complicate the data analysis). The independent variable can be, for example, the degree of insolation, hydration, temperature, various species of organisms studied, the presence / absence of harmful or beneficial factors, the type of soil or soil additives, type of environment, etc.

**The experimental set-up has to contain one dependent variable**, that is a parameter that will be measured or observed during the test. It is also possible to take into account the measurement of several different parameters indicating changes occurring under the influence of an independent variable (several dependent variables), but during statistical analysis of such results, more advanced tests with multidimensional analysis should be applied.

**To determine a dependent variable**, you need to consider what you will be observing and what effect you expect to find. What parameters are expected to change as a result of applying an independent variable? There may be several qualitative and / or quantitative dependent variables for each independent variable. For example in a work about the impact of the type of food on the development of butterflies, the length of larvae and number of live individuals were measured at several specific developmental moments.

All **controlled variables** should be indicated in the experimental set-up. During the experiment you will have to keep them at a constant, unchanged level and the way you can monitor them. It is also worth thinking about the available measuring devices or sensors (for example: thermometer, moisture meter, light meter etc.), which will enable monitoring the parameters of the experiment.

**EXAMPLE**: Study of the influence of the selected factor on the seed germination process (Fig. 1.7).

| | | |
|---|---|---|
| **research question** | *Is water indispensable for seed germination?* |  Fig. 1.7. Germination of the seeds[12]. |
| **hypothesis** | *Water is essential for germination of seeds.* The hypothesis: *water is not essential for germination of seeds* is also good and is logically the same hypothesis as the one stated above. | |
| **independent variable** | It is the availability of water. This variable will take two possible variants: the lack of water and the presence of water in the ground. | |
| **dependent variable** | It is the number of seeds which germinated at a given time. | |
| **controlled variables** | conditions in which seeds germinate remain identical in all experimental tests – substrate, exposure, surface/compaction, air access, air humidity (not to be confused with the presence/absence of water in the substrate, which is an independent variable), ambient temperature, number and quality of seeds tested, duration of the experiment and method of measuring the dependent variable. | |

Many works contain one, two or three independent variables. The lowest number of logical errors can be found in works that contain one independent variable. However, studies that take into account three and more variables usually accumulate so much data that it is difficult to draw coherent conclusions from them without the use of complicated statistical tests. A young researcher who is just learning the rules governing scientific work should create a possibly simple research system with one independent variable, which obviously does not exclude the possibility of conducting research into an original subject and the creative approach to research.

### EX. 1.7. FORMULATING AN EXPERIMENTAL SETUP – *FORTUNE TELLER FISH*

Place the fish one more time on the inside of your palm and observe its behavior. Formulate an adequate research question regarding the way it behaves.

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[12] Figure source: https://pl.freepik.com/darmowe-zdjecie/close-up-z-nasion-kwitnacych_966474.htm.

Formulate two different hypotheses.

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Formulate one independent variable.

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Formulate one dependent variable.

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Formulate controlled variables.

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Discuss with another student your experimental setup. Are any elements from Ex. 1.9 similar to those you have written in the Ex. 1.7?

**AN IMPORTANT FEATURE OF ANY GOOD EXPERIENCE IS ITS REPETITION[13].**

After planning the research and gathering all the necessary resources, the researcher proceeds to the testing phase, i.e. conducts an experiment or deliberate observation.

At the beginning, it is worth performing a series of shorter preliminary test experiments (pilot trials) on smaller research groups, allowing to properly choose the conditions for the main study. The pilot allows you to check the effectiveness of selected research tools, and also to identify possible technical and organizational problems.

[13] E. B. Wilson, *Wstęp do badań naukowych,* Warszawa: Państwowe Wydawnictwo Naukowe 1964.
.

While conducting research, you must constantly take care of reliability and research integrity. Research cannot be burdened with the intention of the researcher (wishful thinking) or be conducted in order to prove the truth of the hypothesis at all costs. Research in which the hypothesis was rejected is just as important for the development of science as the research confirming its validity!

The measurements must be objective and precise. If the results in subsequent replicates of trials or duplicate tests are not similar (repetitive), verify the methods and method of measurement used (Are they reliable? Are all controlled variables stable? Are there no additional external factors affecting the measurement results?). If the results of the experiment vary despite the fact that the studied factor has not been changed, it may mean that the result is influenced by some unknown factors, and the search for such unknown factors may lead to interesting discoveries.

After collecting and analyzing the data, results should be developed. The evaluation process consists of the interpretation of the results and their reference to the literature data. The results of experiments and observations require interpretation in the light of information obtained after statistical analysis, logical analysis and in the light of data obtained by other researchers. The research assessment stage is the most demanding stage of research work – understanding the nature of the results obtained and giving them meaning depends on the researcher's intellectual abilities and the logic of his reasoning. Particular attention should be paid to the distinction between the existing correlation (coexistence) of events and the actual causal relationship.

What if the obtained results and their interpretation do not give an answer to the research question? In such a case, all the stages of the research work should be analyzed and errors found. These errors can occur at any stage, and the research cycle should be repeated from the stage in which the error occurred. Errors may result from inaccurate or faulty experiment / observation – in that case only the testing stage should be repeated. It may turn out that the entire study was defectively designed – in that case a new test plan should be created and re-performed. The results can also prove that the hypothesis was inaccurate.

If, however, the study was correctly planned and designed, and despite that it gave a negative result, it is worth remembering that in the cognitive process, negative research results are as valuable as the positive results, because they increase the verified scientific knowledge about the given phenomenon and give the basis for further research. The history of science shows that the most interesting studies are those which yield unexpected results. They constitute a motor for conducting further in-depth investigations and taking up new research directions.

## 1.3. MISCONCEPTIONS

### DO HEDGEHOGS EAT APPLES? … AND OTHER MISCONCEPTIONS[14]

1. Analyze the picture in the Fig. 1.8 and answer the question.

Fig. 1.8. A cup of coffee.

What is a cloud above the cup of coffee?

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2. Analyze the picture in the Fig. 1.9 and answer the question.

Fig. 1.9. A kettle[15].

What is in the place indicated by the arrow?

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[14] This chapter was written on the basis of two articles written by Marcin Chrzanowski et al.:

1. M. M. Chrzanowski et al., *Vernacular Misconceptions in Teaching Science – Types and Causes*, Turkish Journal of Science Education, 15, 4 2018;
2. M. Markowska, M. Lechowicz, W. Grajkowski, M. M. Chrzanowski, K. Spalik, J. Borgensztajn, E. B. Ostrowska, M. Musialik, *Błędne przekonania w nauczaniu przedmiotów przyrodniczych*, Edukacja Biologiczna i Środowiskowa, 4 2014;

[15] Figure source: https://images.fineartamerica.com/images-medium-large/boiling-kettle-tek-image.jpg.

3. Answer the questions below

1. Science cannot answer all questions. □ true. □ false.
2. Humans are animals. □ true. □ false.
3. Most scientists are atheists or agnostics. □ true. □ false.
4. Scientific explanations change with the times. □ true. □ false.
5. Science rejects supernatural explanations. □ true. □ false.
6. Scientific theories can only be verified by experiments. □ true. □ false.
7. Evolution is a linear progression from inferior to superior organisms. □ true. □ false.
8. Drinking alcohol may cure a bacterial infection. □ true. □ false.
9. Scientists do experiments to prove their hypotheses. □ true. □ false.
10. Great scientific discoveries are usually made by accident. □ true. □ false.
11. Applied research is more important than basic research. □ true. □ false.
12. Mathematics is a science. □ true. □ false.
13. Science and religion are compatible. □ true. □ false.
14. Humans are more evolved than worms. □ true. □ false.
15. The word 'theory' in science means unproven speculation. □ true. □ false.
16. Different scientists might publish conflicting experimental results. □ true. □ false.
17. Homosexuality is a curable condition. □ true. □ false.
18. Vaccines may cause autism. □ true. □ false.

Write down your thoughts about questions you have just answered.

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Watch the movie: *Fish is fish* by Leo Lionni carefully[16].

1. Now think. What can we deduce about the cognitive process on the basis of a fairy tale?
2. Write down your thoughts.

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3. Discuss it in pairs.
4. Write down your final thoughts.

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[16] Video link: https://vimeo.com/39374062.

- Learning is the construction of knowledge structures by a thinking subject, not the process of acquiring ready-made content or templates.
- The mind is not a photographing camera or a mirror reflecting reality – it creates knowledge in the form of images, concepts, judgments and emotions.

To understand the surrounding world, we refer to our views on a given topic: the reality that surrounds us, ideas, concepts and thought structures. When we are trying to understand new ones, previously unknown to us, we create in our head a structure that allows us to organize and build new knowledge. If we do not succeed in fully understanding, the given issue and sorting out the new information, the mind builds incomplete and unclear representations of this issue. These incomplete representations, often based on incorrect assumptions or resulting in oversimplification of reality, are called misconceptions, or misrepresentations. To show that they are often beliefs that contradict the accepted scientific views, they are also called 'alternative concepts' or 'alternative diagrams'. However, it may be confusing, because they are not fully alternative explanations of reality. Included in this category are also *a priori* beliefs, unsupported scientific evidence, misunderstandings, stereotypes manifested in everyday language or mixture of erroneous concepts and dubious theories.

One can say that students do not come to school as blank slates and have some initial conceptions that influence the didactic process and are dynamic, structured, explicit and tacit. These preconceptions may be fully correct, partially correct or incorrect – the first two being referred to as prior knowledge, and the last as misconceptions. **A misconception may be defined as a mental representation of a concept that does not correspond to the currently held scientific theory**. Partially correct conceptions (i.e. those that are not entirely wrong and thus may be fruitfully used in teaching) are sometimes called alternative frameworks, naïve ideas, phenomenological primitives and children's ideas. Hardly anyone is absolutely free of miscomprehension, misperceptions or misjudgments that result from language usage! These may be related not only to science but also to virtually all aspects of life, such as religion, interpersonal relationships, history or simple housework, and may be found both in students and in teachers, regardless of their academic achievements. Some misconceptions display noticeable consistency throughout the populations of the world.

Misconceptions may be divided in two ways: according to their origin or to their functional type (Figure 1.10).

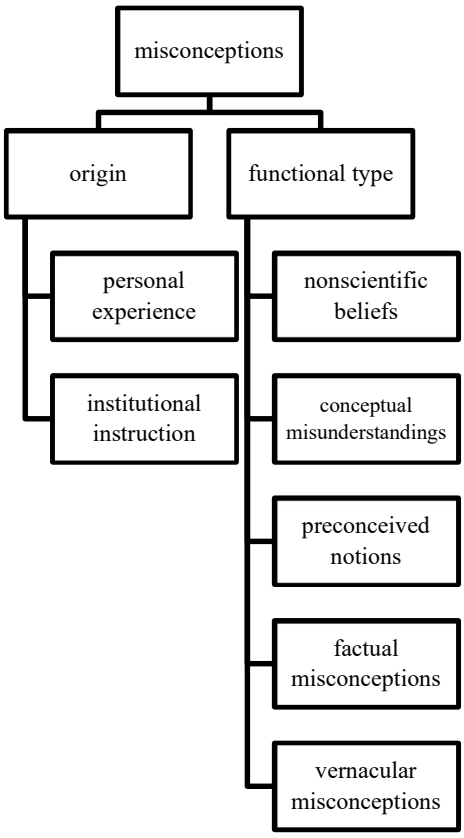


Fig. 1.10. Two ways of misconception division

They may originate from personal experience and institutional instruction. As for the functional type, we distinguish nonscientific beliefs, conceptual misunderstandings, preconceived notions, factual misconceptions and vernacular misconceptions[17].

Principal sources of misconceptions are: overloading the learner's short term memory and wrong mental strategies (teaching with the use of algorithms, covering too much material too hastily). These problems may be due to going on to problem-based activities before the content has been properly internalized, standard student epistemology, sources related to prior knowledge, mismatch of the cognitive demands of the subject matter with the developmental level of the learner, or language-related problems.

### FUNCTIONAL CLASSIFICATION OF MISCONCEPTIONS

**1. Preconceived notions**

This group includes common beliefs rooted in everyday experience. While learning new concepts or phenomena, we usually try to refer them to concepts and phenomena that we already know. We create analogies, which, however, are not always accurate and often distort the picture of reality. Sometimes, our individual experiences and impressions cause the emergence of such misconceptions. For example, when we sit in the park on a wooden bench in the winter, and then on a metal one, we may discover that the metal bench is 'colder than wood'. In fact they have the same temperature (equal to temperature of the air), but the metal bench conducts heat better, hence the feeling that it is cooler than wood.

**2. Conceptual misunderstandings**

Conceptual misunderstandings arise when pupils trying to get to know a new phenomenon, process or concept, turn it into an image in a mechanical way. These concepts often do not merge with other theories or fragments of theories memorized by students. Sometimes, the students themselves note that their image of a given phenomenon is not consistent, but they do not try to overcome this incoherence. If the attitudes of such students are not corrected to a to be in line with a given scientific view, they will believe in their own concepts which are incorrect. Benson, Wittrock and Baur[18] conducted a study consisting of students' description of expected effects of an experiment. The students were to describe the changes occurring in a closed flask after pumping out some of the air. It turned out that 15% of chemistry students sketched the flask in which appear adjacent two zones with air and without air.

**3. Nonscientific beliefs**

If someone's views are justified invoking a particular authority ("master", "Schools") or selectively cited facts containing? statements that are impossible to check with observation or experience, these are unscientific. Before the development of science, the world and its' phenomena were explained using myths, superstitions, as well as religious beliefs. Although today most philosophers of science and researchers believe that science and religion are not in conflict due to the fact that they concern different aspects of explaining the world, their coexistence is not fully peaceful. Many people having fundamentalist beliefs, rejects scientific knowledge about evolution and, above all, about evolutionary development of the human. Nowadays, creationist views often take the form of quasi-science, e.g. intelligent project theory, however, they have no basic features of science - do not use the scientific method. In addition to creationism, the source of which is literal (not allegorical), reading the Book of Genesis, other views also function in unscientific society, which in a serious way distort the understanding of the surrounding. These are, among others, faith in fortune telling and horoscopes, 'bioenergotherapy', homeopathy or many trends rooted in religions of the East.

Unfortunately, unscientific believes are usually deeply rooted in the mind of the person proclaiming them and is often accompanied by affirmative thinking – searching only for facts confirming your views and rejection of all incompatible.

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[17] Committee on Undergraduate Science Education; Board on Science Education; Division of Behavioral and Social Sciences and Education, (1997). *Science Teaching Reconsidered: a Handbook.* Washington: The National Academies Press;

[18] D. L. Benson. M. C. Wittrock, M. E. Baur, *Students' preconceptions of the nature of gases*. Journal of Research in Science Teaching, 30, 6 1997.

Read about the origins of the anti-vaccination movement[19].
Do they have any scientific support? Justify your answer.

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**4. Vernacular misconceptions**

Communication is indispensable for transferring knowledge, and language, as a means for communication, is of vital importance for science literacy. It is used to convey procedures, inquiries and understandings to others in the form of written and spoken communications. Both in scientific research and in teaching science, other representations are useful or even necessary, such as analogies, metaphors, symbolic thinking and valid terminology which is often complex. The language of science is not to be confused with everyday speech (natural language) as it is artificial and aims at monosemy – the vocabulary used for scientific purposes differs considerably from its everyday use, where particular notions may have numerous, often contradictory, meanings that depend upon the situation. Among scientists, there are certain standards of communication, though ambiguity and equivocality may arise as particular specialties have their idiosyncrasies. This discrepancy between the natural language used in everyday life and that used in science classes causes problems that significantly impede the teaching process.

Vernacular misconceptions result from language confusion where mistaking everyday speech lexemes for scientific terms leads to erroneous interpretation of phenomena. This sort of misconceptions is particularly interesting since it is situated somewhere in between experience-based sources and instructional ones. Vernacular misconceptions stem not only from the fact that people acquire some vocabulary and (mis)representations related to it in their childhood (at home) but also because teachers use terminology without being aware that different students may understand it differently or that some students may not be able to face the difficulties the subject matter content entails as far as the vocabulary and syntax are concerned.

Vernacular misconceptions include problems with vocabulary, symbols, as well as analogy and metaphor used in the subject matter. Another issue is the multiple-level representation of symbols in science, where, for instance, one symbol may be used for different purposes by different disciplines or even within one discipline (e.g. the letter 'N' may stand for 'North' in earth science, 'nitrogen' and 'normality' in chemistry, 'newton' in physics), whereas one concept may be represented with different symbols (e.g. 'energy' that is written as 'E', 'Q', 'T' or 'U' etc. depending on the context). Analogies and metaphors may be very helpful in teaching, but they sometimes bring about more problems than they solve. The 'seductive power' of analogy, on the other hand, makes many people neglect the important differences while underlining the similarities. This has considerable impact on the language structures that are established in the way the students think and speak about natural phenomena. Metaphors are also perceived as tools offering a link between the emotional and the cognitive, as they encourage learners to think more creatively, without sticking to rigid theories (their preconceptions included); however, this is only recommended when the metaphor helps the explanation and does not replace it.

[19] A. Hussain, S. Ali, M. Ahmed, S. Hussain *The Anti-vaccination Movement: A Regression in Modern Medicine,* Cureus, 10, 7 2018.

**5. Factual misconceptions**

Factual misconceptions are false information (or conceptions), often remembered by the student in the early childhood and uncorrected up to adulthood. Sometimes these are outdated, rejected scientific views which formerly were served in some textbooks. For example, fungi were classified together with plants (because they do not move), but today we already know that they are more closely related to animals than plants. A superstition that lightning never strikes in the same place – there is no justification in science, however, many people believe in it. This view is in conflict with frequently observed electrical discharges on objects that tower above the surroundings, for example on the Eiffle Tower.

**Some examples of misconceptions.**

- Oxygen is a flammable gas.
- The combustion reaction must be initiated using a flame.
- Air is a chemical element.
- The product of combustion is always carbon dioxide.
- All acids are corrosive.
- All acids are liquid.
- When we heat something, the particles grow or swell.
- The bubbles that form in the water that boils are filled with air.
- Plants do not have DNA.
- Only tomatoes have DNA.
- People lived at the same time as dinosaurs.
- A kilogram of lead is heavier than a kilogram of feathers.

Now think about your area of knowledge. Try to write at least three examples of misconceptions.

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**MISCONCEPTIONS AND THEIR SOCIAL IMPACT**

Look at the picture below (Figure 1.11).


Fig. 1.11. Media and manipulation[20].

[20] https://alphanewsmn.com/wp-content/uploads/2018/02/media-manipulation.jpg.

Write your impressions below.

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Define the term: manipulation.

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Look at the ads for various products, in particular drugs, diet supplements and household chemicals. What techniques do the advertising producers use to convince us to buy the advertised products? Give specific examples.

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In Polish. Listen to the TOK FM radio podcast entitled: *Resort Zdrowia chce ograniczyć reklamy suplementów diety. Słusznie? (Ministry of Health wants to limit the advertising of dietary supplements. Is this decision right?).* There are some misconceptions stated between minutes: 13:32 – 21:00.

Write down a comment to Bohdan Wyżynkiewicz's speech.

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A note about the radio guest:
*Bohdan Emil Wyżnikiewicz, a Polish economist and statistician, in 1991-1992 the president of the Central Statistical Office, vice president of the board of the Institute for Market Economics, chairman of the board of the Institute of Economic Forecasts and Analyses?, member of the Forecasting Committee of the Polish Academy of Sciences, Fulbright scholarship holder.*

Look at the picture below (Figure 1.12).

Fig. 1.12. Three states of water?[21]

[21] Image source: http://www.wiw.pl/obrazki/fizyka/pict/000010-01.gif.

Is the description of the Figure 1.12 correct? Write down your impressions below.

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Enter a query in the search engine search box (Chrome, Opera, Mozilla, etc.). Type in: 'water vapor' in four different languages. Click on the 'figure search' options. What characteristic phenomenon can you see?

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*Common experience with water vapor may be misleading – it is fully acceptable to call the cloud that comes out of a kettle or an iron 'steam/vapor' in everyday life, whereas in science this term has a narrower, precise meaning. This is partly due to the fact that whenever in media, comic books, cartoons etc., a gas is to be represented, it is usually depicted as a cloud, even if in reality it cannot be seen. The words 'vapor', 'steam' or 'gaseous' (regardless of the language we speak: French vapeur, Spanish vapor, Italian vapore, German Dampf, Russian nap 'par', Polish para, or the Japanese 蒸 'jyou') typed into a browser provide us with images of clouds in the sky, fumes coming out of chimneys or white cloudlets bursting from kettles, cooking pots, steam-cooked dishes or even a water pipe. Likewise, we often come across such images in science/chemistry/physics textbooks. Interviews performed with ISCED 2 students about the water vapor confirmed that the knowledge the students have is incomplete, fragmented and often inconsistent. Some of the interviewees' beliefs are listed below.*

- *Water vapor does not have to (or even cannot) be colorless, and may be grey or white;*
- *Water vapor makes students think not only of fog, dew or clouds (in the sky), but also of smoke, fire (of a building), bonfire, or, more generally, of diffusion, cloud of condensed steam;*
- *Glass, nail polish or water can be colorless, but still not invisible, so water vapor may be colorless and visible (as a white cloud) at the same time (which suggests some of the students do not understand the notion of colorlessness);*
- *Water vapor may sometimes be visible, and sometimes invisible, depending on the conditions;*
- *Droplets are 'something bigger, like raindrops', while 'water vapor are really tiny droplets.'*[22]

[22] M. M. Chrzanowski et. al., Vernacular Misconceptions in Teaching Science – Types and Causes, Turkish Journal of Science Education, 15(4) 2018.

# CHAPTER 2. WE LIVE RESPONSIBLY

## 2.1. SUSTAINABLE DEVELOPMENT GOALS

***2030 Agenda for Sustainable Development***

*This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognize that eradicating poverty in all of its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development. All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want and to heal and secure our planet. We are determined to take the bold and transformative steps which are urgently needed to shift the world on to a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind. The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what they did not achieve. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental. The Goals and targets will stimulate action over the next 15 years in areas of critical importance for humanity and the planet.*

***People***

*We are determined to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment.*

***Planet***

*We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations.*

***Prosperity***

*We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature.*

***Peace***

*We are determined to foster peaceful, just and inclusive societies which are free from fear and violence. There can be no sustainable development without peace and no peace without sustainable development.*

***Partnership***

*We are determined to mobilize the means required to implement this Agenda through a revitalized Global Partnership for Sustainable Development, based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people.*

*The interlinkages and integrated nature of the Sustainable Development Goals are of crucial importance in ensuring that the purpose of the new Agenda is realized. If we realize our ambitions across the full extent of the Agenda, the lives of all will be profoundly improved and our world will be transformed for the better*[23].

[23] https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

## EX. 2.1. DISCUSSION ABOUT THE SUSTAINABLE DEVELOPMENT GOALS

Fig. 2.1. presents pictograms of all seventeen sustainable development goals. Think about each of them. Suggest below two topics for discussion on the ways of achieving each goal.


Fig. 2.1. Sustainable development goals[24].

<u>Topics for discussion:</u>

Goal 1.

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Goal 2.

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Goal 3.

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Goal 4.

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Goal 5.

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Goal 6.

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Goal 7.

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[24] Figure source: https://news.un.org/en/story/2015/12/519172-sustainable-development-goals-kick-start-new-year.

Goal 8.

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Goal 9.

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Goal 10.

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Goal 11.

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Goal 12.

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Goal 13.

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Goal 14.

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Goal 15.

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Goal 16.

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Goal 17.

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## Ex. 2.2. Goal 4. Good quality of education

Imagine that you are the Minister of Education and your task is to provide good quality education. What actions will you take?

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## Ex. 2.3. Correlations between goals

Look again at all seventeen goals. Find three correlations (each between at least two goals) and describe them.

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## 2.2. PROBLEM WITH TEMPERATURE

**EX. 2.4.** **ANSWER THE QUESTIONS**

1. Why is the atmosphere referred to as a blanket?

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2. Which kind of transport has the lowest impact on the atmosphere?

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3. Imagine the level of sea increasing by one meter. How would it affect the atmosphere, hydrosphere, lithosphere and biosphere?

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4. The image below shows how Poland could look in 2119 (Fig. 2.2). Write down how the area next to your place of living would be affected.

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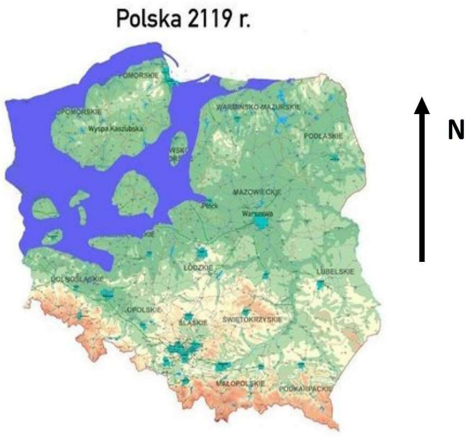


Fig. 2.2. The image of Poland in 2119[25]

[25] Image source: https://cdn.donald.pl/filer_public_thumbnails/filer_public/0c/ae/0caeb01a-b585-4bf9-b1a0-63d4d98bbce6/photo_2019-06-23_113406.jpeg__655x0_q85_crop_subsampling-2_width-655.jpg.

## EX. 2.5. CARBON CYCLE

Draw a diagram showing the carbon cycle on the Earth.

## LAB 2.1. ATMOSPHERE IN A GLASS JAR.

Your team is going to design an experiment that shows the impact of different variables on the temperature inside a glass jar. We will use a heat lamp as the source of heat. Check the materials and reagents prepared for classes, and then perform further exercises.

Ask a research question.

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What is your best guess – write down your hypothesis.

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MATERIALS AND CHEMICALS

- ✓ glass jars with lids,
- ✓ clear plastic wrap,
- ✓ rubber bands,
- ✓ thermometers,
- ✓ sensors,
- ✓ heat lamp,
- ✓ black cloth,
- ✓ tap water,
- ✓ soil,
- ✓ a plant,
- ✓ citric acid,
- ✓ sodium bicarbonate.

Using the materials listed above, design and complete an experiment to test your hypothesis. Describe the procedure. Choose one of the setups given in the table form in the section called 'data.' There are four empty columns – create your own setup. Remember that each time you should compare results from two jars with and without $CO_2$.

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EXPERIMENT DESIGN

Characterize the independent variable.

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Characterize the dependent variable.

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Characterize the controlled variables.

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Draw a diagram of the experiment setup.

Fill in the table. Enter different combinations of independent variables that you propose in empty spaces.

| **empty jar** | | **$CO_2$** | | **soil** | | **soil + $CO_2$** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] |
| | | | | | | | | | | | |
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Note down down your observations.

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| empty jar | | plant | | plant + $CO_2$ | | plant + soil | | plant + soil + $CO_2$ | | methane | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] | t [min] | T [°C] |
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Note down your observations.

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Plot graphs using the data that has been collected. Remember to show the dependent and independent variables on the axes.

Does the presence of a plant or soil affect the temperature in the jar? Describe the effects you could observed.

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Draw conclusions.

Claim: Write down a statement that answers the research question.

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Evidence: Support your claim using the data you have collected.

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Reasoning: Think and describe which phenomenon is modelled by this experiment.

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How realistic was the model of this phenomenon?

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How unrealistic was the model of this phenomenon?

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Which of the experiment setups was the most realistic one? Justify your answer.

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How could you upgrade the setup to obtain more realistic data? Justify your answer.

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How do you think the temperature and level of the gases will change at night in comparison with the daytime?

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## Ex. 2.6. Greenhouse Effect

Read the text A1: *Things Are Heating Up in Solutionville* by Keely Ng, The Solutionville Inquirer. Write down your impressions[26].

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Now you will be working in three groups. Each of the group will read a text on the hypothesis – pages A2, A3 and A4. Your task will be to present your hypothesis to the other groups.
Prepare yourselves for a discussion. Write your notes below.

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Now discuss with other and share your opinions on which of the hypotheses is the most reliable. Justify your answer. Write down any (logical, statistical etc.) mistakes you spotted in the text.

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Watch a video and answer the questions below.
https://www.pbslearningmedia.org/asset/phy03_vid_greenhouse2/

1. Write down all the greenhouse gases mentioned in the video.

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2. What would be the average temperature on the Earth without the greenhouse effect?

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3. Write down three fossil fuels burned by the man that are mentioned in the video.

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[26] Text source:
https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_heatison_solutionvilleinquirerarticle.pdf.

Watch two videos on the mechanism of the greenhouse effect.

- https://youtu.be/BPJJM_hCFj0[27]
- https://youtu.be/sTvqIijqvTg[28]

Now answer the following questions.

1. What do the greenhouse effect and the greenhouse have in common?

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2. How does our everyday behavior influence the level of greenhouse gases?

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Now check how big your environmental footprint is.
Go to the website: https://footprint.wwf.org.uk/#/[29], take a survey and read the results – your carbon footprint. Discuss your results with other students. Write down your impressions.

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What could you change in your lifestyle to lower your carbon footprint?

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What will be your first step in introducing these changes? Write it down.

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Write down the exact date when you are going to start the change.

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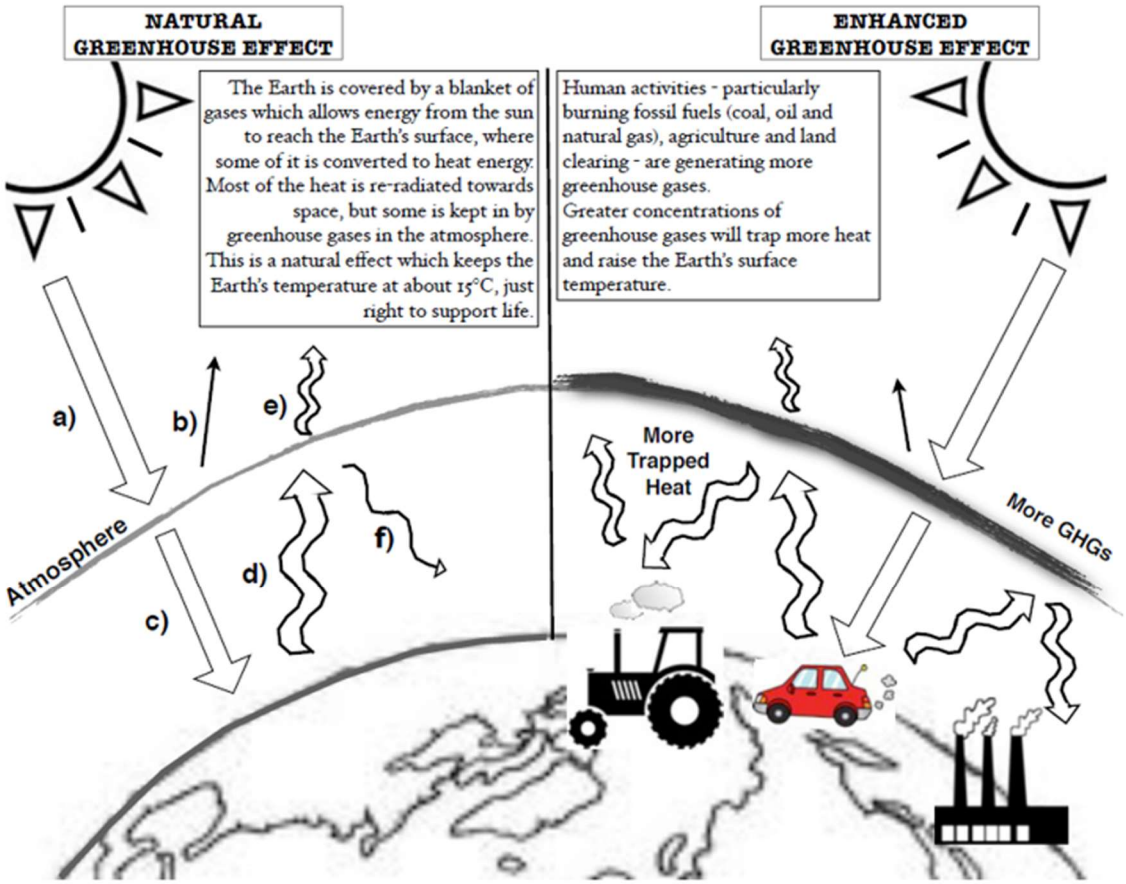
[27] https://youtu.be/BPJJM_hCFj0;
[28] https://youtu.be/sTvqIijqvTg;
[29] https://footprint.wwf.org.uk/#/.

Color the picture presenting the greenhouse effect according to the instruction below[30].




**Coloring instructions:**

- *Color (YELLOW) the arrow coming from the Sun to the Earth.*
- *Color (YELLOW) the small arrow that reflects off the atmosphere .*
- *Color (YELLOW) the arrow that reaches the Earth.*
- *Color (ORANGE) the wavy arrow coming from the Earth.*
- *Color (ORANGE) the wavy arrow going to space.*
- *Color (ORANGE) the wavy arrow pointing back to the Earth.*

[30] Source of the picture and instruction: https://www.cog.ca/wp-content/uploads/2018/08/greenhouseeffectfinalcolouring.pdf.

## 2.3. A FOREST IN A JAR

It was 1960 when David Latimer, a French botanist, planted a garden in a bottle (Fig. 2.3). He last watered it in 1972 and then sealed it for good. It is an example of a closed and functional ecosystem. It wasn't opened for 60 years and it still work perfectly.

Fig. 2.3. David Latimer planted a garden in a bottle[31].

*It might seem strange to some that a sealed terrarium plants garden would thrive like this, but it's not – the garden is a perfectly self-sufficient ecosystem. The bacteria in the compost eat the dead plants and break down the oxygen given off by the plants, turning it into the carbon dioxide for photosynthesis that the plants need to survive. The bottle is an excellent micro version of the Earth as a whole and a great representation of existing types of ecosystems*[32, 33].

**LAB. 2.2. YOUR OWN FOREST IN THE JAR**

MATERIALS AND CHEMICALS

- ✓ glass jars,
- ✓ potting soil,
- ✓ LECA,
- ✓ activated charcoal,
- ✓ plants,
- ✓ moss,
- ✓ glass beads, rocks, etc.,
- ✓ water,
- ✓ thermometers,
- ✓ sensors,
- ✓ spoon / shovel,
- ✓ scissors,
- ✓ paper towels,
- ✓ plastic or paper sheets to cover the table,
- ✓ rubber gloves,
- ✓ long tweezers,
- ✓ black cloth (optional).

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[31] Source: https://www.boredpanda.com/sealed-bottle-garden-david-latimer/?utm_source=google&utm_medium=organic&utm_campaign=organic;
[32] Source: Dovas, BoredPanda Staff, *80-Year-Old Man Hasn't Watered This Sealed Bottle Garden Since 1972 And It's Still Alive.* 2019;
[33] https://www.boredpanda.com/author/dovas/?utm_source=google&utm_medium=organic&utm_campaign=organic.

PROCEDURE

1. Clean the jar thoroughly in soapy water. Rinse it carefully in clean water. Wipe with a paper towel.
2. Fill the bottom of the jar with rocks, pebbles or LECA. The layer of rocks should be approximately 3.5-5cm thick.
3. Pour the layer of activated charcoal at the top of the rock layer.
4. Add soil – as much as needed to plant your garden.
5. Take a plant out of the pot in which it was transported. Break up the hard soil and free the roots. It may be needed to trim the roots a little. If needed – use scissors.
6. Place the plant in the soil. Try to keep the leaves away from the sides of the jar.
7. Add moss or glass beads.
8. Water your plant a little.
9. Place the jar in dim light – avoid exposure to direct sunlight.
10. Put a sensor inside the jar and close the jar with a lid.
11. Observe changes in temperature and both carbon dioxide and oxygen concentrations.

Answer the questions. Write down your answers.

1. What is the role of the rock/LECA layer?

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2. What is the role of the activated charcoal layer?

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Observe the changes in temperature of both carbon dioxide and oxygen concentrations.
Note down the results

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1. Are there any differences between the parameters at night and during the day?

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2. What is the reason for such results? How does a plant affect the parameters tested?

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Here is the place for a photo of your forest.

## LAB. 2.3. CHEMICAL GARDEN

Not only nature can create a garden – it can also be done in the laboratory. Create your own garden and watch it grow[34].

MATERIALS AND CHEMICALS

- ✓ glasses and gloves,
- ✓ glass jar or aquarium,
- ✓ water glass, i.e. an aqueous solution of sodium silicate,
- ✓ water,
- ✓ a large spoon or a stirring rod,
- ✓ salts, e.g. copper, chromium, nickel, iron, cobalt, calcium and aluminum salts,
- ✓ teaspoons.

PROCEDURE

1. Pour the mixture of water glass and water into the aquarium (you can make several gardens – using different proportions of water glass and water).
2. Put salt crystals with teaspoons.

Note down your observations and add a photo of your garden.

[34] S. Sękowski, *Efektowna chemia,* Wydawnictwa Naukowo - Techniczne, Warszawa 1988.

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Try to name and explain the observed phenomenon.

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## 2.4. pH

**In media**

The term **pH** is widely used in media and even little children know this concept. TV commercials provide us with a lot of information on pH in different contexts: **pH** of the skin and the impact of cosmetics, **pH** of the mouth and the influence of chewing gum, results of laboratory analysis (e.g. **pH** of urine may vary within the pH of 5.0-9.0, although in healthy people the pH is about 6.5)[35,36], or the appropriate preparation of soils for the cultivation of specific plants.

**pH scale**

According to the well-known simplified definition, **pH is a negative logarithm of $H^+$ ion concentration $[H^+]$, i.e. pH = -log $[H^+]$**. The value of this concentration is given in mol/dm$^3$. If we were using $[H^+]$, the number of zeros to write at the lowest values would reach a dozen or so. The scientific notation here comes with help, e.g. $[H^+] = 10^{-13}$ mol/dm$^3$. But isn't it easier to give a number between <0; 14>? It should be remembered that the change by one pH unit is a 10-fold change in the concentration of these ions. Widely used for approximate pH measurement, universal indicator papers assume colors from red (at pH = 0), yellowish-green (at pH = 7) to purple-violet (pH = 14) (see Fig. 2.4).

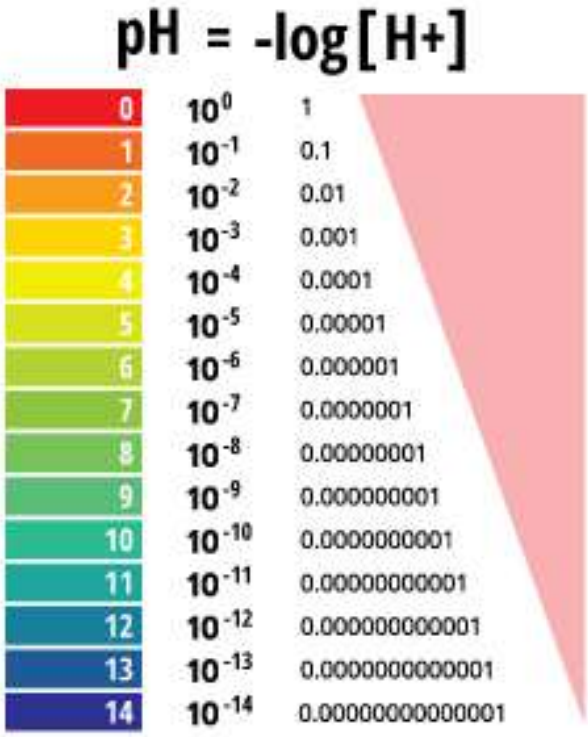


Fig. 2.4. pH values (left) and corresponding $H^+$ ion concentrations (right). Colors (from red to green to navy-violet) correspond to the colors of the universal indicator paper[37].

[35] Katedra Analityki Medycznej Wydział Nauk Medycznych Uniwersytet Warmińsko-Mazurski w Olsztynie. Badanie Ogólne Moczu, 2015;
[36] http://wnoz.uwm.edu.pl/sites/default/files/download/201810/badanie_ogolne_moczu_2015_kamila0.pdf;
[37] Figure source: https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/.

**EX. 2.7.** CALCULATIONS

It is time to calculate. Complete the table. If necessary - use the calculator.

| pH | $[H^+]$ (mol/dm$^3$) |
|---|---|
| 4 | |
| | $10^{-13}$ |
| 1.7 | |
| | $10^{-9,5}$ |
| | $7.2 \cdot 10^{-5}$ |

Which of the examples turned out to be the easiest and which did you find the most difficult? Why?

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**Indicators**

The most common for approximate pH measurement are universal indicator papers, as it has already been mentioned in this subsection. They are tissue paper strips impregnated with a mixture of different substances. They can be wound on a roll or glued onto another matrix. Of course, they are always accompanied by a color scale.

**LAB. 2.4.** pH TESTING OF HOME USE PRODUCTS USING UNIVERSAL PAPER INDICATORS

Look for ten products in your home, pH of which you would like to study. Half of them should be food products. Try to choose them to make the paper turn red, green, yellow, blue and navy blue. Complete the table below.

| product name | color of the universal paper indicator | pH |
|---|---|---|
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Comment on the results you have obtained.

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Now, choose the food products. Try to arrange them in ascending order of pH value. Add information about their pH and taste.

| product name | pH | taste |
|---|---|---|
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Solution with:

- ✓ pH < 7 is acidic,
- ✓ pH = 7 is neutral,
- ✓ pH > 7 is alkaline.

Using this information, comment on the data in the table above.

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## LAB. 2.5. RED CABBAGE

Read the text below.[38]

How to make a red cabbage indicator that will test the acidity or alkalinity of certain liquids.

*1. Peel off three or four big cabbage leaves and put them into a blender that has been filled half full with water. Blend the mixture at high speed until you get purple cabbage juice.*

*2. Pour the purplish cabbage liquid through a strainer to filter out all of the big chunks of cabbage. Save the liquid for the experiments to that will follow.*

*3. Maybe: put three glasses on the table, side by side. Fill each glass three-fourths full with cabbage juice.*

*4. Add a little vinegar to the first glass filled with cabbage juice. Stir the mixture with a spoon and notice how the color changes into red, which indicates that vinegar is classified as an acid. All acids will turn red when mixed with cabbage juice.*

*5. In the second glass, add a teaspoon of washing soda or another laundry detergent. Notice how the liquid turns green, indicating that this chemical is a base.*

*6. Keep these two glasses, i.e. filled with red (acid) and green (base) liquid for future reference. Fill the third glass with purple cabbage juice to show the color of a neutral solution.*

The text above inspired researchers to propose a hypothesis.

**Hypothesis: Red cabbage juice takes only three colors: purple, red and green.**

Become a researcher. Plan and then carry out appropriate experiments to verify this hypothesis. Use pre-selected home products.

Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.

[38] https://www.stevespanglerscience.com/lab/experiments/red-cabbage-chemistry.

Note down your observations.

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Draw conclusions.

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## LAB. 2.6. OTHER NATURAL INDICATORS

Check whether other vegetables or fruits can act as pH indicators. Try to find one fruit and one vegetable, which, in your opinion, could be such indicators. They should have intense colors. Make juice from each of them. Use previously selected home products for research.

Ask a research question.

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Write down the hypothesis

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Plan activities. Write the steps that you will follow.

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List down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

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Draw conclusions.

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## 2.5. ACIDS AROUND US

### EX. 2.8. FIND ANSWERS

Answer the following questions. If you do not know the answer, look for it in the available literature, give this answer and the reference source.

1. The Environmental Protection Agency (EPA) implementing the Acid Rain Program. Do you know what it concerns?

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2. Do you know where the Black Forest is located and where its name comes from?

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3. Do you know where and when the lowest pH rain fell and what the pH was?

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4. Do you know what mofettes, solfataras and fumaroles are? What is their impact on the environment?

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## LAB. 2.7. EFFECT OF GASEOUS AIR POLLUTANTS ON PLANTS

MATERIALS AND CHEMICALS

- ✓ gloves and glasses,
- ✓ 8 test tubes with side arm,
- ✓ 8 rubber cork stoppers,
- ✓ 4 short hoses,
- ✓ 4 test tube holders,
- ✓ spatula or spoon,
- ✓ Pasteur pipette,
- ✓ plant material, e.g. flower petals or leaves,
- ✓ sodium sulphite,
- ✓ sodium sulphide,
- ✓ baking soda,
- ✓ small copper sheet or copper wire,
- ✓ hydrochloric acid at a concentration of approximately 10%,
- ✓ nitric acid at a concentration of approximately 30%.

PRODECURE

1. Put on the gloves and your safety goggles.
2. Build four sets of apparatus: connect the side arms using hoses.
3. Insert the same amount of plant material.
4. Close the sample tubes filled with vegetable material with rubber stoppers.
5. Place the kits in test tube holders.
6. In each of the sets (I-IV), examine the influence of a different factor.
7. **I.** Influence of <u>sulfur dioxide</u>: add a pinch of sodium sulfite to the tube, and then add about 1 ml of hydrochloric acid. Quickly plug the rubber cork stopper into the test tube.
8. **II**. Effect of <u>nitrogen oxides</u>: put a piece of copper, and then add about 1 ml of nitric acid. Quickly plug the rubber cork stopper into the test tube.
9. **III.** Effect of <u>hydrogen sulphide</u>: add a pinch of sodium sulphide to the tube and then add about 1 ml of hydrochloric acid. Quickly plug the rubber cork stopper into the test tube.
10. **IV.** Effect of <u>carbon dioxide</u>: pour a pinch of baking soda in a test tube, then add about 1 ml of hydrochloric acid. Quickly plug the rubber cork stopper into the test tube.

Draw an experimental set and label all of its elements.

Note your observations in the table below.

| name of a pollutant | observations |
|---|---|
| sulfur dioxide | |
| nitrogen oxides | |
| hydrogen sulfide | |
| carbon dioxide | |

Draw conclusions.

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## LAB. 2.8. RECEIVING ACID RAIN

MATERIALS AND CHEMICALS

- ✓ gloves and safety glasses,
- ✓ flask,
- ✓ burning spoon,
- ✓ rubber cork stopper with a hole,
- ✓ stirring rod,
- ✓ spatula or spoon,
- ✓ Petri dish,
- ✓ burner,
- ✓ matches or an igniter,
- ✓ universal indicator papers,
- ✓ sulfur,
- ✓ distilled water.

PROCEDURE

1. Put on gloves and safety goggles.
2. Build the apparatus: put the burning spoon through the hole in the rubber cork stopper and put it into the flask (the burner should be above the distilled water and the stopper tightly adhere to the neck of the flask). Remove the combustion stick from the flask with the stopper.
3. Place the indicator paper on the Petri dish.
4. Pour distilled water into the flask up to the 2-cm mark.
5. Moisten the end of the stirring rod with water from the flask.
6. Touch the indicator paper with the moistened end of the stirring rod.
7. Using a spatula or teaspoon, pour the sulfur onto the combustion spoon.
8. Light the burner and insert the combustion spoon into the burner flame.
9. When you see a flame over sulfur (it will have a characteristic color), transfer the burning sulfur to the flask.
10. Seal the flask tightly with a stopper.
11. Shake the contents of the flask after a few seconds.
12. Moisten the clean end of the stirring rod with the contents of the flask.
13. Touch the indicator paper with the moistened end of the stirring rod.

Note your observations and draw an experimental setup.

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Draw conclusions.

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## LAB. 2.9. SEARCH FOR ACID RAINFALL

Looking at changes in the surrounding nature, we reflect on how clean the environment in which we live is, learn and work is. A very simple attempt to estimate this state is to investigate the pH of the rainfalls. Become a researcher and try to answer the following question: **Are the rainfalls in your environment acidic?** Propose a hypothesis (based on observation of the natural environment), and then plan and conduct appropriate experiments to verify the hypothesis you have come up with.

Write down your hypothesis

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Plan activities. Write the steps that you will follow.

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Write down all the materials and chemicals you would like to use.

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Complete the task as planned.
Note down your observations.

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Draw conclusions.

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## LAB. 2.10. INFLUENCE OF ACID RAIN ON THE ENVIRONMENT

**A. Qualitative research**

Investigate if the acid rain affects selected elements of the natural environment, e.g. rocks, shells of bird eggs, shells of snails and clams. Post a research problem, then formulate a hypothesis (e.g. based on observation of the natural environment), and then plan and conduct appropriate experiments to verify this hypothesis.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write the steps that you will follow.

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Write down all the materials and chemicals you would like to use.

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Complete the task as planned.

Note down your observations.

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Draw conclusions.

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**B. Quantitative research**

Select one of the aspects of the natural environment that were analyzed in the previous part and check how important is the level of acidity of such rain.
You can use, for example, a balance to measure the change in the mass of a test object or a measuring cylinder to measure the volume of the gas produced. Define a research problem, then formulate a hypothesis (e.g. based on observation of the natural environment), and then plan and conduct appropriate experiments to verify this hypothesis.
Ask a research question.

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Write down the hypothesis.

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Plan activities. Write the steps that you will do follow.

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Write down all the materials and chemicals you would like to use.

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Complete the task as planned.
Note down your observations.

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Draw conclusions.

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## Ex. 2.9. Definition of acid rain

1. List down the most important facts about acid rain.

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2. Create a definition of acid rain.

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3. Find a definition in the literature, reference the source of it and compare it with your own definition.

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# CHAPTER 3. WE DISCOVER THE WORLD WITH ALL OUR SENSES

## 3.1. ASSESSMENT OF SKIN

Answer the following questions

1. What is the pH of the surface of human skin surface? Indicate it in the figure below (Fig. 3.1).

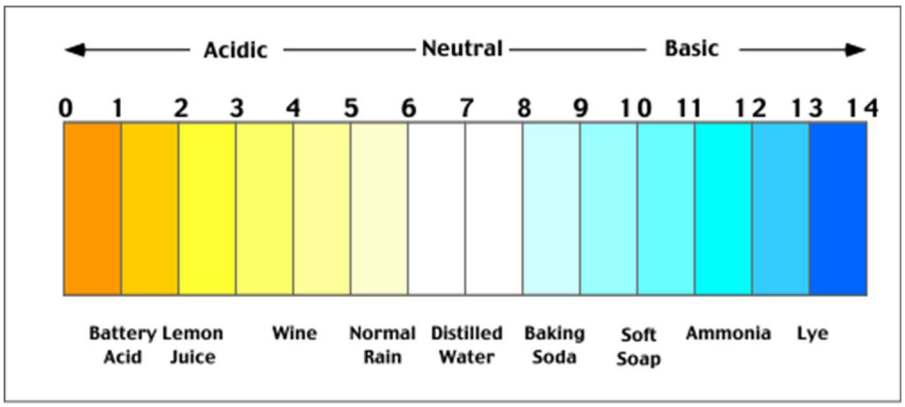


Fig. 3.1. pH range of different substances[39].

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2. What is the reason for this pH value of skin?

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3. What is the pH range of different cosmetics (soaps, liquid soaps, micellar liquids, face serum, face cream, tonic, etc.?

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4. Does it affect the skin pH?

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[39] http://www.edu.pe.ca/gulfshore/Archives/ACIDSBAS/phscale2.jpg.

## LAB. 3.1. ASSESSING THE pH VALUE OF THE VOLAR FOREARM

The purpose of this experiment is to determine how different cosmetics affect the pH value of the volar forearm. The figure below indicates the location of the volar forearm (Fig. 3.2).

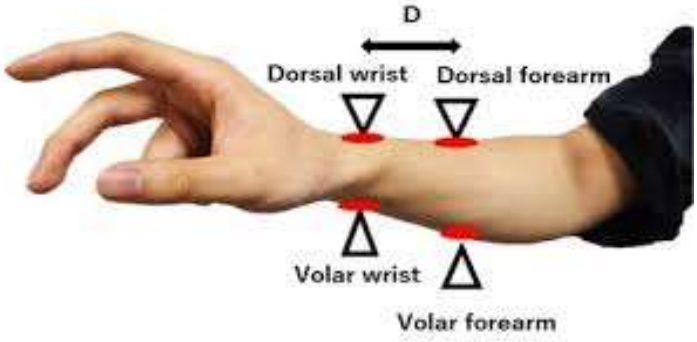


Fig. 3.2. The location of the volar forearm[40].

Ask a research question.

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What is your best guess? Write down the hypothesis.

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MATERIALS AND CHEMICALS

- ✓ pH meter,
- ✓ soap,
- ✓ liquid soap,
- ✓ facial cream,
- ✓ anti-acne facial cream,
- ✓ distilled water,
- ✓ tap water,
- ✓ paper towel.

Measure the pH value of distilled water, soap, liquid soap, micellar liquid, cream and serum.

| product | distilled water | soap | liquid soap | micellar liquid | cream | serum |
|---|---|---|---|---|---|---|
| pH value | | | | | | |

[40] https://encrypted-tbn0.gstatic.com/images?*q=tbn:ANd9GcRe6J2gbduTMvYPDNnYkRcSjN_qelQU_hdlXyowjvt0LeqHk0uVIw.*

PROCEDURE

1. Measure the pH of your volar forearm.
2. Wash hands and forearms with distilled water and wipe your hands with a paper towel.
3. Measure the pH of your volar forearm.
4. Wash hands and forearms with soap.
5. Measure the pH of your volar forearm.
6. Wash your hands and forearm with distilled water and wipe your hands with a paper towel.
7. Measure the pH of your volar forearm.
8. Wash hands and forearms with liquid soap or micellar liquid and wipe your hands with a paper towel.
9. Measure the pH of your volar forearm.
10. Wash your hands and forearm with distilled water and wipe your hands with a paper towel.
11. Measure the pH of your volar forearm.
12. Apply one of the cosmetics (a cream or a serum).
13. Measure the pH of your volar forearm.

EXPERIMENT DESIGN

Characterize the independent variable.

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Characterize the dependent variable.

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Characterize the controlled variables.

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Draw a diagram of the experiment setup.

Note down the results.

| procedure number | pH value | difference: pH value – ‘neutral pH’ value |
|---|---|---|
| 1. before washing – ‘neutral pH’ value | | |
| 3. after using distilled water | | |
| 5. after using soap | | |
| 7. after soap and distilled water | | |
| 9. after using liquid soap | | |
| 11. after the liquid soap and distilled water | | |
| 13. after using cream or serum | | |

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Draw conclusions.

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## 3.2. How to talk about fragrances? The art of fragrances – music and poetry

**Do you know that March 31 is the International Fragrance Day?**

Perfumes may be considered in terms of art. They have a special composition that is complex – not constant and develops over time. Because of this, perfumes may be compared to music and their creators to composers. The fragrance creation process usually takes many years.

The central concepts we use while talking about perfumes are: note and accord. Note is the phase of the fragrance in time.

There are three notes: the head note, middle note and base note (Fig. 3.3).

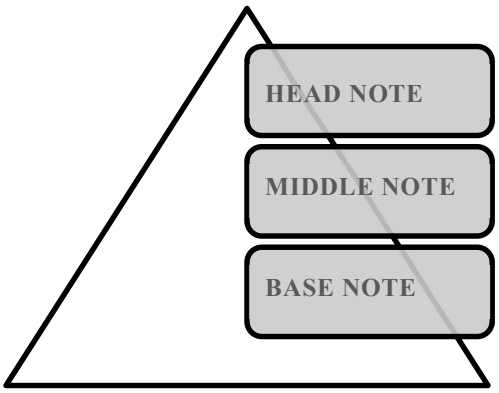


Fig. 3.3. The main three notes of the fragrance composition.

- **head note (top)** – we sense it right after using the perfume or opening the fragrance bottle. This is the most elusive and delicate note. It is responsible for the first fragrance experience. Its duration – the time when it is most intensely perceptible lasts from a few to several minutes.
- **middle note (heart note)** – this note develops most intensely about 20 minutes after opening the bottle. It defines the fragrance and determines to which family of fragrances the composition belongs.
- **note of depth (base note)** – it is composed of intense and heavy fragrances that are often the fixatives of the composition. Base notes are often on the skin for many hours.

There are different ways to present the composition of a given fragrance and its notes. Fig. 3.4 shows the composition of BOHOBOCO Sea Salt Caramel, a Polish brand of perfume.

Information about Sea Salt Caramel published on www.douglas.pl[41]:

*This salty-sweet composition is a harmonious, penetrating, strong breeze of refreshing breeze broken with a few drops of thick caramel. Sea minerals and pink pepper combined with coquettish sweetness, bring to mind the carefree moments.*

[41] https://www.douglas.pl/Beauty-Around-the-World-Marki-polskie-Perfumy-BOHOBOCO-BOHOBOCO-PERFUME-Sea-Salt-Caramel_productbrand_3000083268.html

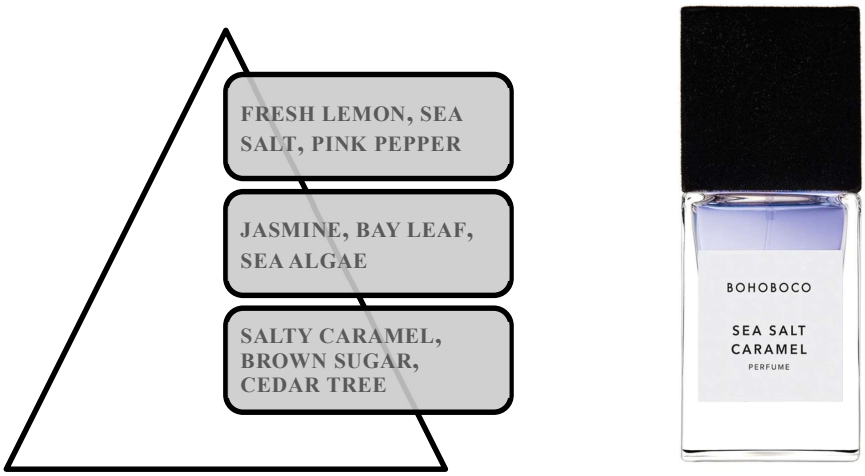


Fig. 3.4. Sea Salt Caramel perfume notes.

The **Accord** is, in turn, the composition of several fragrance notes. Such an combination usually results in a completely new scent, which is difficult to decompose into components (Fig. 3.5). You need a 'well-trained nose' for this.

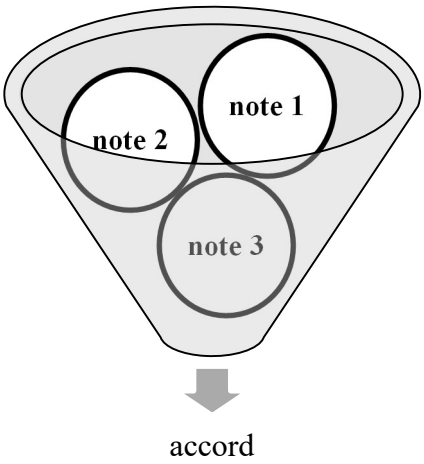


Fig. 3.5. Accord is a balanced set of three or four notes that lose their separate identity, creating a completely new, distinct fragrance.

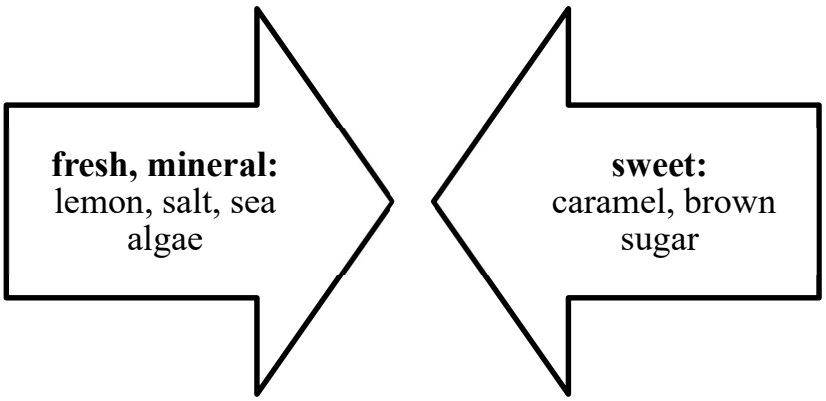


Fig. 3.6. Main accords of *Sea Salt Caramel*, source: www.douglas.com.

**In what other ways are perfumes similar to music?**

**Harmony** – you can talk about harmony when in the composition all fragrance notes harmonize perfectly with each other and create a homogeneous scent.

Professionals also distinguish perfume features such as **tone**, **halftone** and subject matter.

The **theme** defines the leading fragrance motive. The theme should be perceptible in each of the three main notes - gently resound in the note of the head, going to the heart note and hit the note of depth.

Creating compositions is a long and complicated process. The individual components in the notes are intentionally intertwined in a way reminiscent of creating music or **poems**.

One may distinguish many types of compositions:

- there are some that have a leading theme – they are composed in such a way that in all three notes some of the ingredients have a similar smell;
- rhymed compositions, in turn, are characterized by two or more similarly fragrant ingredients in the note of depth and head note, and at the same time absent in the heart note;
- the most difficult to compose, however, are contrast compositions in which there are no repeating ingredients. In their place, highly contrasting aromas are introduced and are complemented by neutral ingredients.

**What are the main components of perfumes?**

You may find them in the Fig. 3.7.

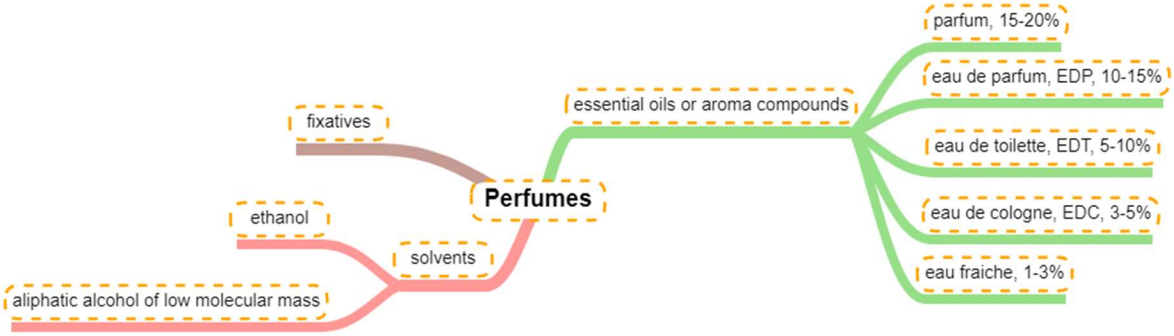


Fig. 3.7. Mind map: the main components of perfumes. Ethanol has been distincted as the most popular solvent.

Ethanol is usually used as a solvent for essential oils and other substances in perfumes, colognes and other odorants. Why is that so?

Think and note down your hypotheses about ethanol used as a solvent.

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**LAB. 3.2. LET'S USE ETHANOL!**

- Spray a small amount of water on the volar forearm of your right arm.
- Spray a small amount of ethanol on the volar forearm of your left arm.

Can you feel any difference? Write down your observation.

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- Spray a small amount of water on a thermometer sensor.
- Spray a small amount of ethanol on a thermometer sensor.
- Observe how the temperature changes on both thermometers.

Write down your observations.

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Try to explain the differences you have observed.

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## LAB. 3.3. DO PERFUMES HAVE GENDER?

For her, for him or for both of them? Feminine, masculine, unisex. Surely, everyone will agree that perfumes, regardless of gender, just like clothes or music, are a kind of interpersonal communication. But today, when you can smell of hay, glue or carrot, does the sex of perfume still have any meaning? Nowadays, most women can wear trousers and look feminine at the same time, and many guys wear long hair look super-male. In 2011, Céline Verleure created Olfactive Studio a perfume brand. As a twenty-eight-year-old fragrance designer, she co-created Kenzo Jungle with such perfumers as Dominique Ropion and Jean-Louis Sieuzac, and then together with Olivier Crespem she designed the iconic l'Eau par Kenzo. Now, the Olfactive Studio offers over 20 unique fragrances. All of them can be used by both woman and man. According to Céline's philosophy, 'perfumes are angels. They do not have sex, but they have souls.' So for some artists the boundary between what is feminine or masculine seems to be very fluid. On the other hand, when we enter a typical perfumery, there are clearly separated sections for women and men. Why do we need these separate sections: pour femme or pour homme? We will assess this subject during our today's experiment.

MATERIALS AND CHEMICALS

- ✓ eppendorf tubes,
- ✓ syringes,
- ✓ 5 fragrance samples for each group (a single sample consists of a plastic eppendorf tube or test tube with a stopper, into which we put a piece of cotton wool and introduce a little perfume. The tube is then tightly closed),
- ✓ cotton wool,
- ✓ containers with coffee for 'cleanse the nasal palate', i.e. reducing the saturation of odor receptors with odors.

PROCEDURE

Each group receives samples of five perfumes marked with numbers 1,2, 3, 4, and 5.

The task consists of three parts:

1. an attempt to assign a sample (organoleptic examination of the head note) to a particular fragrance group - it should be marked in the appropriate fields(s) (1 or 2 fields) in the table below.
2. determining if the perfume sample can be classified as male, female or unisex - type M (masculine), F (feminine) or U (unisex).
3. naming the sample.

Ask a research question about the gender characteristic of perfumes.

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What is your best guess – write down the hypothesis.

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Draw a diagram of the experiment setup.

**Note down your observations (everything you may learn from your senses).**

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Fill in the table.

| perfume sample | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **olfactory group**[42] | | | | | |
| floral | | | | | |
| fruity | | | | | |
| sweet, fougere | | | | | |
| green | | | | | |
| woody and dry | | | | | |
| spicy | | | | | |
| animalic | | | | | |
| citrus | | | | | |
| mineral | | | | | |
| metallic | | | | | |
| oriental | | | | | |
| herbal | | | | | |
| **gender** | M / F/ U | M / F/ U | M / F/ U | M / F/ U | M / F/ U |
| **name** | | | | | |

Draw conclusions.

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[42] Should you have any problems – please go to: https://www.fragrantica.com/ and try to find a particular group of smells.

## 3.3. SENSES

In physiology, the sense is defined as a faculty by which outside stimuli are perceived. Due to the diversity of stimuli, there are many specialized receptors that are sensitive to them. These receptors are most often found in organs called sensory organs. They are sensitive to specific stimuli, e.g. light intensity and colors (eyes), smell and taste (nose and organs of the mouth), temperature (skin). The ability to react to stimuli is a feature of organisms. Interestingly, the organs of the senses or cells sensitive to specific stimuli can be found in organisms with a very simple structure.

Discuss with other students and write down all the senses you know.

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There are a few **central concepts** crucial to understanding the science behind senses.

Find in a dictionary definitions of the following concepts and write them down below.

**senses**

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**sensory system**

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**receptor**

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**receptive field**

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**brain**

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**sensory area**

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Please look at the place you have just listed all the senses that we have. Do you think that we have only 5 senses? Actually, you have 14, or may have even up to 20 senses. *If you close your eyes and lift a finger to your nose, you know exactly where it is, without seeing it.* ***Proprioception*** *is our ability to innately tell where our appendages, muscles, and other body parts are in space. You're able to place that finger on the tip of your nose in total darkness, thanks to this sense*[43]. A shortened list of our senses is given in the figure 3.8.

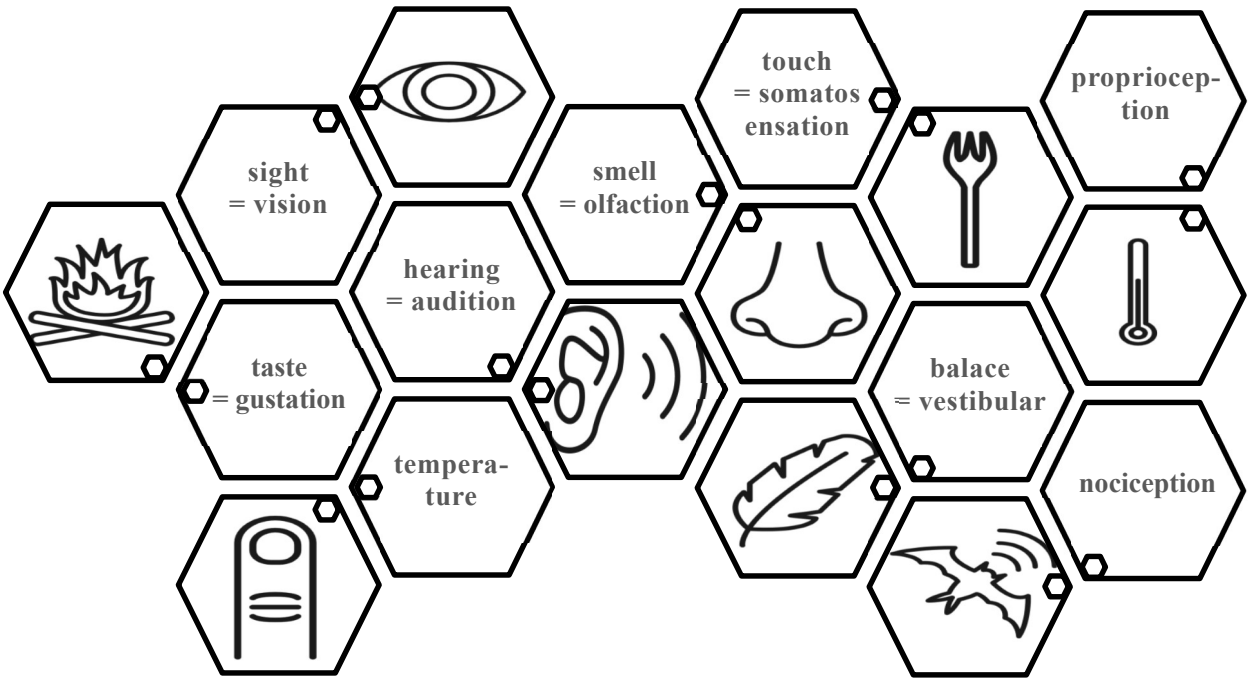


Fig. 3.8. A shortened list of our senses.

List down all other animal/plant senses that you know.

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[43] https://bigthink.com/philip-perry/think-you-have-only-5-senses-its-actually-a-lot-more-than-that.

## 3.4. AN EXTRAORDINARY THIRD SENSE

Two of the senses – smell and taste – are special because they require direct contact of stimuli with receptor cells. That is why olfactory sense as well as the gustation sense are known as the chemical senses. The human olfactory epithelium is the only place in the body where neurons have direct contact with the external environment. There is no other receiving organ with a sensitivity equal to the sense of smell. It is particularly precise and accurate, and has an excellent memory. When comparing to other animals, humans have a fairly weak sense of smell. In humans, the olfactory region covers the area of the nasal turbinate together with the adjacent part of the nasal septum, and rarely reaches the middle turbinate. In total, it covers an area of 4 to 6 $cm^2$ (to compare – olfactory area in dogs has about 150 $cm^2$). However, people have the ability to sense chemical substances with concentrations of 0.5 ppm (which means about 1 olfactory particle among 2 million other particles). The man belongs to *microsmatic* beings, meaning those for whom olfactory impressions are less important than others, for example visual (most important) or auditory (the second place in order of importance for human beings).

Imagine that you have lost your sense of smell. Discuss with other students how your life would change.

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Write down why you think that the sense of smell is important.

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**Why is smell important?**

- Warning (smoke, poisonous gases).
- The location of the source of odor.
- Perception of taste impressions. Selection of foods (their quality and freshness).
- Regulation of appetite.
- Participation in the secretion of saliva and gastric juice.
- The way to reach socially relevant information (recognition of one's mother, relatives, sucking reflex).
- Creating a feeling of mental comfort, impact on the quality of life through the perception of the aromas of the surrounding nature.
- A source of aesthetic experiences and feelings, as well as emotional and sexual behaviors.
- Self-monitoring of hygiene (smell of excretions, sweat, secretions).
- Doing particular jobs (taster, sommelier, cook, pharmacist, fireman, laboratory worker, salesperson, to name a few).

**Emotions**

- Odors affect human thinking and behavior.
- They can be consciously used to increase the tendency to play in casinos, time spent in a restaurant a restaurant or even the desire to buy coffee or bread. The reason for it is that the scents change the emotional state of a person profoundly and quickly.
- There is a strong, individual association between fragrances and specific memories (for example, a lily fragrance reminiscent of a funeral or a gingerbread scent inducing thoughts about Christmas). This is the so-called ‘Proust effect’.

**Aromas and scents – a few words about scents typology**

- There are five odoriferous elements (chlorine, bromine, iodine, fluorine, oxygen in the form of ozone) and several hundred fragrant organic substances.
- Depending on the concentration, the same substance produces a different smell (for example, indole, $C_6H_7N$ which in low concentrations has a jasmine odor, higher – feces fig. 3.9)

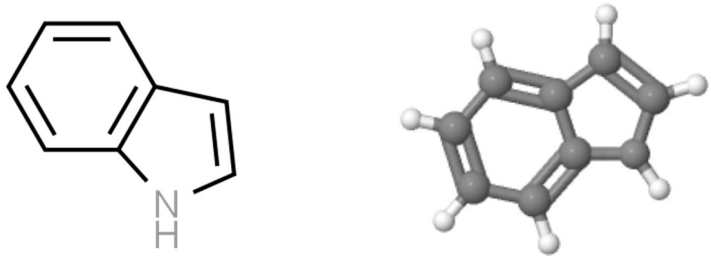


Fig. 3.9. Structure of indole.

- Depending on the stereochemistry, the two isomers may have a different smell, for example (*S*)-Carvone has the odor of caraway, and (*R*)-Carvone has the odor of spearmint (fig. 3.10).

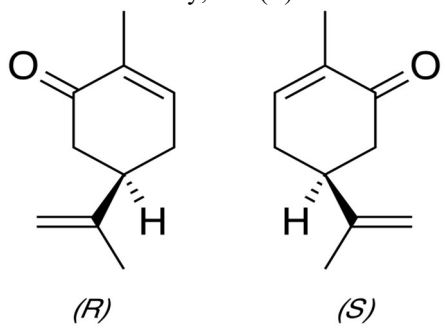


Fig. 3.10. Structure of carvones.

The average person is able to distinguish up to several thousand fragrances, but cannot distinguish components of complex odors when there are more than two.

## LAB. 3.4. HOW GOOD IS YOUR SENSE OF ODOR?

***Strictly speaking, smells exist only in our heads****. Molecules exist in the air, but we can only register some of them as "smells." Odors are perceptions, not things in the world. The fact that a molecule of phenylethyl alcohol smells like rose is a function of our brain, not a property of the molecule. A tree burning in the forest does not smell if no one is there to smell it. The planet Mars has no atmosphere and is too cold for human life, yet the chemical composition of its surface suggests that if we could sniff it, it would reek of sulfur. Perhaps someday we will have the opportunity. Apollo moon-mission astronauts noticed that the lunar dust they tracked back into their craft smelled like wet ashes in a fireplace, or burned powder from a shotgun shell. Humans flying back from Mars may need to hang a little pine tree in the cockpit window*[44].

In this exercise you will be able to the sensitivity of your nose as well as your ability to sense different fragrances.

MATERIALS AND CHEMICALS

- ✓ different substances with a strong, simple odor, for example limonene, citral, linalool, benzyl salicylate, or other esters, aldehydes, terpenes,
- ✓ cotton wool,
- ✓ containers filled with coffee for 'refreshing the nose palette', i.e. reducing the saturation of odor receptors with odors.

[44] A. Gilbert, *What nose knows – the science of scents in everyday life*, New York: Crown Publishers (2008).

PROCEDURE

Each group receives samples of different substances with a strong, simple odor. Your task is to try to assign all the samples to their names found in the literature source.

Note down your observations (everything you may learn from your senses).

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Fill in the table.

| **sample** / **substances** | odor | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| citral | lemon | | | | | |
| thymol | thyme | | | | | |
| benzaldehyde | almonds | | | | | |
| cumarine | hay, weed | | | | | |
| eugenol | cloves | | | | | |
| cinnamaldehyde | cinnamon | | | | | |
| geraniol | rose | | | | | |
| geranial | lemon | | | | | |
| β-ionone | violet | | | | | |
| vaniline | vanilla | | | | | |
| α-pinene | eucalyptus, juniper | | | | | |

What was easy and what was hard in this experience? Draw conclusions.

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**Odor**

Odor is a property of different types of chemical compounds or their mixtures (odorants), consisting in the ability to stimulate the sense of smell.

**What is so special in the aroma of roses?**

The natural aroma of flowers and fruit is complex. It is defined by a mixture of volatile molecules of low molecular weight. Hundreds of volatile aroma components have been identified and vast majority of them belong to one of three groups: phenylpropanoids, terpenoids and fatty acid derivatives[45, 46]. For example there are 35 key aroma compounds in the rose essential oil[47].

The amount of volatile compounds is very small in flowers. For example - about 2.5 g of clear, colorless to yellow rose oil with an intense rose scent can be extracted from 10 kg of blossoms. What is more – all the material has to be collected using hands. It makes this oil very expensive[48].

## LAB. 3.5. HOW DO YOU ISOLATE THE ESSENTIAL OIL?

When obtaining from the plant material poorly water-soluble essential oils, typical straight distillation is not used due to the possibility of organic matter decomposition during high heating - steam distillation is used instead (Fig. 3.11). The figure shows a modern version of the alembic (already known to the alchemists), not the typical laboratory equipment. The water (B) heated by the burner (A) becomes water vapor and removes particles of volatile organic compounds from the biological material (C). The mixture obtained in this way is pumped through a tube (D), condensed (E) and collected into a distillation receiver (F).

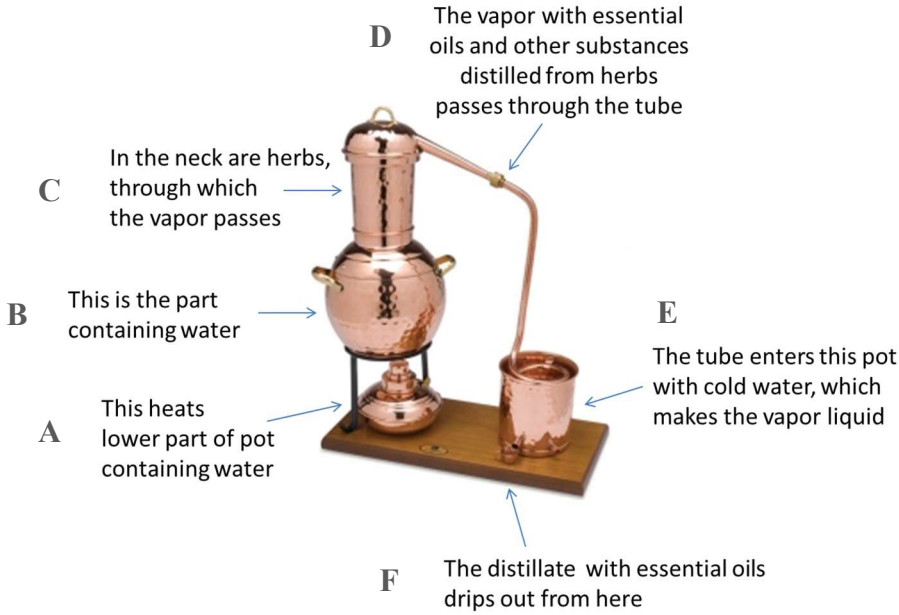


Fig. 3.11. Alembic for making essential oils[49].

Try to build a simplified version of this apparatus and obtain essential oils, e.g. from mint. You can use different types of mint and compare their fragrances.

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[45] J. T. Knudsen, L. Tollesten, G. L. Bergstrom. *Floral scent: A checklist of volatile compounds isolated by head-space techniques*. Phytochemistry, 33, 1993;

[46] R. Croteau, F. Karp, *Origin of natural odorants. In Perfume: Art, Science and Technology*, P. Muller, D. Lamparsky, eds (New York: Elsevier Applied Sciences) 1991;

[47] A. Mesaros, M. Culea, A. Iordache, O. Cozar, *GC-MS Characterization of the Compounds in Some Essential Oil*, Bulletin UASVM Agriculture, 66, 1 2009;

[48] A. Mannschrec, E. von Angerer, *The Scent of Roses and Beyond: Molecular Structures, Analysis, and Practical Applications of Odorants*, Journal of Chemical Education. 88, 2011;

[49] Source of the figure: http://curious-soapmaker.com/alambic-for-making-essential-oils-and-flower-waters.html. Elements of the apparatus were assigned are labeled with letters marks.

MATERIALS AND CHEMICALS

- ✓ gloves and safety glasses,
- ✓ alcohol burner,
- ✓ matches,
- ✓ test tube,
- ✓ rubber cork with a hole,
- ✓ curved glass tube,
- ✓ a small flask or beaker,
- ✓ cotton cloth,
- ✓ stand,
- ✓ clamp,
- ✓ small pieces of a broken cup or brick,
- ✓ distilled water,
- ✓ plant material, e.g. mint.

PROCEDURE

1. Put on gloves and safety goggles.
2. Attach the test tube to the clamp, and the clamp to the stand.
3. Place the alcohol burner under the test tube.
4. Put small pieces of a broken cup or brick into the test tube. They will serve as sieves to prevent overheating of the contents of the vessel.
5. Shred the plant material, e.g. by cutting or tearing up the mint leaves and put it into a test tube.
6. Pour water up to about half the height of the test tube.
7. Place the curved glass tube in the cork and the cork in the test tube so that the system is tight.
8. Wrap the tube with material soaked in cold water.
9. Place a small beaker or flask under the curved end of the tube.
10. Light the burner.

Draw an experimental set and name all its elements.

Note down your observations.

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Draw conclusions.

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You can also use... **a coffee maker**! The procedure is the same as while making coffee. The only difference is that instead of coffee, you should put there fresh or dried plants that have been crushed. The mixture of water and essential oils obtained in this way is called **hydrolate** in cosmetology. Hydrolates have particularty desirable properties for beauty care, e.g.[50].

*Pepper Mint Hydrolate enlivens, refreshes and stimulates, giving a delicate feeling of coolness. It removes fatigue, relieves itching and sunburn. It is especially recommended for the care of oily and mixed skin, tired and irritated. Rose Hydrolate is so delicate that it can be used not only directly on the skin, undiluted, but also directly under the eyes and on the eyelids. It is especially recommended for the care of dry and sensitive skin, capillaries, lacking vitality, gray and mature skin.*

[50] https://www.manufakturakosmetyczna.pl/kategoria/14-hydrolaty.

## LAB. 3.6. SYNTHETIC FRAGRANCE MIXTURE

In this experiment, you will prepare your own synthetic fragrance mixture. All the recipes are given in the table[51]. Your task is to prepare one mixture and assess its fragrance.

| fragrance | ingredients (mass parts) |
|---|---|
| pineapple | ethyl butyrate (19), isoamyl isovalerate (81), ethanol (500) |
| banana | benzyl acetate (15), amyl acetate (4), vaniline (1), butyl laurate (8) |
| peach | benzaldehyde (35), amyl butyrate (90), chloroform (10), ethanol (100) |
| chocolate | dimethyl trisulfide (1), 2,6-dimethylpyrazine (3324), ethyl vaniline (143), isovaleraldehyde (100) |
| pear | amyl acetate (20), amyl butyrate (2.5), ethyl acetate (2.5), chloroform (4), ethanol 90% (30) |
| apricot | amyl acetate (5), amyl butyrate (2), amyl formate (1.5), ethyl butyrate (1), ethyl acetate (1.2), ethanol 90% (24) |
| strawberry | ethyl butyrate (5), ethyl formate (1), ethyl salicylate (1), ethyl acetate (5), amyl acetate (3), glycerin (2), ethanol (100) |

Note down your observations (everything you can learn from your senses).

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[51] W. Mizerski, *Tablice Chemiczne*, Warszawa: Adamantan 2013.

# CHAPTER 4. WE LIVE IN A CLEAN WORLD

## 4.1. pH OF HOUSEHOLD CLEANERS

### LAB. 4.1. pH OF HOUSEHOLD CLEANERS

Determination of pH value is one of the basic physicochemical studies of substances. Use the experimental experience gained in Chapters 2 and 3. Investigate the pH of ten household cleaners. For solids - test the saturated solutions, i.e. solutions in which more solid cannot be dissolved. Pay attention to the pictograms of hazardous substances (see: GHS HAZARD PICTOGRAMS at the beginning of the script) present on the packaging, plan your experiments following the safety rules.

Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you would like to use.

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Complete the task as planned.

Note down your observations.

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Complete the table: write down the name of the household cleaner, its composition (rewrite from the label) and the obtained pH value.

| serial number | name of household cleaner | composition of household cleaner | pH value |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |

Comment on the results obtained for particular types of cleaning product.

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Arrange the cleaning products that have been tested in order of pH, starting from the lowest (enter their names).

…….. < …….. < …….. < …….. < …….. <

…….. < …….. < …….. < …….. < ……

Analyze carefully the composition of each household cleaning product. Consider which substances have the greatest influence on the obtained pH value.

| serial number | substances with the greatest influence on the obtained pH value | pH value |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |

Comment on the information in the table above.

……

……

Draw the pictograms of hazardous substances present on the packaging and enter the names of the substances presence of which caused the manufacturer to affix such marking.

| serial number | pictograms of hazardous substances | substance names |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |

Comment on the information in the table above.

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## 4.2. DIRT REMOVAL AND SURFACE TENSION

### EX. 4.1. FORMULAS

Hard soaps contain sodium salts of palmitic and stearic acids - sodium palmitate and sodium stearate, respectively. Each of these salts contains two types of ions:

Sodium palmitate: $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COO^-$ and $Na^+$
Sodium stearate: $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COO^-$ and $Na^+$

Instead of the group $-COO^-$ detergents have the group $-O-SO_3^-$. The most common detergent is sodium lauryl sulfate (sodium dodecyl sulfate), designated by the abbreviation SDS or SLS:
$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2OSO_3^-$ and $Na^+$.

<u>Finish the formula (count the carbon and hydrogen atoms).</u>

sodium palmitate: $C...H...COO^- Na^+$

sodium stearate: $C...H...COO^- Na^+$

sodium lauryl sulfate: $C...H...OSO_3^- Na^+$

### LAB. 4.2. SOAP MAKING

There are two processes for soap making: hot and cold.[52] The former is used industrially, while the former is currently the most popular method of making homemade soaps. So let's use it and make soap.

MATERIALS AND CHEMICALS

- ✓ gloves and goggles,
- ✓ balance,
- ✓ teaspoons,
- ✓ weighing container,
- ✓ a glass dish or pot,
- ✓ hotplate,
- ✓ magnetic stirrer or blender,
- ✓ soap making molds,
- ✓ plastic food wrap,
- ✓ measuring cylinder,
- ✓ thermometer,
- ✓ pH indicator papers,
- ✓ sodium hydroxide (31g),
- ✓ water (175ml),
- ✓ lard or beef tallow (225g),
- ✓ additives, e.g. poppy seeds, coffee beans, flower petals, fragrance oils.

[52] A. Gumkowska, *Laboratorium w szufladzie*, Warszawa: Wydawnictwa Naukowe PWN SA 2015.

PROCEDURE

Fat phase

1. Weigh the fat and place it in a beaker.
2. Place the beaker on the hotplate and slowly heat it until it reaches 45-50°C. If you want to add fragrance oils, do it now.[53]

Aqueous phase

1. Weigh out sodium hydroxide.
2. Pour the right amount of water into the glass container.
3. Slowly stir in sodium hydroxide (be careful: the solution warms up).
4. Wait until the solution temperature reaches 45-50°C.

Both phases

1. Slowly pour the aqueous phase into the fat phase, stirring gently.
2. Mix thoroughly using a magnetic stirrer or blender.
3. Now you can add the additives, e.g. coffee beans or flower petals.
4. Pour the mixture into molds, secure with plastic food wrap and let it cure (for about a month).
5. Check its pH before use.

Note down your observations.

Draw conclusions.

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[53] http://krainamydlanychinspiracji.blogspot.com/p/blog-page_29.html.

Of course, soaps do not have to be made only with animal fat. There are plenty of tried and tested recipes that use oils, e.g.

*Tangerine dream*[54]

- ✓ sodium hydroxide (100g),
- ✓ natural spring water (268g),
- ✓ coconut oil (235g),
- ✓ palm oil (200g),
- ✓ olive oil (350g),
- ✓ avocado oil (52g),
- ✓ grapefruit seed extract (10 drops),
- ✓ tangerine essential oil (45 drops),
- ✓ mandarin essential oil (45 drops),
- ✓ sweet orange essential oil (30 drops),
- ✓ ground turmeric (1tbsp).

Do you know why this particular recipe was chosen?

……

## EX. 4.2. GLYCERIN SOAP BASE

Currently, a transparent glycerin base produced by various companies is available on the market. It is enough to heat it to approx. 50°C, add e.g. dyes or dried herbs and pour it into molds.

Find the composition of glycerol bases produced by three companies.

Complete the table.

| company name | composition of glycerin soap base |
|---|---|
| | |
| | |
| | |

[54] S. Ade, *Self-Sufficiency Soap making*, New Holland, 2009.

Compare the composition of different glycerin soap bases. Find similarities and differences.

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## LAB. 4.3. DIRT REMOVAL

In the aqueous solution, soap and detergent ions move independently of each other (Ex. 4.1). Due to the fact that the hydrocarbon chains of anions are very long - they are usually called *tails,* while the groups $-COO^-$ and $-O-SO_3^-$ *heads*. The tails are hydrophobic, i.e. water-shy, and the heads are hydrophilic, i.e. water-loving. Removal of hydrophobic dirt is caused by tails surrounding the soap anions and tearing them off the surface.

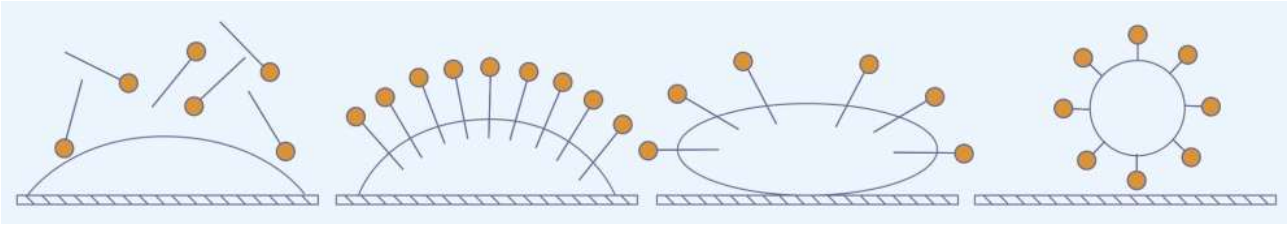

Fig. 4.1. The stages of dirt removal.[55]

**But do all soaps remove dirt equally well?** Check experimentally. Use different types of soaps.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write the steps that you will follow.

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[55] Figure source: https://www.rokopro.pl/zwiazki-powierzchniowo-czynne.

Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

Draw conclusions.

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## EX. 4.3. WATER HARDNESS

It is said that water can be hard or soft. Water hardness is associated with the presence of metal ions, mainly calcium, magnesium, but also iron or manganese. The more ions, the harder the water. There are six classes of water hardness - see the table below.[56]

| type of water | hardness | |
|---|---|---|
| | mmol/l (international unit) | °dH, °n (German degrees) |
| very soft water | < 0.89 | < 5 |
| soft water | 0.89-1.79 | 5-10 |
| medium hard water | 1.79-2.68 | 10-15 |
| water of considerable hardness | 2.68-3.57 | 15-20 |
| hard water | 3.57-5.35 | 20-30 |
| very hard water | > 5.35 | > 30 |

According to the data published by the Municipal Water Supply and Sewerage Company in Warsaw Joint Stock Company, the water that is delivered to the Faculty of Chemistry of the University of Warsaw has a hardness of 13,3°dH[57].

Looking at the table above determine what type of water it is .....

## LAB. 4.4. WATER HARDNESS AND FOAM

Foam appears during washing. The mechanism of its formation is similar to dirt removal (Fig. 4.1). Gas bubbles pressed during washing are surrounded by the tails and the heads are directed into the water. The bubbles rise with some water, forming bubbles.

Investigate whether the hardness of the water affects the amount of foam that is formed. Choose the most typical soap. You can use bottled water with different calcium and magnesium ions content, tap water, and distilled water for comparison. In addition to reading the labels on the bottles, use the papers to test the hardness of water.

Ask a research question.

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Write down the hypothesis.

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[56] http://www.mpwik.org/?page_id=174;
[57] https://www.mpwik.com.pl/view/twardosc-wody.

Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

Draw conclusions.

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## LAB. 4.5. PAINTING ON MILK

How to paint a picture on milk? Prepare a flat transparent glass dish, e.g. a plate or Petri dish. Pour milk into it (the thickness of the milk layer is about 1cm). Prepare food dyes and dissolve them in water. Pipette droplets of colored solutions onto the milk, then dip a cotton bud in the detergent and touch the surface of the milk. Instead of dyes, you can also put pepper or paprika on the surface of the milk. What will happen? Why? You have to check it experimentally.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

Draw conclusions.

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## LAB. 4.6. POWERED WATER VEHICLE

To begin with, take a credit card and cover one of its edges with a detergent. Put the card on the water.

Note down your observations.

Draw conclusions.

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Now take a credit card of a different size and do the same.

Note down your observations.

Draw conclusions.

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And now it is time for your own unique water vehicle. You can make it e.g. from bottle caps and matches. The only limit is your imagination. Check if it will float. You can use different types of detergents.

Note down your observations and include a photo.

Draw conclusions.

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## 4.3. PACKAGING

**What is the packaging?**

*Packaging within the meaning of the Act (on the management of packaging and packaging waste) is a product, including a non-returnable product made of any material, intended for storing, protecting, transporting, delivering or presenting products, from raw materials to processed goods.*

Packaging can be divided into the following levels (Figure 4.2):

1. ***primary*** *packaging - used to transfer the product to the user at the place of purchase;*
2. ***secondary*** *packaging - containing a multiplicity of unit packages of products, irrespective of whether they are passed on to the user or whether they are used to supply points of sale and which can be removed from the product without affecting any characteristics of the product;*
3. ***tertiary*** *(transit) packaging - used to transport products in unitary or collective packaging in order to prevent damage to products, excluding containers for road, rail, water or air transport*[58].

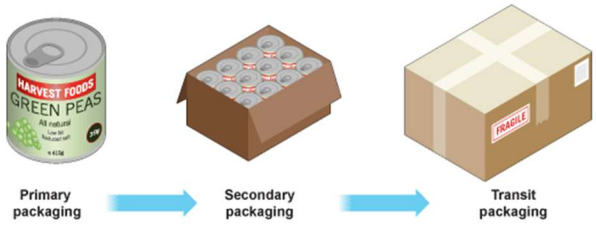


Fig. 4.2. Three levels of packaging.[59]

The main functions of packaging are shown in the figure 4.3.

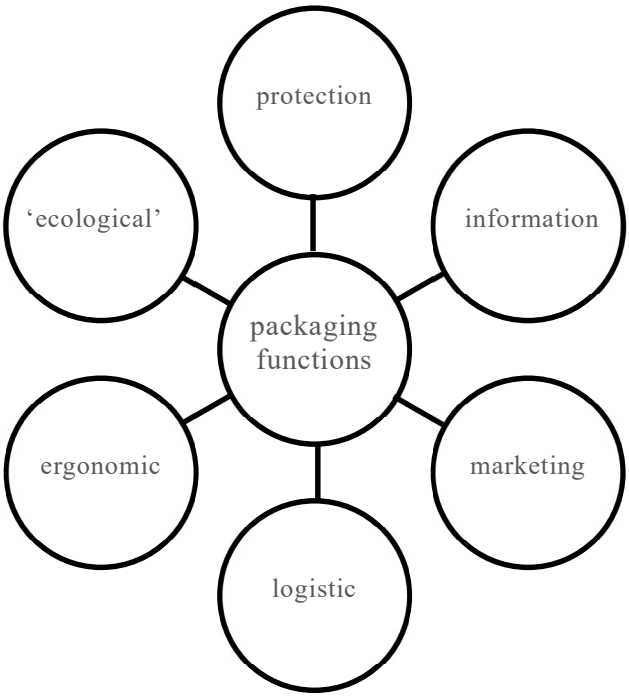


Fig. 4.3. Main functions of the packaging.

[58] Based on: Ustawa z dnia 13 czerwca 2013 r. o gospodarce opakowaniami i odpadami opakowaniowymi. Dz. U. 2013 poz. 888;

[59] Figure source: https://kclcthomas.wordpress.com/2013/11/page/3/.

## EX. 4.4. PACKAGING FUNCTIONS

Find information on particular functions of the packaging on the Internet. Describe them briefly.

**protection**

……

……

**information**

……

……

**marketing**

……

……

**logistic**

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……

**ergonomic**

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**'ecological'**

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## EX. 4.5. 'ECOLOGICAL'

Answer the question below.

**Why has the word 'ecological' (referring to the function) been written in quotation marks? Give reasons for your answer.**

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## LAB. 4.7. MAYONNAISE, KETCHUP AND MUSTARD[60]

**Your task will be to choose the right packaging for the following products: mayonnaise, ketchup and mustard.**

1. Watch the movie: https://www.youtube.com/watch?v=KB43fM_ozKQ&sns=em
2. Read the text.

*Condiments such as ketchup, barbecue sauce, mustard or mayonnaise are widely sold to consumers in a variety of containers, including traditional glass bottles and cheaper and more convenient plastic containers. Depending on the container and its dosing system, the condiments must have different physical properties that allow them to be dispensed, but maintain consistent properties in terms of taste, color and final texture.*
*If a glass bottle is used as a container, it is not expected that the contents will flow freely until the bottle is shaken with a strong impact on the base. In a plastic bottle - on the contrary - the contents should flow when gentle pressure is applied for a few seconds.*

3. Watch the movie: http://www.bbc.com/news/technology-33344955[61].
4. Read the text.

*Imagine that you are an engineer working for a company that sells different types of condiments. Although non-stick packaging has been developed, your company is still using the traditional ones. Your task is to test three different types of condiments that the company is going to launch. Design an experiment that will allow you to examine their consistency. Your team has to collect quantitative data.*

*Then find and present arguments that will make it possible to decide which products should be sold in plastic bottles and which of them in bottles made of glass.*

Ask a research question.

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What is your best guess – write down the hypothesis.

……

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EXPERIMENT DESIGN
Characterize the independent variable.

……

……

Characterize the dependent variable.

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……

……

[60] Based on: *Didactics of Science in International Curricula – Handbook for Students of Biology and Chemistry Faculties of Warsaw University*, edited by: A. Siporska, M. M. Chrzanowski, SCRIPT s.c.,Warszawa, 2017;
[61] Non-stick mayonnaise packaging being developed - Chris Foxx, BBC News.

Characterize the controlled variables.

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List down all the chemicals and materials needed.

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Draw a diagram of the experiment setup.

Describe the procedure.

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Note down the results.

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Plot a diagram.

List down all the conclusions.

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## THE MATERIALS USED TO PRODUCE THE PACKAGING

### EX. 4.6. PICTOGRAMS OF POLYMERS

Write down what the pictograms presented below mean.


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### LAB. 4.8. HDPE, LDPE AND PP

Polymers consist of many repetitive small fragments called mers. Polymers are obtained as a result of polymerization (i.e. combining many fragments) of a monomer, e.g. polyethylene is obtained in the process of polymerization of ethylene (ethylene is a gas emitted by plants during maturation), and polypropylene in the process of propylene polymerization. But can you break down the polymer to reproduce the monomer? If successful, ethylene (PE) or propylene (PP) will be released. These are gases that, if passed through a solution of potassium permanganate, should discolor it. What is definitely needed here is heating. But will the ease of decomposition of HDPE, LDPE and PP be the same? Try to answer this question. Conduct a quantitative experiment.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

Draw conclusions.

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### EX. 4.7. WATER BOTTLE

There is a mark on the water bottle. It is presented in the table below. Write down what this information means and why it can be important.

| | |
|---|---|
| BPAFREE | |

## PACKAGING AND ENVIRONMENTAL POLLUTION.

### EX. 4.8. RECYCLING AND UPCYCLING

Find definitions of the following terms in available sources.

| recycling | upcycling | |
|---|---|---|
| | |  Fig. 4.4. Pictograms of upcycling (left) and recycling (right)[62]. |

Read the text entitled: *Zara creates first 'green clothing' collection*[63], and then write whether it is an example of upcycling or recycling. Give reasons for your answer.

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### EX. 4.9. ENVIRONMENTALLY FRIENDLY PACKAGING

Answer the question. Which packaging is the most environmentally friendly - made of paper, glass or polyethylene? Try to explain your answer in a few points. Write down your opinion.

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[62] Figure source: https://4.bp.blogspot.com/-HW7g7AA4_9o/WBkpTayLr-I/AAAAAAAAGW4/sbhhqcbs6-crlTReczQQDMUUA2mCYc9ywCK4B/s1600/3773430_orig.jpg;
[63] http://www.climateaction.org/news/zara_creates_first_green_clothing_collection.

Discuss your opinion with another student.

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Now read part of the report (pp. 92-94).

*Life Cycle Assessment of grocery bags*, Environmental Project no. 1985 Ministry of Environment and Food of Denmark (February 2018)[64]. URL: https://www2.mst.dk/udgiv/publications/2018/02/978-87-93614-73-4.pdf[65]

Discuss your thoughts with another student again. Has anything surprised you?

Are your predictions consistent with the data from the report? Write down your thoughts below.

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## EX. 4.10. MEANING OF PICTOGRAMS

What is the meaning of pictograms in the table? Explain them shortly.

| pictogram | meaning |
|---|---|
| | |
| | |
| | |
| | |
| | |

[64] *Life Cycle Assessment of grocery bags*, Environmental Project no. 1985 Ministry of Environment and Food of Denmark (February 2018);
[65] https://www2.mst.dk/udgiv/publications/2018/02/978-87-93614-73-4.pdf.

| | |
|---|---|
| ekoland® | |
| ENERGY STAR | |
| | |
| PEFC™ | |
| CE | |
| | |
| | |
| alu | |
| FSC® | |
| PRZYJAZNY DOBRA ŻYWNOŚĆ | |
| FAIRTRADE | |
| cruelty free NOT TESTED ON ANIMALS | |
| Vegan® | |
| EU Ecolabel | |
| MARINE STEWARDSHIP COUNCIL | |

Waste segregation leads to significant reduction in the amount of garbage ending up in landfill sites and, at the same time, reduces the consumption of materials. Each type of waste should be placed in a suitably marked container:

- blue garbage containers for waste segregation: paper,
- yellow garbage containers: metals and plastics,
- white and green garbage containers – glass (respectively – colorless and colored),
- green garbage containers: vegetable waste,
- brown garbage containers: biodegradable waste,
- black garbage containers: mixed waste.

### Ex. 4.11. Where should waste be disposed of?

Write down where drugs, needles, syringes and mercury thermometers should be disposed of.

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Write down what the electronic waste is and where it should be disposed of.

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Write down where you should dispose of accumulators, car oils and coolants.

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Write down how to dispose of bulky waste.

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Write down what the PET packaging is.

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Which container should be used for PET packaging?

……

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## Ex. 4.12. Waste management color coding system

Indicate the color of the container to which the waste listed in the table should be disposed of.

| waste | color of container | | | | | |
|---|---|---|---|---|---|---|
| | **blue** | **yellow** | **white** | **green** | **brown** | **black** |
| styrofoam | | | | | | |
| shopping bag | | | | | | |
| mown grass | | | | | | |
| cardboard | | | | | | |
| egg shells | | | | | | |
| jar | | | | | | |
| wilted flowers | | | | | | |
| leftovers of food | | | | | | |
| bones | | | | | | |
| litter from the litter box | | | | | | |
| notebook | | | | | | |
| tin can | | | | | | |
| sanitary napkins | | | | | | |
| old trousers | | | | | | |
| broken glass | | | | | | |

## 4.4. People and the environment

### Ex. 4.13. World Earth Day and Cleaning up the world

Earth Day is celebrated on April 22 and there are many events aimed at promoting pro-environmental attitudes in society. It was endorsed by the UN Secretary General, Sithu U Thant, who said:

> *„May there only be peaceful and cheerful Earth Days to come for our beautiful Spaceship Earth as it continues to spin and circle in frigid space with its warm and fragile cargo of animate life.*

Another action, *Clean Up the World*, takes place around the world on the third weekend of September. It has been run since 1989 by Clean up the World, an international organization for the protection of the environment based in Australia. 35 million people have already participated in Clean Up the World.[66] One of the Polish organizations, Our Earth Foundation used the following slogan to promote the idea of cleaning up the world: **'There is no waste – there are raw materials**'.[67]

What do you think about this slogan? Write a short essay based on examples.

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[66] https://www.cleanuptheworld.org;

[67] https://pomorska.pl/sprzatanie-swiata-2017-nie-ma-smieci-sa-surowce/ar/12455776.

## EX. 4.14. MICROPLASTICS

Microplastics, defined as small pieces of plastic debris with a diameter of no more than 5 mm, are getting more and more attention in science, media and social media. In 2100, it is anticipated that there will be 50 times more microplastics floating in the oceans than today. It is even expected that adverse environmental effects will appear from the second half of the 21st century.[68] Microplastics are eaten by aquatic organisms and, consequently, also by humans. Fortunately, disposable plastic items such as plates, cutlery, straws, balloon sticks will be banned in the European Union from 2021.

How much polluted with microplastics is water in particular regions of the world? Look at: **https://www.adventurescientists.org/microplastics.html**[69] and analyze the map very carefully. Indicate the places where the concentration of microplastics is the highest. Take into account geographical and social reasons.

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[68] G. Everaert, L. van Cauwenbergheb, M. De Rijckea, A. A. Koelmansc, J. Meesa, M. Vandegehuchtea, C. R. Janssen *Risk assessment of microplastics in the ocean: Modelling approach and first conclusions, Environmental Pollution*, 242, Part B 2018;

[69] https://www.adventurescientists.org/microplastics.html.

## Ex. 4.15. PET FLEECE SWEATSHIRT

Even a fleece sweatshirt can be made of PET. Think about advantages and disadvantages of using it in textile industry. Complete the table.

| pros | cons |
|---|---|
| | |

It is estimated that the inhabitants of Poland empty approximately 110,000 tones of PET bottles annually. 1 tone of polymer is used to make 25,000 PET bottles[70], and 35 PET bottles are needed to make one fleece sweatshirt.[71] Calculate how much time it would take to produce and collect all PET bottles that would be enough to make fleece sweatshirts for all inhabitants of Poland.

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[70] http://pszok.wfosigw.torun.pl/2017/11/26/butelek-pet-wykorzystujesz-ciagu-roku/;
[71] http://www.karguii.pl/ekologia.html.

## EX. 4.16. EUTROPHICATION OF LAKES

Industrial, municipal and agricultural wastewater entering the water cycle causes an increase in concentration of phosphorus, nitrogen, and other elements in the lakes. Too high concentrations of these elements disturb the balance of lake ecosystems.

Draw a cross-section of the lake and mark on it all the factors causing the increase in the concentration of phosphorus and nitrogen, and the effects they cause. If it is not possible to label everything in the drawing, use the space below to write other information.

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# CHAPTER 5. WE LIVE HEALTHY

## 5.1. MEDICINAL PRODUCTS (DRUGS) AND DIETARY SUPPLEMENTS

**What are the definitions of 'medicine', and 'dietary supplement'?**
According to the Act of 6 September 2001 on Pharmaceutical Law (Journal of Laws 2001 No. 126, item 1381), there is no concept of a medicine, but only a medicinal product.
*'A medicinal product is a substance or a mixture of substances, presented as having properties for the prevention or treatment of diseases occurring in humans or animals or administered for the purpose of diagnosis or to restore, improve or modify the physiological functions of the body through pharmacological, immunological or metabolic action.'*
The concept of a dietary supplement can be found in the Act of 25 August 2006 on food safety and nutrition:
*'A dietary supplement is the purpose of which is to supplement a normal diet, being a concentrated source of vitamins or minerals or other substances exhibiting a nutritional or other physiological effect, excluding products having medicinal product properties.'*

What is the easiest way to recognize whether we are dealing with a medicine or a dietary supplement if the product is not prescription only?
The packaging of the medicine shall always clearly state that it is an: 'OTC drug' (OTC stands for over-the-counter) or 'OTC medicinal product'[72]. Each medicine authorized for marketing also has a marketing authorization number on its packaging.[73]

### SALICYLIC ACID AND ASPIRIN (ACETYLSALICYLIC ACID)

Antipyretic and analgesic properties of plant extracts, e.g. willow bark decoction, have been known to mankind since antiquity. This effect is caused by the presence of salicylic acid derivatives. Salicylic acid dissolved in a mixture of ethyl alcohol and water has antibacterial properties.

### LAB. 5.1. SALICYLIC ACID

After adding the iron (III) salt solution to salicylic acid, a characteristic color should appear. Check what color it is.

MATERIALS AND CHEMICALS

- ✓ two small beakers,
- ✓ two teaspoons,
- ✓ stirring rod,
- ✓ Pasteur pipette,
- ✓ salicylic acid,
- ✓ ethanol,
- ✓ iron(III) chloride,
- ✓ water.

[72] Rozporządzenie Ministra Zdrowia z dnia 14 listopada 2008 roku w sprawie kryteriów zaliczenia produktu leczniczego do poszczególnych kategorii dostępności (Dz.U.08.206.1292 z dnia 21 listopada 2008 r.);
[73] https://www.gov.pl/web/zdrowie/pozwolenie-na-dopuszczenie-do-obrotu1.

PROCEDURE

1. Pour a pinch of iron(III) salt into the beaker, add a small amount of water and mix.
2. Pour ethanol into another beaker and add a pinch of salicylic acid. Add the contents of the second beaker to the first beaker, one drop at a time.

What color did the contents of the beaker take (after mixing the contents of both beakers)? .....

The name **Aspirin** can only be used for the product made by Bayer and is a blend of names of two components Aspirin contains: **'a'** from acetyl - the systematic name of the compound, and **'spir'** from the meadow plant called spirea.[74] Aspirin contains acetylsalicylic acid, which does not form a colorful combination with iron(III) salts. However, when improper storage conditions are used, e.g. when the temperature is higher than 30°C[75], acetylsalicylic acid will decompose even before the expiration date and reconstitution of the salicylic acid takes place. Then the color reaction will appear again.

## LAB. 5.2. ASPIRIN

Check if the aspirin you have is suitable for use.
Ask a research question.

……

……
Write down the hypothesis.

……

……
Plan activities. Write down the steps that you will follow.

……

……

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……
Write down all the materials and chemicals you are going to use.

……

……

……

……
Complete the task as planned.
Note down your observations.

[74] D. Lewis, *Aspirin. A curriculum resource for post-16 chemistry courses*, The Royal Society of Chemistry 1998;
[75] https://aspirin.pl/static/media/pdf/aspirin-pro.pdf.

Draw conclusions.

……

……

**Ex. 5.1.** **Structure of the salicylic and acetylsalicylic acid molecules**

Look at the structure of the salicylic and acetylsalicylic acid molecules (Fig. 5.1).

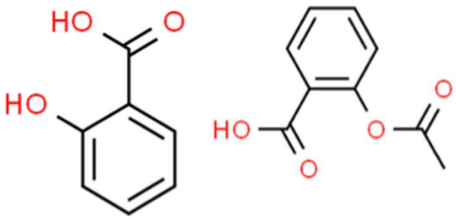


Figure 5.1. Models of salicylic acid (left) and acetylsalicylic acid (right) molecules.[76]

With ball-and-stick model available, build models of molecules of these acids. Count the number of atoms of each type and complete the table.

| name of acid | number of atoms in the molecule | | | molecular formula |
|---|---|---|---|---|
| | C | H | O | |
| | | | | |
| | | | | |

What is the difference between the molecules of both acids? Which element of the structure is responsible for the appearance of the characteristic color of the solution in the reaction of salicylic acid with the iron(III) salt?

……

……

[76] Figure source: http://www.chemspider.com.

## Ex. 5.2. Other medicines containing acetylsalicylic acid

Find other medicines containing acetylsalicylic acid. Complete the table below and comment on the information it contains.

| drug name | manufacturer | mass of acetylsalicylic acid in 1 tablet |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Comment:

……

……

**Did you know that aspirin prolongs the life of cut flowers?**
All you have to do is throw the tablet into the vase water,
stir to make sure it dissolves completely and put the flowers.
You only need to change the water every few days ... [77]

### HEARTBURN MEDICATIONS

Probably each of us sometimes suffers from heartburn. It is a painful burning feeling that appears in the sternum or epigastric region, moving towards the mouth. It usually appears after a meal or with a horizontal body positioning and is caused by the discharge of stomach contents into the respiratory tract. Products which increase the likelihood of experiencing these symptoms include is conducive to these symptoms, include sweets and sour dishes.[78] Gastric juices contain, inter alia, hydrochloric acid, pH of which is 2-3.[79]

*How to get rid of heartburn?* You can follow a proper diet, but it might be difficult to constantly avoid sweets and sour dishes. Home remedies and medicines come to the rescue. You can, for example, drink a glass of water with half a teaspoon of baking soda, or use herbs, e.g. chamomile, mint, cumin or fennel.[80] You can also use a medication available in your pharmacy.

[77] https://www.rd.com/home/decorating/how-to-make-flowers-last-longer/;
[78] M. Śmiechowska, M. Cugowska, *Rola Żywności i Żywienia W Chorobie Refluksowej*, Bromatologia i Chemia Toksykologiczna – XLIV, 3 2011;
[79] P.-J. Lu, *Gastric juice acidity in upper gastrointestinal diseases*, World Journal of Gastroenterology 21, 16 (43) 2010;
[80] https://www.doz.pl/czytelnia/a14360-Naturalne_sposoby_na_zgage.

## EX. 5.3. HEARTBURN MEDICATIONS

Find heartburn medications. Complete the table below and comment on the information it contains.

| drug name | manufacturer | the active substance | form (e.g. tablets) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Comment on the data in the table above.

……

……

## LAB. 5.3. HEARTBURN IN A GLASS

Check which of the drugs listed above will most effectively eliminate heartburn. Conduct quantitative tests - you can use e.g. a balance or a measuring cylinder. First you need to prepare heartburn in a glass.

Ask a research question.

……

……

Write down the hypothesis.

……

……

Plan activities. Write down the steps that you will follow.

……

……

……

……

Write down all the materials and chemicals you are going to use.

……

……

Complete the task as planned.
Note down your observations.

Draw conclusions.

……

……

## DIETARY SUPPLEMENTS

The number of dietary supplements introduced into the market is growing every year. In Poland, in 2008, 1,115 new applications were submitted to the Main Sanitary Inspectorate, and in 2018 - 13,845.[81] The number of products sold is growing and so is the number of people who take supplements.

### EX. 5.4. TAKING DIETARY SUPPLEMENTS

Conduct a survey of a group of at least twenty people and try to determine whether or not the following statement is true:
***Three out of four Polish residents buy dietary supplements, with half of them taking them every day.***[82]
Design a table and place the results of your survey in it.

[81] https://www.prawo.pl/zdrowie/suplementy-diety-planowana-zmiana-przepisow,367120.html;
[82] https://strefabiznesu.pl/suplementy-diety-juz-co-drugi-polak-spozywa-je-codziennie-czy-to-ma-sens/ar/13578744.

Draw conclusions.

……

……

……

## Ex. 5.5. Dietary supplements - age and gender

Analyze the figure below (Fig. 5.2).

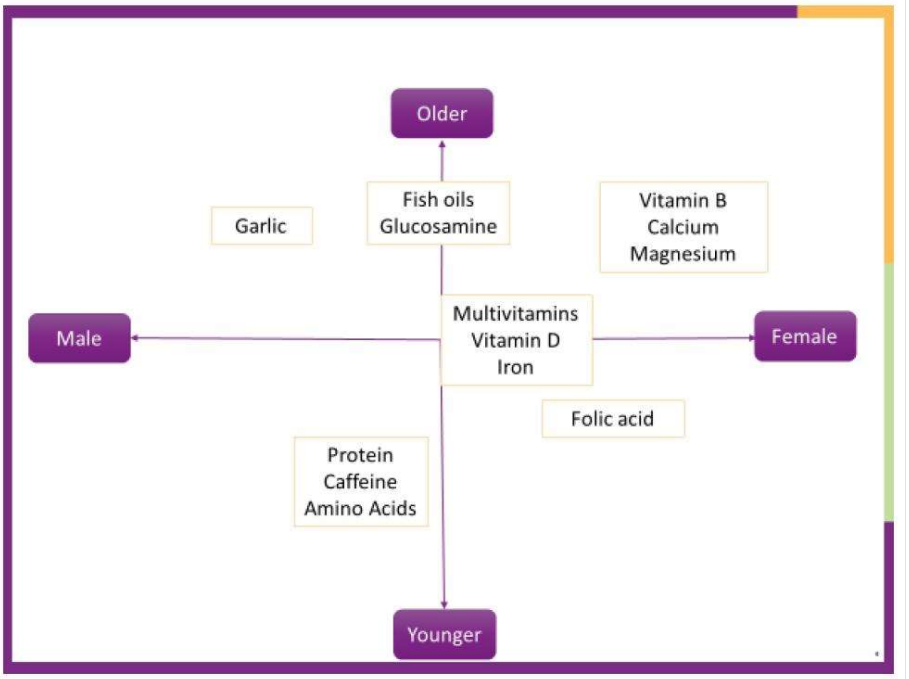


Figure 5.2. The most popular dietary supplements depending on gender and age.[83]

Make a short note - describe the figure above.

……

……

……

……

……

……

……

[83] Figure source: Food Supplements Consumer Research, Final Report for Food Standards Agency, May 2018.

Conduct a survey of ten people, both men and women, at different ages, who take dietary supplements. Check what dietary supplements they take most often.
Design a table and place the results of your survey in it, assigning a number to each person on your list.

Draw conclusions.

……

……

……

……

……

Add the results you have obtained to the picture above (Fig. 5.2). If any new supplements have been mentioned by the respondents, put their names in the appropriate sections.

## Ex. 5.6. Categories of dietary supplements

Dietary supplements can be divided into four categories:[84]

1. Day-to-day health
2. Herbal remedies
3. Sport nutrition
4. Weight loss

[84] *Food Supplements Consumer Research, Final Report for Food Standards Agency*, May 2018.

Analyze leaflets of dietary supplements and find three examples of products from each category. Write down the name, manufacturer, the most important ingredient and a quote from the leaflet, which will confirm the possibility of including the supplement into a given category. Complete the table below.

| **category** | **name** | **manufacturer** | **the most important ingredient** | **quote from the leaflet** |
|---|---|---|---|---|
| Day-to-day health | | | | |
| | | | | |
| | | | | |
| Herbal remedies | | | | |
| | | | | |
| | | | | |
| Sport nutrition | | | | |
| | | | | |
| | | | | |
| Weight loss | | | | |
| | | | | |
| | | | | |

## 5.2. VITAMINS

The concept of 'vitamin' was introduced by Kazimierz Funk in 1912. The first vitamin he extracted from rice bran in that year was $B_1$, or thiamine. Without the right amount of each vitamin, the human body is unable to function properly. So what are the symptoms of a particular vitamin deficiency?

### EX. 5.7. SYMPTOMS OF VITAMIN DEFICIENCY

Find in the literature that is available (including websites) what symptoms and diseases caused by a lack of specific vitamins are. Enter your findings into the table below.

| vitamin | name | symptoms of deficiency | source |
|---|---|---|---|
| A | | | |
| D | | | |
| E | | | |
| K | | | |
| C | | | |
| $B_1$ | | | |
| $B_2$ | | | |
| $B_3$ | | | |
| $B_6$ | | | |
| $B_9$, $B_{11}$ | | | |
| $B_{12}$ | | | |

### VITAMIN C (ASCORBIC ACID)

The human body is unable to produce vitamin C, therefore it must be supplied with it. It is also unable to store it. Symptoms of vitamin C deficiency have been known to mankind since the times of Hippocrates, considered as the father of medicine. Scurvy (which is the name ascorbic acid comes from) was a disease most sailors suffered from, as they had no access to fresh vegetables and fruit during their long journeys at sea.

Vegetables are a very good source of this vitamin (table below).[85]

| vegetable species | content in mg/100g vegetables | vegetable species | content in mg/100g vegetables | vegetable species | content in mg/100g vegetables |
|---|---|---|---|---|---|
| broccoli | 89.2 | parsley | 17.0 | cucumber | 3.2 |
| brussels sprout | 85.0 | radish | 14.8 | pumpkin | 9.0 |
| kale | 120.0 | root celery | 8.0 | eggplant | 2.2 |
| cauliflower | 48.2 | parsley leave | 133.0 | red pepper | 127.7 |
| green cauliflower | 88.1 | leek | 12.0 | green pepper | 80.4 |
| cabbage | 36.6 | lettuce | 3.7 | red tomato | 13.7 |
| beetroot | 4.9 | spinach | 28.1 | onion | 7.4 |
| carrot | 5.9 | zucchini | 17.0 | potato | 10.8 |

## EX. 5.8. YELLOW COLOR OF VITAMIN C TABLETS

Which ingredient(s) make(s) Vitamin C tablets yellow? To answer this question, review the section of the package leaflet shown below. Find the characteristics of the individual substances listed on the leaflet using sources that are available to you and decide which substance(s) is(are) responsible for the yellow color of the tablets.
Write down their name(s): ……..……..

Composition:

One tablet contains:

active substance: ascorbic acid (vitamin C) 500mg;

excipients: sucrose, corn starch, talc, tartaric acid, stearic acid;

the tablet shell: gelatin, water, riboflavin, sodium lauryl sulfate.

## EX. 5.9. TASTY VEGETABLE SALAD

The recommended daily intake of vitamin C for an average adult is 80mg. Based on the contents of vitamin C in vegetables given in the table above, compose a tasty vegetable salad weighing 100 g and containing 80 mg of vitamin C.

[85] Instytut Ogrodnictwa *Wartości odżywcze i zdrowotne owoców i warzyw*, Instytut Ogrodnictwa Skierniewice 2017.

| vegetable species | content in mg/100 g vegetables | mass | mass of vit. C in mg |
|---|---|---|---|
| | | | |
| salad | | 100 g | 80 mg |

Can such a salad be left on the kitchen table for a long time and have the same nutritional value? What factors influence the durability of vitamin C (ascorbic acid). To try to answer these questions as well as any other ones, first check whether ascorbic acid reacts with the iodine in, for example, Lugol's iodine.

## LAB. 5.4. REACTION OF ASCORBIC ACID WITH LUGOL'S IODINE

MATERIALS AND CHEMICALS

- ✓ gloves and goggles,
- ✓ small beakers,
- ✓ cylinder,
- ✓ Pasteur pipettes,
- ✓ stirring rod,
- ✓ ascorbic acid,
- ✓ water,
- ✓ Lugol's iodine,
- ✓ starch.

PROCEDURE

1. Put on protective gloves and goggles.
2. Prepare solutions of ascorbic acid and starch.
3. Using a cylinder, measure any volume of ascorbic acid solution and pour it into the beaker.
4. Add a few drops of an aqueous starch solution and mix, then add iodine dropwise until it becomes stable.
5. Repeat the procedure three times. Note down the results in the table.

| sample no. | volume of ascorbic acid solution | number of Lugol's iodine drops |
|---|---|---|
| | | |
| | | |
| | | |

The average amount of iodine added is ..... drops.

Answer the questions:

1. Is ascorbic acid water soluble? .....

2. Does ascorbic acid react with iodine? .....

3. What color does iodine take in the presence of starch? .....

## LAB. 5.5. EFFECT OF VARIOUS FACTORS ON ASCORBIC ACID STABILITY

MATERIALS AND CHEMICALS

- ✓ gloves and goggles,
- ✓ small beakers,
- ✓ cylinder,
- ✓ Pasteur pipettes,
- ✓ stirring rod,
- ✓ lamp,
- ✓ apparatus for producing oxygen and enabling it to pass through the solution,
- ✓ spirit burner or water bath,
- ✓ thermometer,
- ✓ ascorbic acid,
- ✓ water,
- ✓ Lugol's iodine,
- ✓ starch,
- ✓ aluminum and steel cutlery,
- ✓ baking soda,
- ✓ vinegar.

Ask a research question.

……

……

Write down the hypothesis.

……

……

Plan activities. Write down the steps that you will follow.

……

……

……

……

Complete the task as planned.
Note down your observations.

Draw conclusions.

……

……

Answer the following questions.

1. Why is vitamin C one of the substances added to juices (after pasteurization at high temperature)?

……

2. Should we leave vegetables in hot water?

……

3. Why should we eat raw vegetables?

……

4. Why should foods containing vitamin C be stored in a fridge?

……

5. Why the cutlery is used for serving salads?

……

## Ex. 5.10. Vitamins as food additives, so-called E

Among the food additives labeled Exxx, there are also vitamins necessary for proper human functioning. Try to find three such vitamins. Complete the table.

| E number | name | E category* |
|---|---|---|
| | | |
| | | |
| | | |

*Choose from: Dyes / Preservatives / Antioxidants and acidity regulators / Thickeners, stabilizers and emulsifiers / pH regulators and anti-caking agents / Flavor enhancers / Antibiotics

### 5.3. CAFFEINE AND THEINE

As we all know, caffeine is found in coffee and theine is found in tea. But are they really two different substances? Let's compare the formulas of their molecules - Fig. 5.3.

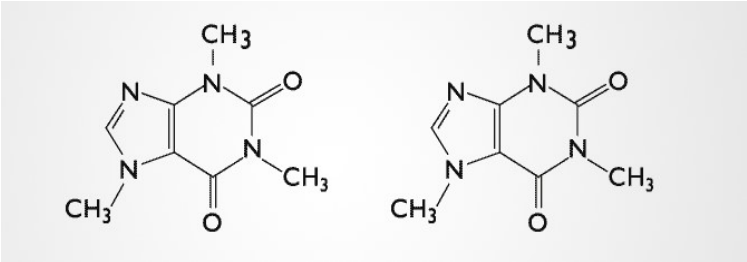


Fig. 5.3. Formulas of caffeine (left) and theine (right) molecules.[86]

It turns out that it is the same substance (1,3,7-trimethylxanthine), and the fact that it has two different names is due to the fact that it can be found in different plants. Among the raw materials containing 1,3,7-trimethylxanthine there are, e.g. guarana seed (*Paulliniae semen*), kola embryo (*Colae embryo*) and mate leaf (*Mate folium*).

Caffeine has a stimulating effect on the following centers in the brain: vasomotor, respiratory, metabolism and thermoregulation. Caffeine is considered an addictive substance. Typical symptoms of caffeine withdrawal syndrome are headache, drowsiness, weakness, anxiety, depressed mood disorder, tremors, nausea and vomiting.[87]

Caffeine is found in many drugs and dietary supplements.

#### EX. 5.11. CAFFEINE IN MEDICINES AND DIETARY SUPPLEMENTS

Find six drugs and six dietary supplements that contain caffeine. Complete the table below.

| category | name | manufacturer | form, e.g. tablets, capsules | maximum caffeine mass in the recommended daily dose |
|---|---|---|---|---|
| drugs containing caffeine | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

[86] Figure source: https://www.liberaldictionary.com/theine/;

[87] R. Siwek, E. Witkowska-Banaszczak, M. Szymański, *Kofeina w lekach i suplementach diety - znaczenie w lecznictwie*, Farmacja polska, 69, 7 2013.

| | | | | |
|---|---|---|---|---|
| dietary supplements containing caffeine | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Comment on the data in the table.

……

……

……

**Ex. 5.12.** **1,3,7-TRIMETHYLXANTHINE IN PLANT RAW MATERIALS**

The content of 1,3,7-trimethylxanthine in plant raw materials is different, which (for selected raw materials) is presented in the table below.[88]

| species | organ | content (%) |
|---|---|---|
| *Coffea arabica* | seeds | 1.2-1.4 |
| | leaves | 0.8-1.9 |
| *Coffea canephora* | seeds | 1.2-3.3 |
| *Camellia sinesis* | leaves | 2.0-3.0 |
| *Theobroma cacao* | seeds | 0.6-0.8 |
| *Ilex paraguariensis* | leaves | 1.0-2.0 |
| *Paulinia guarana* | seeds | 1.1-7.0 |
| *Cola nitida* | embryo | 1.5-2.5 |

Comment on the compiled data.

……

……

……

[88] R. Siwek, E. Witkowska-Banaszczak, M. Szymański, *Kofeina w lekach i suplementach diety - znaczenie w lecznictwie*, Farmacja polska, 69, 7 2013.

## LAB. 5.6. CAFFEINE AND BLOOD PRESSURE

It is well-known that **coffee raises blood pressure** due to the caffeine it contains. Plan an experience that will allow you to verify this hypothesis. Use different types of coffee and different ways to brew it. Test different people – those who rarely drink coffee, as well as those who are addicted to it.

Plan activities. Write down the steps that you will follow.

……

……

……

……

Write down all the materials and chemicals you are going to use.

……

……

Complete the task as planned.
Note down your observations.

Draw conclusions.

……

……

……

……

## LAB. 5.7. THEINE AND BLOOD PRESSURE

Caffeine and theine are the same chemical compound.
**Problem question: Does tea raise blood pressure?**
Use different teas and brewing methods.
Write down the hypothesis.

……

……

Plan activities. Write down the steps that you will follow.

……

……

……

……

Write down all the materials and chemicals you are going to use.

……

……

Complete the task as planned.
Note down your observations.

Draw conclusions.

……

……

Compare the influence of caffeine and theine on human blood pressure.

……

……

……

## 5.4. HOMEOPATHY AND DILUTION SOLUTIONS

ANSWER THE QUESTIONS

1. What are homeopathic drugs?

……

……

2. What do you think about reimbursing homeopathic drugs by the state?

……

……

3. What kinds of substances may be found in homeopathic drugs?

……

……

Write down five examples of different substances that you can find at home, the packaging of which provides the consumer with information about specific concentrations of ingredients.

1……

2……

3……

4……

5……

Write down the equation for the percentage concentration.

……

……

### EX. 5.13. CONCENTRATION CALCULATION

10g salt was dissolved in 90g water. Calculate the concentration of the solution.

……

……

### EX. 5.14. MASS CALCULATION

Calculate the mass of sodium chloride and water needed to prepare 0.6kg of cucumber pickling liquid (an 8% solution of sodium chloride in water).

……

……

……

……

## EX. 5.15. ONE TOMATO

The human daily carotene intake should be 30mg. Tomatoes contain 5mg of beta carotene per 1 kg. Calculate what percentage of the daily dietary requirement for beta carotene will be covered by eating one tomato that weighs 90g.

……

……

……

……

During many activities related to work, study or everyday life, we add water or other solvent to various liquids (solutions of a substance). The process that happens is called dilution. As a result, we increase the amount (mass) of the solvent, while the amount (mass) of the solute does not change.

Answer the following question: what happens with the percentage concentration of the diluted solution?

……

……

……

## HOMEOPATHY

Watch a video. Try to remember as many facts as possible. Take short notes while watching.
Video: https://www.youtube.com/watch?v=8HslUzw35mc

……

……

……

……

Write down five keywords that would best describe the video you have just watched.

1……

2……

3……

4……

5……

## EX. 5.16. HEXES

Now each of the four-person groups will receive 20 hexes (Fig. 5.4). Each person will get 5 hexes. On each of them you should write with a whiteboard marker a keyword related to the film on homeopathy. The task will be to arrange the hexes into a honeycomb so that one concept can be logically connected with ones written on the adjacent fields. Each choice must be justified.

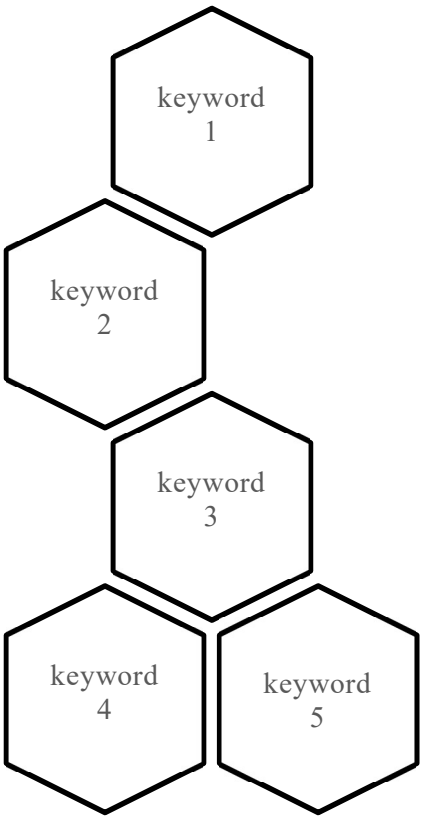


Fig. 5.4. Educational hexes used in the exercise 5.16.

**SUBSEQUENT DILUTIONS OF SOLUTIONS**

*How to get a solution dilution 10 times?*

You should take 10 $cm^3$ of the solution using a pipette, then pour this liquid into a flask containing 90 $cm^3$ of diluting liquid (do not immerse the pipette in the liquid) and mix thoroughly. In this way, a 1:10 dilution is obtained, designated as 1.

*To obtain a dilution 100 times from the first (1:10) dilution* (thoroughly mixed), pour 1 $cm^3$ liquid into a test tube containing 9 $cm^3$ of diluting liquid (without immersing the pipette in the liquid). In this way a dilution of 1: 100 is obtained, i.e. 2.

*Preparing a dilution of 1000 times.*

After mixing thoroughly and transferring liquid with a new glass pipette (or the tip of an automatic pipette), 1 $cm^3$ of the liquid dilution 2 to 9 $cm^3$ of diluting liquid, a dilution of 1: 1000, i.e. 3 is obtained.

**HOW IS THE 'HOMEOPATHIC MEDICINE' CREATED?**

The whole process of the homeopathic medicines (or 'remedies') preparation can be divided into several stages:

1. Preparation of the pre-solution - in the case of raw materials of vegetable origin, this is done by macerating plants in a water-alcoholic solution. It lasts a minimum of 3 weeks. After this process, the products are strained, filtered and stored in appropriate conditions. The whole process takes place in the laboratory.
2. The pre-solution that has been prepared can be poured into bottles of a specified volume and used as a finished product or to prepare homeopathic dilutions and other forms of the drug: granules, tablets or ointments.
3. In order to prepare a homeopathic dilution, the pre-solution is subjected to a potency process, i.e. multiple dilution and shaking. The process of dilution and succussion is termed 'dynamization' or 'potentization'.

There are three logarithmic scales that are used in homeopathy (C, X or D and dilution). Samuel Hahnemann, the father of homeopathy, created and used for most of his life the **C scale**, diluting the substance by a factor of 100 at every step. **Dilution 2C requires the substance to be diluted in a ratio of 1: 100, and then part of the substance is again diluted in a ratio of 1: 100.** This results in a dilution of 1: 10000, i.e. 0.01% of the original substance will remain in the formulation.

$$\frac{1}{100} \cdot \frac{1}{100} = 10^{-2} \cdot 10^{-2} = 10^{-4} = \frac{1}{10000}$$

In the case of 6C dilution, this process is repeated six times. The result is a solution of the substance diluted by a factor of $100^{-6}$:

$$\frac{1}{100} \cdot \frac{1}{100} \cdot \frac{1}{100} \cdot \frac{1}{100} \cdot \frac{1}{100} \cdot \frac{1}{100} = 10^{-2} \cdot 10^{-2} \cdot 10^{-2} \cdot 10^{-2} \cdot 10^{-2} \cdot 10^{-2} =$$

$$10^{-12} = \frac{1}{1000000000000}$$

The dilution recommended by Hahnemann for most medical applications was 30C (1: $10^{-60}$).

The most frequently scaled scale is the D scale (homeopaths refer to it as D scale or X scale). D scale means diluting the substance with factors of 10 at each stage (not 100). Thus, the value on the D scale will be 2 times greater than the same dilution on the C scale (for example an equivalent to 12X is 6C).
Analyze the table below with different dilutions given on X scale and C scale[89].

| X Scale | C Scale | dilution | notes | comment |
|---|---|---|---|---|
| Ø | Ø | 1:1 | not diluted | |
| 1X | – | 1:10 | low potentization | |
| 2X | 1C | 1:100 | higher potentization | |
| 6X | 3C | $10^{-6}$ | | |
| 8X | 4C | $10^{-8}$ | allowable concentration of arsenic in drinking water in the USA | |
| 12X | 6C | $10^{-12}$ | | |
| 24X | 12C | $10^{-24}$ | | |
| 60X | 30C | $10^{-60}$ | the dilution recommended by Hahnemann for most applications | The patient would need to take about $10^{41}$ tablets (one billion Earth masses) or more than $10^{33}$ liters of liquid preparation to consume a single molecule of the original substance. |
| 400X | 200C | $10^{-400}$ | dilution of the popular *Oscillococcinum* homeopathic preparation | This is a much lower concentration than if the entire observable universe was filled with water and there was only one particle of the active substance in it (dilution would be around 55C, much lower than 200C). |

[89] Source of the table: https://www.wikiwand.com/pl/Homeopatia

## 5.5. HOMEOPATHIC BLEACH

### LAB. 5.9. A HOMEOPATHIC BLEACH

Your team is going to make a homeopathic solution of 30C bleach.

MATERIALS AND CHEMICALS

- ✓ pipettes,
- ✓ automatic pipettes,
- ✓ glasses or falcons,
- ✓ water,
- ✓ bleach.

Using materials listed above design and conduct an experiment.

Describe the procedure.

……

……

……

……

……

……

Draw a diagram of the experiment setup.

Note your observations.

……

……

……

……

Draw conclusions.

……

……

……

……

## LAB. 5.8. A HOMEOPATHIC ACID!

Your team is going to conduct experiments with phosphoricum acidum (Fig. 5.5) , a homeopathic remedy and phosphoric acid.


Fig. 5.5. Phial containing phosphoricum acidum 30C (Boiron).[90]

MATERIALS AND CHEMICALS

- ✓ phosphoric acid,
- ✓ phosphoricum acidum,
- ✓ pipettes,
- ✓ zinc,
- ✓ indicators,
- ✓ water,
- ✓ vinegar,
- ✓ citric acid,
- ✓ bleach,
- ✓ sodium bicarbonate (baking soda).

[90] Source: https://i.pinimg.com/originals/d7/5c/6a/d75c6a827b8cba1d57d4b29082362aff.jpg.

Analyze the label of this product. What information can you find there? What is the dilution of the pre-solution?

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Should the solution of this substance be acidic or alkaline? Answer the question and explain your answer.

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**READ THE MSDS CARD (SAFETY DATA SHEET) FOR THE PHOSPHORIC ACID CAREFULLY AND ANSWER THE QUESTIONS BELOW.**

Look at the hazard pictogram (GHS) on the label? What danger does this sign show?

| | **description** |
|---|---|
|  | |

Write down the meaning of the abbreviations (precautionary statements) that can be found in the MSDS card.

P260

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P264

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P280

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P301+P330+P331

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P303+P361+P353

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P305+P351+P338

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P363

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Write down what first-aid measures should be taken following skin contact.

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Write down what kind of personal protective equipment should be used while using the phosphoric acid.

| | | | |
|---|---|---|---|
|  |  |  |  |
| description | | | |
| | | | |

**Compare properties of phosphoric acid and homeopathic phosphoricum acidum.**
Ask a research question.

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What is your best guess – write down the hypothesis.

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PROCEDURE

1. Prepare solution of homeopathic phosphoricum acidum by using at least 10 granules of the remedy and dissolving them in 20 $cm^3$ water. Stir the solution thoroughly until the granules dissolve completely.
2. Prepare 10% solutions of bleach, citric acid, baking soda and vinegar.
3. Carry out the (re)actions:
    - phosphoric acid solution + zinc,
    - homeopathic phosphoricum acidum solution + zinc,
    - effect of homeopathic phosphoricum acidum solution on indicator solution,
    - effect of phosphoric acid solution on indicator solution,
    - effect of 10% solutions of bleach, citric acid, baking soda and vinegar on indicator solution.
4. Fill in the tables with your observations

**Reaction with zinc**

Draw a diagram of the experiment setup.

| observations | | | |
|---|---|---|---|
| **reaction setup** | **before reaction** | **during reaction** | **after reaction** |
| zinc | | x | x |
| homeopathic solution | | x | x |
| phosphoric acid solution | | x | x |
| homeopathic solution + zinc | x | | |
| phosphoric acid solution + zinc | x | | |

Draw conclusions.

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**Effect of different solutions on indicator 1.**
Name the indicator 1 used. ……

Fill in the table with your observations.

| indicator 1 + | observations | possible pH value |
|---|---|---|
| water | | |
| vinegar solution | | |
| citric acid solution | | |
| phosphoric acid solution | | |
| homeopathic solution | | |
| baking soda solution | | |

Draw conclusions.

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**Effect of different solutions on indicator 2.**

Name the indicator 2 used. ……

Fill in the table with your observations

| indicator 2 + | observations | possible pH value |
|---|---|---|
| water | | |
| vinegar solution | | |
| citric acid solution | | |
| phosphoric acid solution | | |
| homeopathic solution | | |
| baking soda solution | | |

Draw conclusions.

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The following information on the homeopathic phosphoricum acidum (potentization 15CH) can be found on a pharmacy website[91]:

*We note that the same drug can be used in the treatment of various diseases, and its therapeutic indications are very wide, therefore, the information leaflet is not included in the medicine and information on the dosage method is not placed on the packaging.*

[91] https://www.aptekawsieci.pl/pl/p/BOIRON-Phosphoricum-acidum-15CH-granulki-4-g/11887

*Conducted research and clinical observations have shown that this drug has an effect on: nervous system with a significant degree of weakness, gastrointestinal tract with painless diarrhea, urogenital system and bones associated with growth disorders and periostitis.*

**Now, answer the questions below.**

Do you know any medicines sold without a leaflet?

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Are there any specific disorders which may be cured with phosphoricum acidum?

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## 5.6. DRUGS AND THE ENVIRONMENT

**What to do with expired drugs?**

They should be thrown into special bins, which can be found in pharmacies. The list of collection points should be published on local government websites that ensure the disposal of medicines in accordance with the Waste Act.[92] In Warsaw, there are over 600 pharmacies that manage collection of expired medicines.[93]

### EX. 5.17. PHARMACIES

Visit 5 pharmacies that collect expired drugs and enter their addresses into the table below.

| number | pharmacy name | address of the pharmacy |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

Take photos of containers for expired medicines and put them below.

[92] https://www.gov.pl/web/zdrowie/przechowywanie-i-utylizacja-lekow;
[93] https://czysta.um.warszawa.pl/documents/10181/0/apteki%2011.2018.pdf.

Compare these containers.

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## Ex. 5.18. Pharmaceuticals in environment

Unfortunately, many pharmaceuticals are released into the environment (Fig. 5.6).

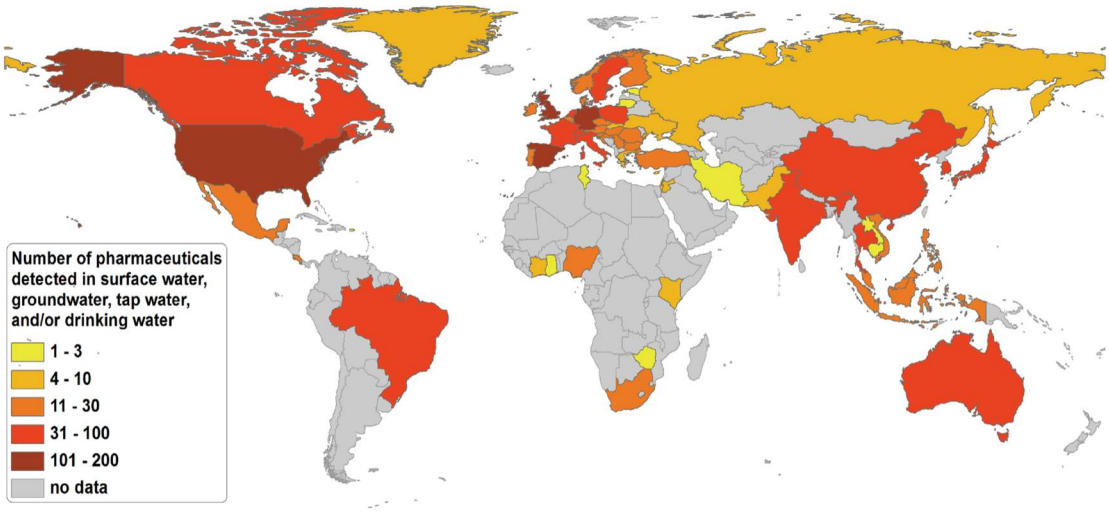


Fig. 5.6. The number of pharmaceuticals found in the environment in surface, ground, tap and drinking water in various countries of the world.[94]

Describe the map above. What factors play a role in causing such big differences between countries?

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[94] T. aus der Beek, F.-A. Weber, A. Bergmann, *Pharmaceuticals in the environment. The global perspective*, GGHH Webinar Series 2016.

## Ex. 5.19. Circulation of pharmaceuticals in the environment

Analyze the diagram below (Fig. 5.7).

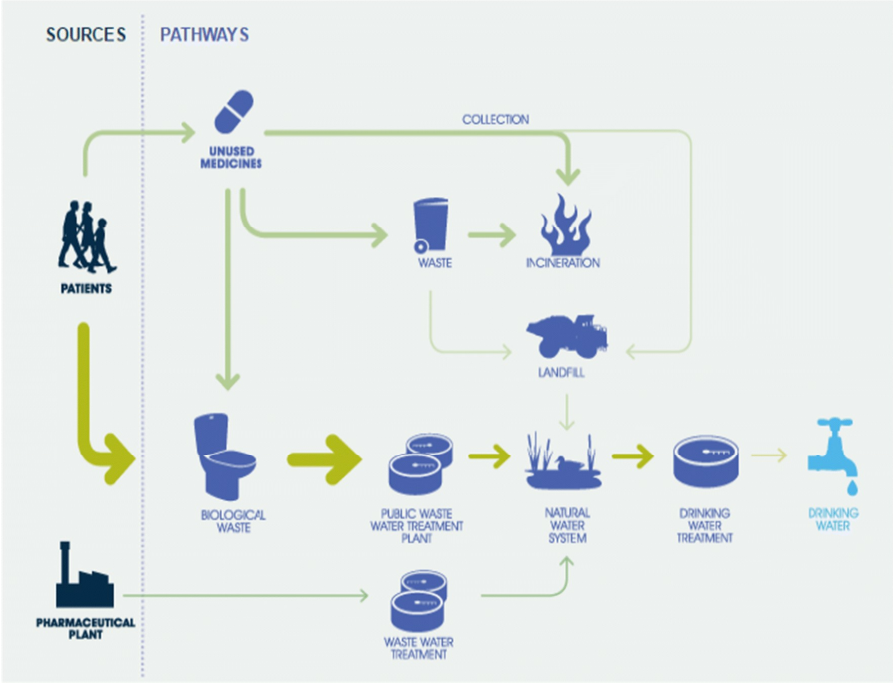


Fig. 5.7. Main sources and routes of pharmaceutical residues in the environment.[95]

<u>Describe the circulation of pharmaceuticals in the environment.</u>

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## Ex. 5.20. Ibuprofen

[95] Figure source: http://en.sanofi.com/csr/planet/priorities/pharma_environment/pharma_environment.aspx.

Ibuprofen is one of the most commonly used painkillers. Analyze the leaflet of ibuprofen and check the mass of the active substance in one tablet. The average concentration of ibuprofen in surface waters of UN countries is 0.108 micrograms / liter (6,950 measurements), and the highest value was 303.0 micrograms/liter.[96] The average volume of surface water resources in Poland is about 62 $km^3$ .[97]

Calculate how many ibuprofen tablets would have to reach surface waters of Poland to reach the concentration level equaling the average value for UN countries.

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### Ex. 5.21. A social campaign

Imagine that you are asked to help in the preparation of a social campaign targeted at adults, which aims to increase the awareness and knowledge of citizens of how expired drugs should be dealt with.

Create an advertising slogan.

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Design a poster.

## Chapter 6. Scientist in the kitchen

[96] T. aus der Beek, *Pharmaceuticals in the environment*, Environmental Toxicology and Chemistry, 9999 2016;

[97] http://hydro.geo.uni.lodz.pl/index.php?page=zasoby-wodne.

## 6.1. THE KITCHEN IS NOT A PHARMACY! RECIPE ANALYSIS

This session should be preceded by some introductory activities in two previous lessons:

- Lesson 1: The students vote for their favorite cake. The teacher gives them a list of 10 cakes and asks students to choose their favorite one. They assign points (3, 2 and 1) to cakes they like best (3 points - the most favorite one). The cake that scores best wins the vote.
- Lesson 2: The teacher announces the results of the vote for the favorite cake and gives homework to students. Each of students can bring a recipe for the 'winner' cake.

**During this session students try to check whether there are any rules regarding the weight ratios or volume constituents in different recipes for the same cake.**

### LAB. 6.1. ANALYZING RECIPES

The recipes for the same cake may differ significantly in the percentage composition of the ingredients, yet the cakes after baking will have a similar appearance and taste. Your task is to analyze your cake recipes and discuss them.

Read the recipes carefully. Write down the similarities and differences.

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Ask a research question about weight ratios or volume constituents in different recipes for the same cake.

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What is your best guess – write down the hypothesis.

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Examples of research questions:

- What type of ingredients are present in the recipes (flour, fat, sugar, etc.)?
- Are the ingredients similar or different in different recipes?
- What is the percentage ratio of sugar to flour in different recipes for the same cake?
- What is the percentage ratio of fats to flour in different recipes for it same cake?
- What is the percentage ratio of fluids to flour in different recipes for the same cake?
- What is the percentage ratio of baking powder to flour in various recipes for the same cake?

- What steps should be followed to make the dough - are they the same or different?
- Is the order of these steps the same in different recipes?

Examples of hypotheses:

- Making dough of a particular type is always the same/different.
- The percentage ratio of flour to sugar is similar/different in all recipes.

Write down which ingredients are present in all the recipes and, therefore, can be considered as essential.

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Your task will be to analyze the recipes quantitatively.

Decide which units your group will use to present the results: mass or volume. Now convert mass of products into volume of products or vice versa using the 'Change volume units into mass units' table so that all results obtained by the group can be presented in the same mass/volume units.

| product | 1 table spoon (dag) | 1 spoon (dag) | 1 cup (dag) |
|---|---|---|---|
| sugar | 0.5 | 1.5 | 25 |
| powdered sugar | 0.3 | 1.9 | 15 |
| cocoa | 0.2 | 0.6 | 10 |
| wheat flour | 0.3 | 1.9 | 15 |
| starch | 0.3 | 1.9 | 15 |
| baking powder | 0.4 | 1.2 | |

| unit | volume (ml) | equivalent |
|---|---|---|
| 1 ts | 5 | - |
| 1 s | 15 | 3 ts |
| 1/4 c | 63 | 4 s |
| 1/3 c | 83 | 5 s |
| 1/2 c | 125 | 8 s |
| 1 c | 250 | 16 s |

| classification of eggs by weight | symbol | egg mass (g) |
|---|---|---|
| very big | XL | more than 73 |
| big | L | from 73 to 63 |
| medium size | M | from 63 to 53 |
| small | S | less than 53 |

**Results:**

| number of recipe | mass (grams) or volume (ml)* | | | | | | flour to sugar ratio** |
|---|---|---|---|---|---|---|---|
| | flour | sugar | fat | milk | eggs | baking powder | |
| 1. | | | | | | | |
| 2. | | | | | | | |
| 3. | | | | | | | |
| 4. | | | | | | | |
| 5. | | | | | | | |
| 6. | | | | | | | |
| 7. | | | | | | | |
| 8. | | | | | | | |
| 9. | | | | | | | |
| 10. | | | | | | | |
| 11. | | | | | | | |
| 12. | | | | | | | |
| 13. | | | | | | | |
| 14. | | | | | | | |
| 15. | | | | | | | |
| 16. | | | | | | | |
| 17. | | | | | | | |
| mean | | | | | | | |
| standard deviation | | | | | | | |
| The maximum ratio of flour to sugar | | | | | | | |
| The minimum ratio of flour to sugar | | | | | | | |
| Standard deviation of flour to sugar content | | | | | | | |

*If you decide to calculate in units of volume in this column, enter the volume and give the appropriate units.

**In this column, you should enter data depending on what you want to verify the hypothesis.

**UNIVERSAL CAKE RECIPE**

Prepare your own recipe for the universal cake. Specify the average amount of each ingredient (listed in the table) needed to. If you wish, you can add other ingredients. Write down all the steps to follow.

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Write a draft of a short essay inspired by the following statement:

*People preparing tasty baked goods claim that they approach the recipes intuitively as they believe that the kitchen is not a pharmacy.*

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## 6.2. COLORS

When we see food that has very vivid colors, we want to eat it immediately. It is caused by food colorings. Each of the food colorings has a number consisting of the symbol E and three digits (the same as other food additives, e.g. vitamins – see subchapter 5.2). For colorings, the first number is 1. The list of organic colorings, most commonly found in food, is shown in the table below.[98,99]

| number | name | color | origin | products |
|---|---|---|---|---|
| E100 | curcumin | yellow | natural – ex. 6.1 | ex. 6.1 |
| E101 | riboflavin | yellow | natural (in many products) | very common |
| E102 | tartrazine (yellow 5) | yellow | synthetic | drinks, mustard |
| E110 | orange yellow (yellow 6) | orange | synthetic | jams, drinks |
| E120 | cochineal (red 4) | red | natural (*dactylopius coccus*) | hamburgers, sauces, sweets, drinks, fruit yogurts[100] |
| E122 | azorubine | red | synthetic | jams, drinks, sweets |
| E129 | allura red (red 40) | red | synthetic | drinks, sweets[101] |
| E133 | brilliant blue (blue 1) | blue | synthetic | jelly beans, colorful jelly, drinks[102] |
| E140 | chlorophylls | green | natural | very common |
| E151 | brilliant black | black | synthetic | sweets, caviar |
| E160a | carotene | orange | natural | sweets, fats |
| E160b | annatto | orange-red | natural (*bixa orellana l.*)[103] | fats |
| E162 | betanin | red | natural | sauces |
| E163 | anthocyanins | different colors | natural | drinks, fruit preserves |

[98] Witold Mizerski „Tablice Chemiczne", Adamantan, Warszawa 2013;
[99] https://www.researchgate.net/publication/274390256_Safe_Food_additives_A_review;
[100] S. Voltolini, S. Pellegrini, M. Contatore, D. Bignardi, P. Minale, *New risks from ancient food dyes: cochineal red allergy*, European Annals of Allergy and Clinical Immunology, 46, 6 2014;
[101] https://www.independent.co.uk/life-style/food-and-drink/news/food-agency-calls-for-ban-on-six-artificial-colours-807806.html;
[102] https://stalowezdrowie.pl/e133-czyli-blekit-brylantowy-fcf-co-musisz-o-nim-wiedziec/;
[103] A. Satyanarayana, P. G. Prabhakara, D. G. Rao, *Chemistry, Processing and Toxicology of Annatto (Bixa orellana L.)*, Journal of Food Science and Technology, 40, 2 2003.

## Ex. 6.1. Curcumin

Curcumin is obtained from the rhizomes of *Curcuma longa,* known as turmeric or Indian saffron. It has anti-inflammatory, anti-cancer, antioxidant and antibacterial properties. Curcumin constitutes approximately 10% of the weight of dried turmeric. It is added to many food products. The table below sets limits for curcumin when used in selected foods[104].

| product | coloring content |
|---|---|
| desserts and other dairy products | 150 mg/kg |
| mustard | 300 mg/kg |
| soup | 50 mg/kg |
| sausages, pâtés | 20 mg/kg |
| candied fruit | 200 mg/kg |
| ice cream | 150 mg/kg |
| pastries, cookies | 200 mg/kg |
| fish paste | 250 mg/kg |

Imagine that you are working in an ice cream factory and would like to launch a new product - mango and turmeric ice cream. In your factory, the amount of mixture prepared in a huge container is 450 kg. What is the maximum number of - teaspoons, spoons and cups of turmeric that can be added to it (conversion factors can be found in section 6.1)?

Present your calculations.

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[104] S. Przybylska, *Kurkumina – prozdrowotny barwnik kurkumy*, Problemy Higieny i Epidemiologii, 96, 2 2015.

## LAB. 6.2. COLORS OF CURCUMIN

Can curcumin only be yellow? Use your knowledge and skills (subsection 2.4) and check whether the color changes depending on the pH of the solution.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.

Note down your observations.

Draw conclusions.

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## EX. 6.2. COLORS IN CANDIES

A lot of food colorings can be found in sweets, especially colorful candies. One example of such a label can be found below (Fig. 6.1).


Fig. 6.1. Food product label.[105]

List down the names and numbers (Exxx) of colorings that can be found in candies.

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## EX. 6.3. COLORINGS IN FOOD PRODUCTS

Analyze the labels of five food products you really like and find natural colorings used in the production process (at least one in each product). Complete the table below.

| food product | natural colorings | |
|---|---|---|
| | numbers (Exxx) | names |
| | | |
| | | |
| | | |
| | | |
| | | |

[105] Figure source: https://community.kidswithfoodallergies.org/blog/how-to-read-Halloween-candy-allergen-labels.

## 6.3. KITCHEN EXPERIMENTS

The kitchen is an unusual place – full of different substances inspiring for not only experienced scientists but also those who are new to this field.

### LAB. 6.3. THE BEST RAISING AGENT

Check which of the raising agents (also known as leavens or leavening agents) will be the best for your favorite cake (it can be the same cake as in the subchapter 6.1). Use, for example, baking soda, baking powder or the so-called ammonia (ammonium bicarbonate). Analyze the labels of the raising agents available

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.

Note down your observations and add your photos.

Draw conclusions.

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## LAB. 6.4. THE BIGGEST DRAGON

Below is a recipe for making the chemical dragon, but the ratio between baking soda and powdered sugar has not been disclosed by the author. Adjust the proportions in such a way that the dragon will grow as large as possible. Use your previous experimental experience from this chapter.

MATERIALS AND CHEMICALS

- ✓ gloves and safety glasses,
- ✓ baking tray,
- ✓ urine container,
- ✓ three plastic spoons,
- ✓ mortar,
- ✓ matches,
- ✓ powdered sugar,
- ✓ baking soda,
- ✓ denatured alcohol (highly flammable liquid and vapor, irritating to eyes),
- ✓ ash.

PROCEDURE

1. Using a teaspoon, apply a thin layer of ash onto the baking tray.
2. In a mortar, crush baking soda with powdered sugar. Put this mixture into the urine container and shake it to aerate it.
3. Form a volcanic cone from the mixture of baking soda and powdered sugar, and then cover it with denatured alcohol.
4. Set denatured alcohol on fire.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations and add your photos.

Draw conclusions.

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Now, make another dragon for the best composition you have worked out, but this time without ash. Write down your observations and think about the role of ash in this experiment.

Note down your observations.

What is the role of ash?

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## LAB. 6.5. YO-YO

Yo-yo is one of the best known and most commonly conducted chemical experiments. A typical procedure for preparing it is as described below.

MATERIALS AND CHEMICALS

- ✓ a tall glass vessel, e.g. a tall glass or a tall jar,
- ✓ glass,
- ✓ pipette,
- ✓ oil,
- ✓ baking soda,
- ✓ vinegar,
- ✓ dye.

PROCEDURE

1. Put baking soda into a tall glass vessel so that it covers the bottom.
2. Pour the oil gently onto the side of the tall glass vessel so that it slowly flows down.
3. Pour vinegar into an empty glass, add some dye and let it dissolve.
4. Add a mixture of vinegar and dye to the tall glass vessel with a pipette.

Your task is to prepare your own colorful yo-yo. You can use a variety of food colorings (subchapter 6.2) or pH indicators (subchapter 2.4). Instead of vinegar, you can use, for example, lemon or citric acid.

Plan activities. Write down the steps that you will follow.

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Complete the task as planned.

Note down your observations and add your photos.

Draw conclusions.

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Why, in your opinion, is this experiment called *Chemical yo-yo?*

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Why does the *Chemical yo-yo* work?

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## LAB. 6.6. THE BEST DESCALER

Any appliances, devices and vessels that use water, such as a kettle, over time get covered in limescale. If we do not remove it – it will clog the pipe over time.

*What is the composition of the limescale?* It depends on the composition of the water, but there are always calcium and magnesium compounds in it, and when the limescale is yellowish - also iron. These are mainly carbonates.

*So how do you remove the limescale from the kettle?* In order to descale a kettle you have to use an acid that is stronger than a carbonic acid that would displace carbon dioxide from the limescale. For this purpose, you can use citric acid, vinegar (10% acetic acid solution) or boric acid (available in the pharmacy). You can also use a commercially available descaler.

Compare the effect of using these acids with that of a descaler purchased in the store. Also, analyze the label of the product that has been purchased.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations and add your photos.

Draw conclusions.

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## LAB. 6.7. SWEETNESS OF SWEETENERS

Traditionally, in Poland, white sugar – sucrose – is what is used for sweetening food products. Increasingly, however, other sweeteners are also used for this purpose, e.g. glucose, fructose, xylitol or erythritol.

Compare the sweetness of the tested sweeteners - choose only two of them.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.

Note down your observations.

Draw conclusions.

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Compare the results you have obtained with the literature data - cite the source.

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## 6.4. LIQUIDS, COHESION AND STATISTICS

Think about five different liquids:

- water,
- ethanol,
- olive oil,
- gasoline,
- honey.

What are the similarities and differences between them?

| similarities | differences |
|---|---|
| | |

Define the liquid state of matter.

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Did you know that: **LIQUIDS = FLUIDS + GASES?**

What are the similarities and differences between gases and liquids?

| similarities | differences |
|---|---|
| | |

**Liquids** have a number of properties that make them different from both solids and gases. Those properties include: **viscosity** (fluid friction), **surface tension**, and **vapor pressure**.

## LAB. 6.8. GLYCERIN, WATER AND ETHANOL

Try to predict how many drops of water, glycerin and pure ethanol can be applied to a coin on the 'tail side' so that the liquids do not flow off.

Ask a research question.

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What are your best guesses – write down the hypotheses.

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Write down all the materials and chemicals you are going to use.

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Chemicals

| water | ethanol | glycerin |
|---|---|---|
| characterize properties of the substances | | |
| | | |

Take measurements for 5 series and save the results.

- Take measurements in the following order:
  - water, then
  - ethanol, and finally
  - glycerin.
- After each measurement, rinse the coin with water and then thoroughly wipe it with a paper towel.

Note down the results.

| **substance** | **water** | | | | |
|---|---|---|---|---|---|
| measurement no. | 1 | 2 | 3 | 4 | 5 |
| result | | | | | |
| substance | ethanol | | | | |
| measurement no. | 1 | 2 | 3 | 4 | 5 |
| result | | | | | |
| substance | glycerin | | | | |
| measurement no. | 1 | 2 | 3 | 4 | 5 |
| result | | | | | |

Conduct a basic statistical analysis. Calculate the mean, median, mode, standard deviation and range.

| | **mean** | **median** | **mode** | **deviation** | **range** |
|---|---|---|---|---|---|
| water | | | | | |
| ethanol | | | | | |
| glycerin | | | | | |

Fill in the table.

| **Chemical formula** | **water** | **ethanol** | **glycerine** |
|---|---|---|---|
| molecular | | | |
| structural | | | |
| semistructural | | | |

**Conclusions and verification of hypotheses**

Before writing conclusions, search for the definitions of: viscosity, density, cohesion strength and surface tension – look for the meanings of these words/terms on the Internet.

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## FORMULAS AND CONCEPTS TO BE USED

**MEAN**

To calculate the **mean** we have to add all the results to each other (from $a_1$ to $a_n$) and then divide the sum by the number of these results.

Mean M of n results: $a_1$, $a_2$, $a_3$…….$a_n$:

$$M = \frac{a_1 + a_2 + a_3 + \cdots + a_n}{n}$$

**MEDIAN**

The median divides all our observations into two equal in number: results lower than the median and results higher than the median. In other words, the median value indicates that half of our results are below the median value and the other half is above the median value.

So if we have 5 results arranged from the smallest to the largest, the median will be the result number 3.

**MODE**

The mode belongs to the group of central measures. It describes the most common value in the data set. If two values appear equally often, both are the mode.

**RANGE**

To calculate the range, find the highest and lowest value in the collected set of results and subtract the lowest from the highest value. The range cannot be a negative number.

The formula for the R range is:

$$R = X_{max} - X_{min},$$

where:

R – range,

$X_{max}$ – the highest value in the set,

$X_{min}$ – the lowest value in the set.

**DEVIATION**

How to understand the **deviation**?

The higher the value of the standard deviation, the more observed values are distant from the average. The smaller the value, the more concentrated they are around the average. For example, each of three populations: {0,0,10,10}, {5,5,5,5}, {4,4,6,6} has an average of 5. Their standard deviations are 5, 0 and 1 respectively. The last one, i.e. the third population, has a much lower standard deviation than the others, because the values of its elements are close to 5.

The standard deviation is calculated according to the formula:

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - x_m)^2}{n\,(n-1)}}, \text{ where:}$$

S – standard deviation

$\sum_{i=1}^{n} ()^2$ – sum of values in brackets (from the first, i = 1, to the last, i = n).

$x_i$ – successive values of a given random variable in the sample,

$x_m$ – sample mean,

n – number of measurements.

The final result can be presented in the following form: $X = x_m \pm S$.

Example of deviation calculation for the first group: {0, 0, 10, 10}:

$$S_1 = \sqrt{\frac{(0-5)^2 + (0-5)^2 + (10-5)^2 + (10-5)^2}{4}} = \sqrt{\frac{25+25+25+25}{4}} = \sqrt{25} = 5$$

Sometimes it is useful to make a table:

| $x_i - x_m$ | $(x_i - x_m)^2$ | $\sum_{i=1}^{n} (x_i - x_m)^2$ | $\frac{\sum_{i=1}^{n} (x_i - x_m)^2}{n}$ | $\sqrt{\frac{\sum_{i=1}^{n} (x_i - x_m)^2}{n}}$ |
|---|---|---|---|---|
| $0 - 5 = -5$ | $(-5)^2 = 25$ | | | |
| $0 - 5 = -5$ | $(-5)^2 = 25$ | | | |
| $10 - 5 = 5$ | $(5)^2 = 25$ | | | |
| $10 - 5 = 5$ | $(5)^2 = 25$ | 25 + 25 + 25 + 25 = 100 | 100 : 4 = 25 | $\sqrt{25} = 5$ |

## COHESION, ADHESION AND VISCOSITY[106]

### Cohesion

*If you have ever used oil for cooking or working on a car, you know that it is nice and slippery. That is probably why you used it: it keeps stir-fry pieces from sticking to each other or the pan, and it helps engine pistons and other moving parts slide easily.*

*One of the reasons oils are good for these applications is because they have low cohesion: the liquid molecules don't interact particularly strongly with each other because the intermolecular forces are weak. The primary intermolecular forces present in most oils and many other organic liquids – liquids made predominantly of carbon and hydrogen atoms, also referred to as non-polar liquids – are London dispersion forces, which for small molecules are the weakest types of intermolecular forces.* ***These weak forces lead to low*** *cohesion. The molecules do not interact strongly with each other, so they can slide right past one another.*

*On the other end of the cohesion spectrum, consider a dewdrop on a leaf in the early morning. How can such a thing exist if, as explained earlier, liquids flow and take the shape of the container holding them? As described above and in the Water module, water molecules are held together by strong hydrogen bonds. These strong forces lead to high cohesion: The water molecules interact with each other more strongly than they interact with the air or the leaf itself. (The interaction of the water with the leaf is an example of adhesion, or the interaction of a liquid with something other than itself; we will discuss adhesion in the next section.) Due to the fact that the cohesion of water is strong, the molecules form a spherical shapes to maximize their interactions with each other.*

*This* ***strong*** *cohesion* ***also creates*** *surface* ***tension****. You may have noticed insects walking on water on an outdoor pond, or seen a small object such as a paperclip resting on the surface of water instead of sinking; these are two examples of the surface tension of water in action. Surface tension results from strong cohesive forces of some liquids. These forces are strong enough to be maintained even when they experience external forces like the gravity of an insect walking on its surface.*

### Adhesion

***Adhesion is the tendency of a compound to interact with another compound.*** *(Remember that, in contrast, cohesion is the tendency of a compound to interact with itself.) Adhesion helps to explain how liquids interact with their containers and with other liquids.*

*An example of such an interaction with high adhesion is the one between water and glass. Both water and glass are held together by polar bonds. Therefore, the two materials can also form favorable polar interactions with each other, leading to high adhesion. You may have even seen these attractive adhesive forces in action in the lab. When water is in a glass graduated cylinder, for example, the water creeps up the sides of the glass, creating a concave curve at the top called a meniscus, as shown in the figure below. Water in graduated cylinders made*

[106] R. Bernstein, A. Carpi, *Properties of Liquids,* Visionlearning CHE-3, 5 2015.

*out of some types of non-polar plastic, on the other hand, forms a flat meniscus because there are neither attractive nor repellant cohesive forces between the water and the plastic.*

**Viscosity**

*Consider the ease with which you can pour yourself a glass of water, as compared to the relative challenge of pouring thick, slow-moving motor oil into an engine. The difference is in their viscosity, or resistance to flow. Motor oil is quite viscous; water, not so much so. But why?*

*Before we dive into the differences between water and motor oil, let's compare water with another liquid: pentane ($C_5H_{12}$). While we don't think of water as viscous, it is actually more viscous than pentane. Remember, water molecules form strong hydrogen bonds with each other. Pentane, on the other hand, made up of just hydrogen and carbon atoms, is nonpolar, so the only types of intermolecular forces it can form are London dispersion forces which are relatively weak. Weaker intermolecular forces mean that the molecules can more easily move past each other, or flow – hence, lower viscosity. But both water and pentane are relatively small molecules. When we are looking at liquids made of up of bigger molecules, size comes into play as well. For example, compare pentane with motor oil, which is a complex mixture of large hydrocarbons - much larger than little pentane – and some with dozens or even hundreds of carbons in a chain. If you have ever poured motor oil into an engine, you know it is pretty viscous. Both liquids are nonpolar and as a result, have relatively weak intermolecular forces; the difference is the size. The big, bendy motor oil hydrocarbons can literally get tangled with their neighbors, which slows down the flow. It is almost like a pot of spaghetti: If you do not prepare it correctly, you can end up with a blob of tangled noodles that are very difficult to serve because they are all sticking together – in a sense, it is a viscous pasta blob. Shorter noodles – or smaller molecules – do not get tangle so much, so they tend to be less viscous (Fig. 6.2).*

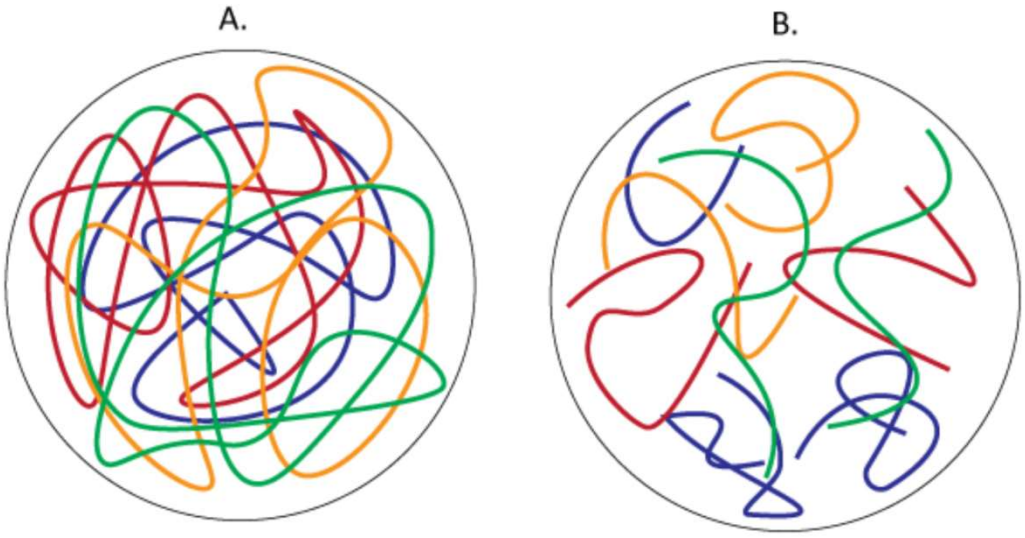


Fig. 6.2. Group A consists of large molecules in a tangled blob (a viscous liquid) and Group B consists of smaller molecules with fewer entanglements (a less viscous liquid).

*Returning to our original comparison of motor oil versus water, even though water has such strong intermolecular forces, the much larger size of the molecules in the motor oil makes the oil more viscous.*

# CHAPTER 7. WE LIVE IN A WORLD OF FABRICS

## 7.1. FIBERS. TEXTILES AND THEIR PROPERTIES

Clothing is an integral part of our lives. The basic units of raw material used in clothing industry are fibers. Fibers from which threads are made, are used for making fabrics and other production materials. Clothing can also be made directly from fibers.

Answer the questions

1. What are the main functions of clothing?

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2. Is it the clothing that makes us feel warm? Why do we feel warm when we get dressed?

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3. Why do we feel cold in wet clothes?

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4. Why do some types of clothing materials get wet from the inside while being used?

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5. Why should we wear light-colored clothes on sunny days?

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6. What are the features of a hygienic clothing material?

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**FIBERS**

The fibers are classified according to their origin - there are two basic groups: natural fibers and chemical fibers (Figure 7.1).

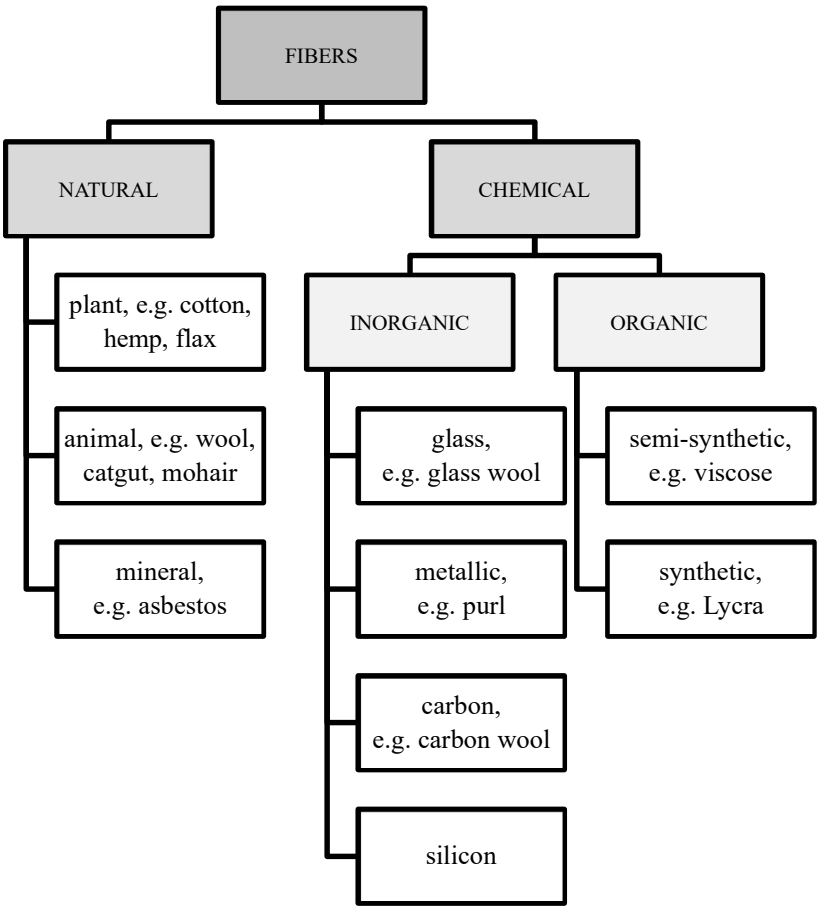


Fig. 7.1. Classification of fibers.

**Natural fibers** may be divided into three main groups – animal, plant and mineral fibers.

PLANT FIBERS

Plant fibers are made of different parts of plants: seeds (coconut), stems (flax, hemp, jute), leaves (sizal) and fruit (cotton – Figure 7.2). They consist mainly of cellulose and they are resistant to moisture and temperature - they withstand the temperatures of up to 165°C.

Plants that play the most important role in clothing industry are cotton and flax.


Fig. 7.2. Cotton fibre pictogram.[107]

[107] Figure source: https://www.freepik.com/free-vector/grunge-cotton-logo_760178.htm

**Cotton fibers**

- The length of cotton fibers ranges from 8 to 60 mm. The fibers are very thin. The thinner the fiber, the better the parameters of a thread obtained from it will be. The textile made of thin thread will be thin and strong.
- Cotton fibers have high tensile strength, especially when wet. Fabrics obtained from high-quality cotton do not get crumpled easily.
- Woven cotton fabrics have good insulating properties - they have high thermal insulation – they give a feeling of warmth when touched.
- At increased humidity (over 65%), cotton contains about 25% water. Despite this, it does not feel wet. Therefore, cotton is used for the production of underwear and other clothes that have direct contact with human skin.
- Cotton is hygroscopic and can be made wet easily. As a result, dyeing it is fairly simple and it is easy to remove dirt while washing.
- Because of their thinness, cotton fibers are nice and soft to touch (Fig. 7.3).



Fig. 7.3. Cotton textile texture.[108]

**Flax fibers**

- Linen fibers are very durable. Their strength increases after getting wet.
- The fibers are very stiff and not very flexible. Therefore, linen fabrics tend to crease and it is difficult to iron out creases and wrinkles.
- Linen has poor thermal insulation properties, hence the characteristic feeling of cold when you touch it.
- The fibers are highly hygroscopic. They can absorb water up to 25% of its mass. Water quickly spreads over the textile surface, which makes the drying process easier due to faster evaporation of water. Therefore, wipes, bedding, towels and clothing fabrics are often produced from linen.
- Fabrics made of linen have good hygienic properties – they get dirty more slowly than cotton and are easy to wash.
- Linen is not as nice to touch as cotton. Due to the specific fiber structure, the yarn is characterized by thickening and granular surface (Figure 7.4).

Fig. 7.4. Linen textile texture.[109]

[108] Figure source: https://www.freepik.com/free-photo/abstract-white-canvas-textures-surface_4202461.htm;
[109] Figure source: https://www.freepik.com/free-photo/sackcloth-texture-background_1246206.htm.

ANIMAL FIBERS

The animal fibers can be divided into two main groups – mammalian hair and secretions of some arthropods (e.g. insects or spiders) and bivalve mollusk. They are made of proteins – creatine (hair) and fibroine and sericin (silk). Therefore, they are not very resistant to high temperatures – long-term heating at a temperature of about 100°C causes damage to wool, and 140°C – silk. Neither are animal fibers resistant to alkaline solutions, especially at higher temperatures as such exposure causes hydrolysis of wool fiber proteins. Similarly, wool can be damaged by active oxygen which is produced during washing in solutions containing chemical bleachers.

**Ex. 7.1. pH AND COTTON**

Check the pH of different washing product solutions. Write down which of them could be used to wash a cotton sweater and which of them could be damaging for a woolen one.

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**Sheep's wool**

Fabrics and knitted fabrics made of wool that meet the quality requirements specified by International Wool Secretariat shall be marked with the Woolmark sign – Industry trade mark owned by Australian Wool Innovation Limited (Fig. 7.5).


Fig. 7.5. Clothing label with the Woolmark logo.[110]

- The natural hair of the sheep is covered with wool wax (or wool grease) containing lanoline.
- The fiber has a cylindrical shape, with three layers in it. The fibers are not straight, but they bend into sinus-like forms (they are called crimps). The thinner the fiber is, the more crimps there are per unit length. This increases the volume of air contained in the fiber, which improves its thermal insulation properties.
- Wool fibers are less tensile than cotton ones. These fibers, however, have a great ability to extend when stretched (up to 70% if the fiber is wet). Wet wool can, however, permanently be deformed by load.

[110] Figure source: https://eurowolle.pl/wp-content/uploads/2014/10/wszywka_metka_z-numerem_licencji_woolmark_symbolami_konserwacji_produktow_z_czystej_zywej_welny_znakiem_CE-980x312.jpg.

**Natural silk**

- Natural silk is the thinnest known natural fiber. As a result, it is possible to produce very thin fabrics with a shiny surface.
- Silk is extremely resilient so when after folding, it regains its original look quickly.
- It is characterized by lower thermal insulation than wool.
- It is hygroscopic - it can absorb up to 30% of water without making the impression of being wet.

**Chemical organic fibers** may be divided into two main groups: **semi-synthetic** and **synthetic** fibers.

**SEMI-SYNTHETIC ORGANIC FIBERS**

They are produced from naturally occurring polymers, e.g. proteins - casein, soy proteins (e.g. Lanital, Wipolan), polysaccharides - cellulose (e.g. viscose) or rubber (e.g. Elaston).

**CELLULOSE FIBERS**

- Cellulose fibers include: viscose fiber (viscose silk), cupro fiber and acetate fiber (acetate silk).
- Viscose fiber belongs to the cheapest and **most widespread fibers in the world**. It is mainly produced from wood cellulose.
- Cellulose fibers have a low tensile strength that drops significantly when they are wet.
- They are generally not very flexible.
- They are characterized by high hygroscopicity.
- The color of the fibers is almost white but can take any color if dyed.

## LAB. 7.1. UNIQUE BUTTONS

Galalith, also known as the artificial horn, is a semi-synthetic organic fiber made from casein, a protein found in cow's milk. Enzymes or acids cause precipitation[111], while immersion in formalin for a long time - hardening of the obtained fiber. Galalith products can be dyed easily into any color. Galalith was used in the production of buttons, buckles or toiletries, and many more.[112]

List down the features of material that can be used for the production of buttons.

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Make your unique buttons[113] and check if you have achieved the features that you have listed above. Use different types of milk, different types of vinegar and different proportions of milk to vinegar.

MATERIALS AND CHEMICALS

- ✓ milk (various types),
- ✓ dyes, e.g. food colorings,
- ✓ vinegar (various types),
- ✓ pot,
- ✓ strainer,
- ✓ paper towel,
- ✓ spoon.

[111] https://encyklopedia.pwn.pl/haslo/galalit;3903627.html;
[112] http://plastiquarian.com/?page_id=14228;
[113] https://www.youtube.com/watch?v=VFvik_THcNQ.

PROCEDURE

1. Heat the milk (it should be warm, but it should not be boiled. You can add a dye.
2. Add vinegar and stir.
3. When curds appear, filter the mixture through a strainer.
4. Crush the curds, dry on a paper towel.
5. Give the buttons a unique shape.
6. Put in a warm place and dry.

Ask a research question.

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Write down the hypothesis

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Plan activities. Write down the steps that you will follow.

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Complete the task as planned.

Note down your observations

Draw conclusions:

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## LAB. 7.2. THE FIBER FROM THE PHOTOGRAPHIC FILM

In today's era of ubiquitous digital technology, few artists use photographic films. However, they are a fantastic source of cellulose acetate for the production of acetate silk.

Make acetate silk[114]. Check that the obtained fiber has the characteristics attributed to cellulose fibers written above, i.e. poor strength, low and high hygroscopicity.

MATERIALS AND CHEMICALS

- ✓ syringe with plunger,
- ✓ a rectangular glass tube,
- ✓ knife,
- ✓ glass bowl,
- ✓ spoon,
- ✓ a source of warm air,
- ✓ photographic film,
- ✓ acetone,
- ✓ water.

PROCEDURE

1. Put on the gloves and safety glasses.
2. Pour water into a bowl and soak the photographic film in it.
3. When the membrane swells, scrape off the surface layer. Pour out the water.
4. Pour some acetone into a bowl, put in a membrane and stir. Dense pulp should form in the bowl.
5. Remove the plunger from the syringe, insert the pulp into the syringe and insert the plunger.
6. Push the pulp slowly over the source of warm air, while winding the rising thread onto the glass tube.

Note down your observations.

Draw conclusions.

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[114] E. Grosse, Ch. Weissmantel, *Z chemią za pan brat*, Warszawa: Państwowe Wydawnictwo „Iskry" 1963.

**SYNTHETIC ORGANIC FIBERS**

They are produced from polymers obtained as a result of the organic synthesis. The categories of fibres according to the type of chemical compounds they were produced from can be found in the Figure 7.6. Their characteristic feature is that they have a predetermined cross-section with the help of which you can get changes in parameters, such as strength, extensibility or gloss. Their characteristic features are:

- high elasticity,
- high tensile strength,
- chemical resistivity.

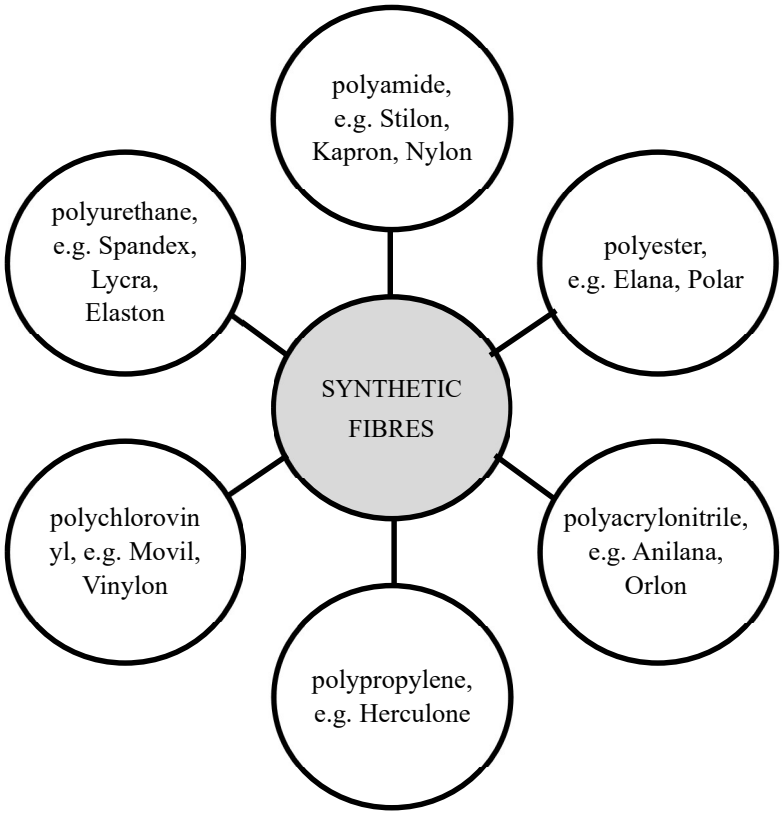


Fig. 7.6. Main groups of synthetic fibers.

**TEXTILES**

**Thread** - a linear textile product in the form of a continuous fiber - also known as silk (can be natural, artificial and synthetic); made of composite fibers – yarn.

**Clothing textile** – a flat product, thickness of which is very small comparing with its length and width. It can be made from:

- fibers (e.g. cotton wool, felt, nonwovens) or
- threads (e.g. textiles, knitwear, braids, grid, tulles).

**Fabric** - a flat product created in the process of weaving on a loom, consisting of a system of two threads - warp and weft. The warp and weft are intertwined to form a weave.

Basic types of fabrics:

- cotton and cotton-like,
- of pure cotton, of cotton mixed with viscose or synthetic fibers, e.g., lawn, zephyr, calico, mole, bark, denim, texas, velveteen,
- wool and wool-like,

- of yarn – made of pure wool, or wool combined with Elana, Argona, Anilana, pure Anilana e.g. a panama, georgette (georgette), crepe, cashmere, flannel, tweed, fleece, velor, cloth, mohair,
- silk and silk-like, natural silk (young), most of viscose, acetate, Stilon, Torlen and their blends e.g. Chiffon (chiffon), foulard, georgette (georgette), satin, taffeta, rep, damask, glitter.

**Clothing products** - clothes, which are: covers, clothing, personal underwear, headwear, hand cover tip. They are made of fabrics, knitted fabrics, yarns, nonwovens, braids, furs, hides and other raw materials.

The main roles of clothing may be:

- protection of the human body,
- ensuring well-being,
- ensuring hygiene and health,
- aesthetic and social functions.

## 7.2. How to choose the right clothing textile?

The clothes we wear should be primarily adapted to the temperature of the environment and the season. We warm up the clothes with the heat that our body produces. We emit about 3,000 kcal of energy in the form of heat per day. The temperature of the human body averages around 37 degrees Celsius. We continuously emit excess heat produced by the body. However, if it is too cold, the clothing allows you to keep some of the heat you produce.

Fabrics are usually bad heat conductors. Why do you think it is the case? Write down your answer below.

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A sweatshirt made of which fabric would you wear on a hot day: flax or sheep's wool? Justify your choice.

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The air is a very bad heat conductor. Therefore, the more free space for air in the fabric, the better it isolates us from the environment. The best heat is kept by fluffy angora sweaters and camel wool. Flax, silk and cotton keep the heat much less. These fabrics also absorb moisture well. The water fills up the space taken previously by air and makes it easier for the heat to escape from the surface of the skin.

Clothing should be light and must not restrict movement. The amount of clothes worn by a man in the summer can reach up to 5% of his body weight, and in winter even up to 10%. When it comes to women, the figures are significantly lower - for example, in the summer this weight of clothes is only less than a percent of the woman's weight.

### Ex. 7.2. Weight of clothes

Use a kitchen scale. Take off your clothes and weigh them. What percentage of your body weight is your clothing? Write the calculation and your result below.

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To choose the right fabric to produce clothing one has to take into account a wide range of textile properties:

1. A wide range of **technological properties** of the material, thanks to which it can be used for production, e.g.

- length, width, thickness,
- density,
- texture of the fabric;

2. Properties that are the most important when it comes to the use of clothing:

a. hygienic

- water vapor permeability,
- air permeability,
- thermal insulation,
- the ability to receive and remove dirt;

b. aesthetic

- crumpling,
- contractility,
- durability of coloring,
- bruising,
- strength,
- flexibility and resistance to deformtion,
- abrasion resistance;

c. confection

- stiffness, ductility,
- lubricity,
- thickness and density,
- tendency to fray,
- thermal properties.

Find definitions of the following terms in a dictionary and write them below.

**texture**

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**permeability**

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**abrasion**

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**lubricity**

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**density**

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## LAB. 7.3. RIGHT FABRICS

Your task will be to examine a series of fabrics and the selection of fabrics suitable for the following products: umbrellas, shopping bags, underwear and jackets.

Ask research questions.

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What is your best guess – write down the hypothesis.

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MATERIALS AND CHEMICALS

- ✓ pieces of different fabrics,
- ✓ water,
- ✓ body oil,
- ✓ copper sulphate,
- ✓ Pasteur pipets,
- ✓ syringes,
- ✓ jars,
- ✓ jar lids,
- ✓ some plastic cups,
- ✓ scissors,
- ✓ paper towel,
- ✓ duct tape,
- ✓ kettle,
- ✓ thermometers,
- ✓ gas burner,
- ✓ laboratory scale,
- ✓ rubber bands.

PROCEDURE

List down all the textile properties you want to analyze. Write down all the steps you are going to follow.

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Characterize the independent variables.

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Characterize the dependent variables.

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Characterize the controlled variables.

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Draw a diagram of the experiment setup.

Note down the results.

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Draw conclusions.

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## 7.3. HOME STAIN REMOVAL METHODS

As we all know, stains always happen in the least appropriate moment, for example during a dinner in a restaurant and they damage things that we cherish most, e.g. a unique blouse brought back from vacation in a distant corner of the world.

How to try to get rid of stains before using chemical means to remove them? This, unfortunately, depends on what caused the stains and what kind of fabric has been stained. However, there are several universal ways:[115]

1. Stains should be removed as soon as possible.
2. Stains from liquids should be dried first.
3. Stains from food should first be delicately scraped with a knife.
4. Stains that are not greasy, should be soaked in cold water.
5. The stain should always be rubbed on the left side of the fabric.

Ways of dealing with some common types of stains:[116]

**Food stains:**

Stain from coffee or cocoa – the fabric should be rubbed in hot water, and in case of failure - rub with a mixture of vinegar and glycerin, and wash with alcohol.

Stain from butter – the fabric should be washed in very hot water.

Milk stain - the fabric should be washed in warm soapy water or cleaned with gasoline.

Stain from fruit should be rubbed with salt, rinsed with cold water, soaked in detergent and finally washed in hot water.

Stain from the wine should be rubbed with salt and then soaked in cold water for half an hour.

**Other stains:**

Stain from blood - the fabric should be soaked in cold salted water and then washed in lukewarm water with vinegar.

Stain from ink should be rubbed with salt then sprinkled with citric acid, lemon or sour milk. For stains on more delicate materials, use warm milk. The ink stain should be wiped several times with alcohol and the fabric rinsed or ventilated.

The stain of iodine should be rubbed with a cloth soaked in a solution of sodium thiosulphate, and then rinsed with cold water (sodium thiosulfate is found in hand warmers and dechlorinators for water in ponds and aquariums).

Stain from rust should be treated with lemon juice and left for about an hour.

Stain from the grass should be removed with alcohol and rinsed with water.

If you know any other home remedies to get rid of stains, enter them below.

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[115] B. Philips, *ABC gospodarstwa domowego. 4000 porad*, Warszawa: Agencja Muza 1991;

[116] E. Praska *Poradnik domowy na co dzień*, Warszawa: Wydawnictwo Przemysłu Lekkiego i Spożywczego 1956.

## LAB. 7.4. LIKE SHERLOCK HOLMES...

You have just got dirty trousers from a friend asking you for help in cleaning them. Unfortunately, you do not have chemical stain removers and you do not know what the stain was caused by. On the basis of its appearance, however, you can try to guess what has been spilled onto the fabric. Look carefully at the stain and try to suggest a way of getting rid of it.

Ask a research question.

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Write down the hypothesis.

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.

Note your observations.

Draw conclusions.

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## LAB. 7.5. THE BEST DETERGENT

You have various detergents, e.g. washing liquid, washing powder, laundry soap, detergent and pieces of different fabrics with the same stains. Check which of the detergents will be the most effective. You can also use an optical brightener*.

*Optical brighteners do not remove stains, they only absorb invisible UV radiation and emit radiation in the visible spectrum.

Ask a research question.

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Write down the hypothesis

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations.

Draw conclusions.

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## LAB. 7.6. INFLUENCE OF TEMPERATURE AND AMOUNT OF DETERGENT ON STAIN REMOVAL EFFECTIVENESS

Based on the results of previous experiments, select one type of stain, one detergent and one fabric. Prepare pieces or fabrics with stains (all pieces of the fabric and all stains should have the same size). Check the effect of the amount of detergent and temperature on the effectiveness of getting rid of stains.

Ask a research question.

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Write down the hypothesis

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Plan activities. Write down the steps that you will follow.

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Write down all the materials and chemicals you are going to use.

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Complete the task as planned.
Note down your observations

Draw conclusions.

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# BIBLIOGRAPHY AND SOURCES

**(Accessed August 2019)**


**About the project**

1. Report: *Laboratorium myślenia. Diagnoza nauczania przedmiotów przyrodniczych w Polsce 2011-2014*;
2. M. Jędrzejczyk, *Motywacja w procesie edukacyjnym*, Centrum Kształcenia Praktycznego w Radomsku, J. Madalińska-Michalak, *Pasja w pracy nauczycieli osiągających sukcesy zawodowe a potrzeba rozwijania ich kompetencji emocjonalnych*, ROZPRAWY, Studia z Teorii Wychowania, VII: 2016 4(17).

**Chapter 1**

3. W. Mizerski, ABC ucznia. *Matematyka, fizyka, chemia,* Warszawa: Adamantan 2008;
4. G. Kiru, C. Bicknell, E. Falaschetti, J. Powell, N. Poulter, *An evaluation of the effect of an angiotensin-converting enzyme inhibitor on the growth rate of small abdominal aortic aneurysms: a randomised placebo-controlled trial (AARDVARK),* Health Technology Assessment, 20, 59 2016;
5. D. D'Orazio *Cubes of fruits, vegetables, and meats will make you see food in a new light*, The VERGE, May 16, 2015miz;
6. www.followthecolours.com.br/wp-content/uploads/2015/05/follow-the-colours-cubos-alimentos-Lernert-Sander-01.jpg;
7. https://66.media.tumblr.com/74c6cdebade475b67f105de5c30d139a/tumblr_mp0dalWV8H1qzs7m3o1_500.jpg;
8. Jack Guichard: *Observer pour la comprendre: les sciences de la vie et de la terre*, Paris: Hachette, 1998;
9. J. Lilpop, M. Zachwatowicz, Ł. Banasiak, M. Chrzanowski, P. Bębas, *Jak przygotować pracę badawczą na Olimpiadę Biologiczną? Poradnik*, Edukacja Biologiczna i Środowiskowa, 2 2017;
10. = 9;
11. T. Kotarbiński. Dzieła wszystkie. *Elementy teorii poznania, logiki formalnej i metodologii nauk*. Kraków: Ossolineum 1990;
12. https://pl.freepik.com/darmowe-zdjecie/close-up-z-nasion-kwitnacych_966474.htm;
13. E. B. Wilson, *Wstęp do badań naukowych,* Warszawa: Państwowe Wydawnictwo Naukowe 1964;
14. 1. M. M. Chrzanowski et. al., *Vernacular Misconceptions in Teaching Science – Types and Causes*, Turkish Journal of Science Education, 15, 4 2018;
    2. M. Markowska, M. Lechowicz, W. Grajkowski, M. M. Chrzanowski, K. Spalik, J. Borgensztajn, E. B. Ostrowska, M. Musialik, *Błędne przekonania w nauczaniu przedmiotów przyrodniczych*, Edukacja Biologiczna i Środowiskowa, 4 2014;
15. https://images.fineartamerica.com/images-medium-large/boiling-kettle-tek-image.jpg;
16. https://vimeo.com/39374062;
17. Committee on Undergraduate Science Education; Board on Science Education; Division of Behavioral and Social Sciences and Education, *Science Teaching Reconsidered: a Handbook*. Washington: The National Academies Press 1997;
18. D. L. Benson. M. C. Wittrock, M. E. Baur, *Students' preconceptions of the nature of gases*. Journal of Research in Science Teaching, 30, 6 1997;
19. A. Hussain, S. Ali, M. Ahmed, S. Hussain *The Anti-vaccination Movement: A Regression in Modern Medicine,* Cureus, 10, 7 2018;
20. https://alphanewsmn.com/wp-content/uploads/2018/02/media-manipulation.jpg;
21. http://www.wiw.pl/obrazki/fizyka/pict/000010-01.gif;
22. = 14.1.

**Chapter 2**


23. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E;
24. https://news.un.org/en/story/2015/12/519172-sustainable-development-goals-kick-start-new-year;
25. https://cdn.donald.pl/filer_public_thumbnails/filer_public/0c/ae/0caeb01a-b585-4bf9-b1a0-63d4d98bbce6/photo_2019-06-23_113406.jpeg__655x0_q85_crop_subsampling-2_width-655.jpg;
26. https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_heatison_solutionvilleinquirerarticle.pdf;
27. https://youtu.be/BPJJM_hCFj0;
28. https://youtu.be/sTvqIijqvTg;
29. https://footprint.wwf.org.uk;
30. https://www.cog.ca/wp-content/uploads/2018/08/greenhouseeffectfinalcolouring.pdf;
31. *https://www.boredpanda.com/sealed-bottle-garden-david-latimer/?utm_source=google&utm_medium=organic&utm_campaign=organic;*
32. Dovas, BoredPanda Staff, *80-Year-Old Man Hasn't Watered This Sealed Bottle Garden Since 1972 And It's Still Alive.* 2019;
33. https://www.boredpanda.com/author/dovas/?utm_source=google&utm_medium=organic&utm_campaign=organic;
34. S. Sękowski, *Efektowna chemia*, Warszawa: Wydawnictwa Naukowo - Techniczne 1988;
35. Katedra Analityki Medycznej Wydział Nauk Medycznych Uniwersytet Warmińsko-Mazurski w Olsztynie. Badanie Ogólne Moczu, 2015;
36. http://wnoz.uwm.edu.pl/sites/default/files/download/201810/badanie_ogolne_moczu_2015_kamila0.pdf;
37. https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/;
38. https://www.stevespanglerscience.com/lab/experiments/red-cabbage-chemistry.


**Chapter 3**


39. http://www.edu.pe.ca/gulfshore/Archives/ACIDSBAS/phscale2.jpg;
40. *https://encrypted-tbn0.gstatic.com/images?=tbn:ANd9GcRe6J2gbduTMvYPDNnYkRcSjN_qelQU_hdlXyowjvt0LeqHk0uVIw;*
41. https://www.douglas.pl/Beauty%20Around%20the%20World-Marki%20polskie-Perfumy-BOHOBOCO-BOHOBOCO-PERFUME-Sea-Salt-Caramel_productbrand_3000083268.html;
42. https://www.fragrantica.com/;
43. https://bigthink.com/philip-perry/think-you-have-only-5-senses-its-actually-a-lot-more-than-that;
44. A. Gilbert, *What nose knows – the science of scents in everyday life*, New York: Crown Publishers 2008;
45. J. T. Knudsen, L. Tollesten, G. L. Bergstrom. *Floral scent: A checklist of volatile compounds isolated by head-space techniques*. Phytochemistry, 33, 1993;
46. R. Croteau, F. Karp, *Origin of natural odorants. In Perfume: Art, Science and Technology*, P. Muller, D. Lamparsky, eds (New York: Elsevier Applied Sciences) 1991;
47. A. Mesaros, M. Culea, A. Iordache, O. Cozar, *GC-MS Characterization of the Compounds in Some Essential Oil*, Bulletin UASVM Agriculture, 66, 1 2009;
48. A. Mannschrec, E. von Angerer, *The Scent of Roses and Beyond: Molecular Structures, Analysis, and Practical Applications of Odorants*, Journal of Chemical Education. 88, 2011;
49. http://curious-soapmaker.com/alambic-for-making-essential-oils-and-flower-waters.html;
50. https://www.manufakturakosmetyczna.pl/kategoria/14-hydrolaty;
51. W. Mizerski, *Tablice Chemiczne*, Warszawa: Adamantan 2013.

**Chapter 4**


52. A. Gumkowska, *Laboratorium w szufladzie*, Warszawa: Wydawnictwa Naukowe PWN SA 2015;
53. http://krainamydlanychinspiracji.blogspot.com/p/blog-page_29.html;
54. S. Ade, *Self-Sufficiency Soap making*, New Holland, 2009;
55. https://www.rokopro.pl/zwiazki-powierzchniowo-czynne;
56. http://www.mpwik.org/?page_id=174;
57. https://www.mpwik.com.pl/view/twardosc-wody;
58. Ustawa z dnia 13 czerwca 2013 r. o gospodarce opakowaniami i odpadami opakowaniowymi. Dz. U. 2013 poz. 888;
59. https://kclcthomas.wordpress.com/2013/11/page/3/;
60. A. Siporska, M. M. Chrzanowski, *Didactics of Science in International Curricula – Handbook for Students of Biology and Chemistry Faculties of Warsaw University*, Warszawa: SCRIPT s.c. 2017;
61. http://www.bbc.com/news/technology-33344955;
62. https://4.bp.blogspot.com/-HW7g7AA4_9o/WBkpTayLr-I/AAAAAAAAGW4/sbhhqcbs6-crlTReczQQDMUUA2mCYc9ywCK4B/s1600/3773430_orig.jpg;
63. http://www.climateaction.org/news/zara_creates_first_green_clothing_collection;
64. *Life Cycle Assessment of grocery bags*, Environmental Project no. 1985 Ministry of Environment and Food of Denmark;
65. https://www2.mst.dk/udgiv/publications/2018/02/978-87-93614-73-4.pdf;
66. https://www.cleanuptheworld.org;
67. https://pomorska.pl/sprzatanie-swiata-2017-nie-ma-smieci-sa-surowce/ar/12455776;
68. G. Everaert, L. van Cauwenbergheb, M. De Rijckea, A. A. Koelmansc, J. Meesa, M. Vandegehuchtea, C. R. Janssen *Risk assessment of microplastics in the ocean: Modelling approach and first conclusions, Environmental Pollution*, 242, Part B 2018;
69. https://www.adventurescientists.org/microplastics.html;
70. http://pszok.wfosigw.torun.pl/2017/11/26/butelek-pet-wykorzystujesz-ciagu-roku/;
71. http://www.karguii.pl/ekologia.html.


**Chapter 5**


72. Rozporządzenie Ministra Zdrowia z dnia 14 listopada 2008 roku w sprawie kryteriów zaliczenia produktu leczniczego do poszczególnych kategorii dostępności (Dz.U.08.206.1292 z dnia 21 listopada 2008 r.);
73. https://www.gov.pl/web/zdrowie/pozwolenie-na-dopuszczenie-do-obrotu1;
74. D. Lewis, *Aspirin. A curriculum resource for post-16 chemistry courses*, The Royal Society of Chemistry 1998;
75. https://aspirin.pl/static/media/pdf/aspirin-pro.pdf;
76. http://www.chemspider.com;
77. https://www.rd.com/home/decorating/how-to-make-flowers-last-longer/;
78. M. Śmiechowska, M. Cugowska, *Rola Żywności i Żywienia W Chorobie Refluksowej*, Bromatologia i Chemia Toksykologiczna – XLIV, 3 2011;
79. P.-J. Lu, *Gastric juice acidity in upper gastrointestinal diseases*, World Journal of Gastroenterology 21, 16 (43) 2010;
80. https://www.doz.pl/czytelnia/a14360-Naturalne_sposoby_na_zgage;
81. https://www.prawo.pl/zdrowie/suplementy-diety-planowana-zmiana-przepisow,367120.html;
82. https://strefabiznesu.pl/suplementy-diety-juz-co-drugi-polak-spozywa-je-codziennie-czy-to-ma-sens/ar/13578744;
83. Food Supplements Consumer Research, Final Report for Food Standards Agency, May 2018;
84. =83;
85. Instytut Ogrodnictwa, *Wartości odżywcze i zdrowotne owoców i warzyw*, Instytut Ogrodnictwa Skierniewice 2017;
86. https://www.liberaldictionary.com/theine/;

87. R. Siwek, E. Witkowska-Banaszczak, M. Szymański, *Kofeina w lekach i suplementach diety - znaczenie w lecznictwie*, Farmacja polska, 69, 7 2013;
88. =87;
89. https://www.wikiwand.com/pl/Homeopatia;
90. https://i.pinimg.com/originals/d7/5c/6a/d75c6a827b8cba1d57d4b29082362aff.jpg;
91. https://www.aptekawsieci.pl/pl/p/BOIRON-Phosphoricum-acidum-15CH-granulki-4-g/11887;
92. https://www.gov.pl/web/zdrowie/przechowywanie-i-utylizacja-lekow;
93. https://czysta.um.warszawa.pl/documents/10181/0/apteki-11.2018.pdf;
94. T. aus der Beek, F.-A. Weber, A. Bergmann, *Pharmaceuticals in the environment. The global perspective*, GGHH Webinar Series 2016;
95. http://en.sanofi.com/csr/planet/priorities/pharma_environment/pharma_environment.aspx;
96. T. aus der Beek, *Pharmaceuticals in the environment*, Environmental Toxicology and Chemistry, 9999 2016;
97. http://hydro.geo.uni.lodz.pl/index.php?page=zasoby-wodne.

**Chapter 6**

98. W. Mizerski, *Tablice Chemiczne*, Warszawa: Adamantan 2013;
99. https://www.researchgate.net/publication/274390256_Safe_Food_additives_A_review
100. S. Voltolini, S. Pellegrini, M. Contatore, D. Bignardi, P. Minale, *New risks from ancient food dyes: cochineal red allergy*, European Annals of Allergy and Clinical Immunology, 46, 6 2014;
101. https://www.independent.co.uk/life-style/food-and-drink/news/food-agency-calls-for-ban-on-six-artificial-colours-807806.html;
102. https://stalowezdrowie.pl/e133-czyli-blekit-brylantowy-fcf-co-musisz-o-nim-wiedziec/;
103. A. Satyanarayana, P. G. Prabhakara, D. G. Rao, *Chemistry, Processing and Toxicology of Annatto (Bixa orellana L.)*, Journal of Food Science and Technology, 40, 2 2003;
104. S. Przybylska, *Kurkumina – prozdrowotny barwnik kurkumy*, Problemy Higieny i Epidemiologii, 96, 2 2015;
105. https://community.kidswithfoodallergies.org/blog/how-to-read-Halloween-candy-allergen-labels;
106. R. Bernstein, A. Carpi, *Properties of Liquids,* Visionlearning CHE-3, 5 2015.

**Chapter 7**

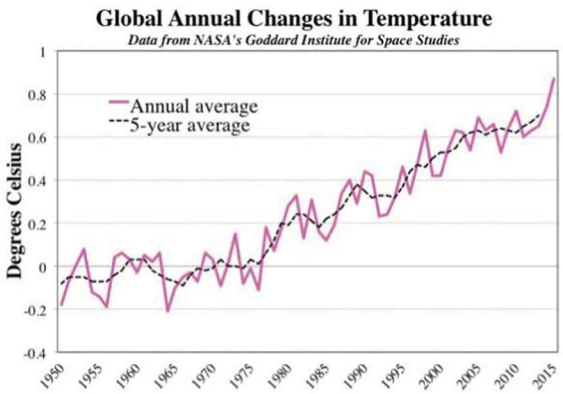
107. https://www.freepik.com/free-vector/grunge-cotton-logo_760178.htm;
108. https://www.freepik.com/free-photo/abstract-white-canvas-textures-surface_4202461.htm;
109. https://www.freepik.com/free-photo/sackcloth-texture-background_1246206.htm;
110. https://eurowolle.pl/wp-content/uploads/2014/10/wszywka_metka_z-numerem_licencji_woolmark_symbolami_konserwacji_produktow_z_czystej_zywej_welny_znakiem_CE-980x312.jpg;
111. https://encyklopedia.pwn.pl/haslo/galalit;3903627.html;
112. http://plastiquarian.com/?page_id=14228;
113. https://www.youtube.com/watch?v=VFvik_THcNQ;
114. E. Grosse, Ch. Weissmantel, *Z chemią za pan brat*, Warszawa: Państwowe Wydawnictwo „Iskry" 1963;
115. B. Philips, *ABC gospodarstwa domowego. 4000 porad*, Warszawa: Agencja Muza 1991;
116. E. Praska *Poradnik domowy na co dzień*, Warszawa: Wydawnictwo Przemysłu Lekkiego i Spożywczego 1956.

The Solutionville Inquirer

# Things Are Hea ting Up in Solutionville

By Keely Ng
Solutionville Inquirer Staff Writer

For over 60 years now, thermometers on land-based weather stations and buoys floating in the ocean have been measuring the air and water temperatures around Solution ville. And what do they show? Like a play-offs match-up between the Solutionville Suns and the Smog City Oilers, things are definitely heating up. And it turns out this isn't just happening in Solutionville, but is a trend be ing measured around the globe. Not only have temperatures been steadily increasing, but over the past fifteen years, the Earth has experienced record high temperatures. In fact, 15 of the warmest years on record have occurred since 2001!



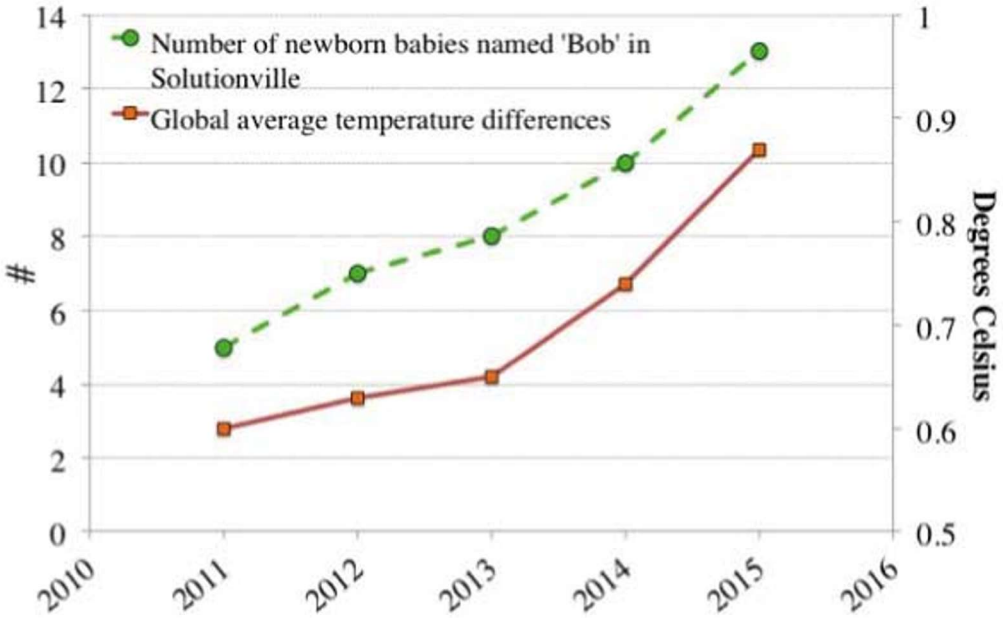

"The heat is really doing a number on things," says farmer Barry Patch. "My corn is popping, my blueberries are turning into brownberries, and my chickens are laying hard-boiled eggs!"

## Residents Propose Causes and Solutions

At a recent town hall meeting at the Solutionville Community Center, residents expressed not only their growing concerns, but also brought their own hypotheses about what might be causing the warming temperatures. Three residents in particular presented data they believe support their claims. Residents of Solutionville are encouraged to voice their opinions on the credibility of each of these three hypotheses.(continued on pages A2-A4)

# Hypothesis #1: It's All About Bob

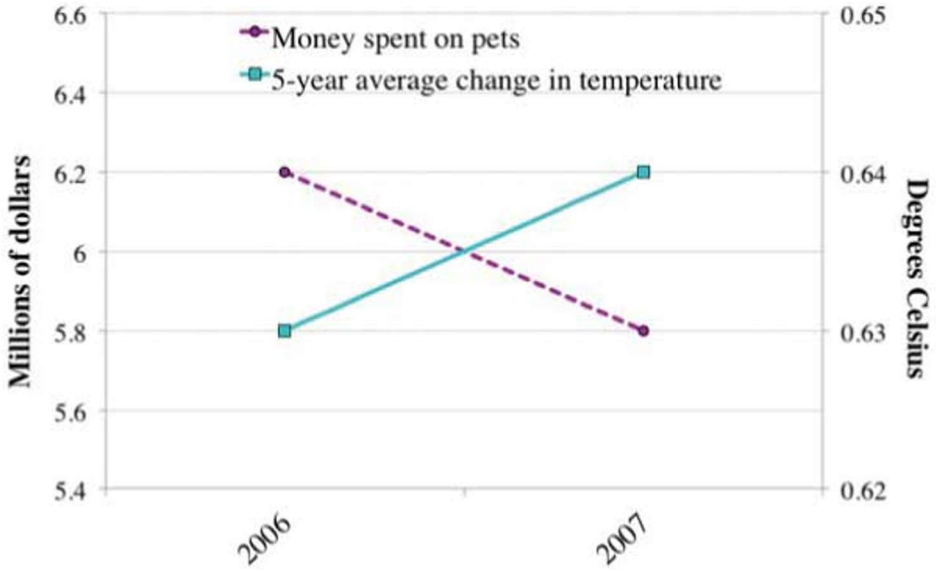
Howie Many, a government employee in charge of the annual census in Solution-ville, discovered that an increase in the number of newborn babies named 'Bob' in Solutionville since 2011 almost exactly matches the increas-ing temperatures. A census is an annual survey of the people living in a region to learn more about them. Howie recalls that the two Bobs he knows often complain about being too hot and are pretty sweaty guys, so it makes sense that they might heat up the environment around them. He argues that if people named 'Bob' changed their name to 'Mike' or 'Pat', or new parents stopped naming their newborns 'Bob', temperatures in Solutionville--and around the globe--would stop increasing.

# Hypothesis #2: Cool Cats

Kat Zendoggs, the local pet store owner, argues that according to her store's re cords, between 2006-2007 the amount of mon ey people spent on their pets in Solutionville decreased in a way that almost exactly mirrors the increasing temperatures. Kat's theory is that hamsters and parrots are happier and less stressed out when they have lots of toys, food, and other fun pet accessories. Stressed and upset animals generate heat, which can be transferred to their surroundings.

Kat believes this is what is causing tempera tures to increase in Solutionville, and encour ages residents to come to her store and spend lots of money on diamond-studded dog collars, lizard hammocks, and catnip caviar.

# Hypothesis #3: Frozen in Time

Climate scientist Dr. Brie Search and her team at the University of Solutionville reconstructed a history of carbon dioxide concentrations in the Earth's atmosphere and global temperature variations for the past 420,000 years from air bubbles preserved in Antarctic ice cores. Dr. Search explains that in places like Antarctica, thick layers of ice have been forming for hundreds of thousands to millions of years, and that bubbles frozen in the ice captured how much carbon dioxide and other gases were in the atmosphere at the time they formed. There are also ways we can deduce from the bubbles how temperatures hundreds of thousands of years ago compare to today.

The $CO_2$ and temperature trends over the last 420,000 years are remarkably similar to one another. Dr. Search conducted a scientific experiment based on her hypothesis that carbon dioxide in the Earth's atmosphere can raise the temperature of the Earth's surface. The results of her experiment, which she repeated several times, show that carbon dioxide acts like a blanket that can trap heat underneath it. To learn more about using ice cores to reconstruct past climate, Dr. Search recommends checking out this article from NASA's Earth Observatory.