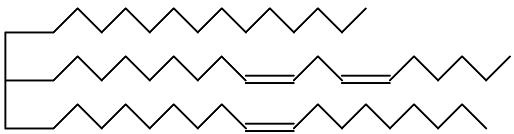
Teacher Information Regarding "Fat in Food" Experiments

Every human, animal and plant cell contains fats. In floral species, there are a large number of oleaginous seeds, germ cells and fruits. Animal fats are extracted from the high-fat parts of slaughtered animals or as milk fat during dairy production.
This means that, on the one hand, fats are produced in our body and, on the other hand, we also ingest fats from plants and animals. Fats are an important energy source for all organisms, and thus also an important reserve substance. When the metabolism breaks down fat, the organism is supplied with twice as much energy (38 kJ/g of fat) as during the breakdown of carbohydrates (17 kJ/g of carbohydrate).

In general, solid fats are called fat and liquid fats are called oil.

The chemical structure of fats

Similar to carbohydrates and proteins, fats are built up according to a certain principle. As minimum particles, molecules, fat has the typical E-form. Fats have a characteristic head section and three long tails (fatty acids) attached to it. The zigzag part of the tail consists only of carbon (C) and hydrogen atoms (H). (For a more specific formula, see the appendix)



One "fat-E" can have three different tails. There are a large number of different fatty acids resulting in a huge diversity of fats. However, regarding their basic composition, all fats have a uniform structure (fat-E). Due to the large number of possible fatty acid combinations (there are 200 fatty acids), though, there is a substantial number of different fats.
The long tails in the molecule provide the typical fatty behaviour (hydrophobic).
Another particularity is the group of fats with unsaturated fatty acids that have single or multiple double bonds (in the example above, the two lower fatty acids). We can illustrate that as follows: as we have already mentioned, the zigzag tails consist of a carbon-hydrogen structure. The C-atoms constitute the basic structure; they hold each other's "hands" and form a long chain. However, the C-atoms do not only have two, but four hands and can therefore also grab a hydrogen atom above and below. This means, they have four neighbours. Instead of holding onto the hydrogen atoms, the C-atoms can also hold each other with two hands thus forming a double bond.

Comparing fat and water (H_2O), the most obvious difference is the size of the particles (molecules). Fats, with their long tails consisting of numerous carbon and hydrogen atoms, are huge compared to the small water particles with two hydrogen atoms and one oxygen atom.
Fats are large, rather immobile particles that do not move as easily as the smaller water particles. This characteristic is called viscosity. It can be illustrated by swirling a glass of water in comparison to a glass of oil, or by pouring oil into a frying pan. Fats

have high boiling points (water at 100 °C, fats generally over 200 °C); it is therefore possible to fry food in fat at comparatively high temperatures (e.g. at 180 °C).

Correct nutrition: The importance of fats for a balanced diet

A balanced nutrition is a prerequisite for a healthy and effective organism. It is important to take in the necessary energy together with all vital nutrients. Carbohydrates, fats and proteins are the energy sources in the food. Carbohydrates are recommended to supply 50-55% of the energy demand, fats 30% and proteins 10-15%. In addition to the nutrients that supply energy, i.e. fats, carbohydrates, and proteins, nutrients that do not supply any energy - such as vitamins, minerals, as well as trace elements, dietary fibres, and water - are also important.

In the industrialized western countries like Germany, there is a big problem in that many people are too fat. Our bodies transform ingested fat that is not used up into "fat deposits". These are fat layers in the subcutaneous tissue and the internal organs. The continuous ingestion of too much fat makes people at first fat and then sick.

Essential fatty acids are particularly important for nutrition. One such example is linoleic acid. The body cannot produce the essential fatty acids itself, but needs them nevertheless. Therefore, we have to ingest them with our food. Essential fatty acids are mono- or polyunsaturated fatty acids and are found mainly in vegetable oils and fats. 10% of the ingested fat should consist of these essential fatty acids.

Nutritionally, fats are also important as carriers for fat-soluble vitamins. Vitamins A, D, E and K need fat to be able to enter the metabolism.

As we in general eat too much fat, fat consumption should be reduced. We should eat less animal fat and rather more vegetable fats and oils with a content of essential fatty acids. The easiest option is to reduce visible fats such as spreadable, frying and cooking fats. But also regarding hidden fats in cheese and sausages, we recommend lower-fat products.

Not to forget the connection between high-fat diet, high blood pressure, and vessel alterations (arteriosclerosis) that we are mentioning here only in passing.

For our body, it is very important to get the right food. As we can hardly judge from the outside what substance our food contains, we need methods to find out what is in there. Only if we know what our food contains can we eat a balanced diet. In the following, we would like to illustrate some detection methods using the following experiments.

Background for the "Grease Stain Test"

As opposed to water, fats have very large molecules (particles) due to their long fatty acid chains. They have high boiling points (water 100 °C, fats often over 200 °C). The small water molecules are more mobile and can evaporate much faster as they have a lower boiling point. Therefore, water stains dry quickly.

During evaporation, the following occurs: Due to applied heat, the particles have more energy and become more mobile. They begin to accelerate. At a certain point, the particles' speed is high enough for them to leave the surface of the liquid and fly away, that means to evaporate. The larger the molecule, the more energy is necessary for it to move and to evaporate. The large, clumsy fat particles are not able to evaporate as quickly as water; and they leave large stains on filter paper. This way we can use the grease stain test to qualitatively proof the presence of fats and oils.

Background for the "Solubility of Fats and Oils" experiment

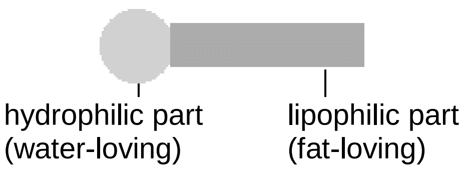
The goal of this experiment is for the children to become aware of how the liquids behave in mixtures.

In the first part of the experiment, we will have a scientific look at "salad dressing". The children are to find out that vinegar and water will immediately blend. The rule of thumb says that "like dissolves like" and therefore watery liquids blend. And vinegar is a watery liquid. Oil, on the other hand, forms isolated oil drops on top of the water-vinegar mix.

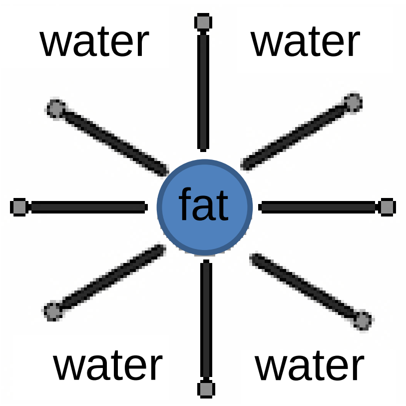
The solution characteristics of substances are mainly determined by their structure. Watery substance are called "hydrophilic" (hydros = water; philos = friend). Different oils and fats can also be blended. These substances are called "lipophilic" (lipos = fat, philos = friend). However, water and oil cannot dissolve in one another.

During the next part, the children are to observe that, on the one hand, olive oil forms isolated oil drops on water, and on the other hand, also dissolves in petrol. Oil dissolves well in petrol because of the fact that "like dissolves like", as we mentioned above. In everyday life, stain removers use this characteristic of petrol to remove greasy stains.

If we now add a few drops of a washing-up liquid to the water-oil mix, the oil drops break up into tiny droplets. Washing-up liquids contain tensides, or so-called surface-active substances. Tensides actually constitute bridges that establish a connection between hydrophilic and lipophilic liquids. The result is that we can blend the liquids. These tensides operate as "solution mediators".



Tenside molecule



Tensides support to disperse fat in water

During the third part of the experiment, the children are supposed to start out finding, that even in a test tube oil does not dissolve in water, but forms an oily layer on top of the water. However, oil dissolves in petrol - in line with the previous experiment.

After vigorous agitation, a turbid, milky mix of water and oil forms – for a short while. After that, the oil and water separate again. The oil again floats as a layer on top of the water. The children should be able to observe that oil and fat float on water. Oils and fats have a lower density than water and therefore float on the water (as can be observed during an oil spill).

Background for the "Milk Race" experiment

Due to their different fat contents, milk and cream have different viscosities. Skimmed milk is thinner and flows faster than cream. The children should work on this experiment as thoroughly as possible, i.e. precisely stop and read out the time. We also recommend rinsing the glass tube before starting the experiment as a dry glass tube will distort the results. It is important that the different milk types have the same temperature and thus test conditions are being held constant.

We can use the sphere model to illustrate why coffee cream is more viscous than skimmed milk: In milk and cream, fat is emulsified in water. In order to visualize the proportions, we use a model where the water particles constitute small globules with a diameter of 1 mm. In contrast to this, fat particles form very large globules with diameters of between 1 and 100 m. Due to the larger fat content, cream contains many more large fat globules than skimmed milk. If we now imagine the globules to flow through a funnel, the large globules will obviously get into each other's way in the tube. As cream contains a much larger number of big globules, the high-fat cream flows more slowly through the tube.

Milk constitutes an emulsion of fat in water. The fat - which is insoluble in water - is surrounded by so-called emulsifiers and thus becomes water-soluble.
The above-mentioned tensides are examples of emulsifiers. They cause the washing-up liquid to dissolve the fat, and the fat to remain floating in the water. This also applies to milk in a similar way. Here the milk drops are encapsulated by a so-called fat globule coating that is comprised of, amongst others, phospholipids, glycerides, casein and cholesterin.

To make this experiment even more tangible, you can illustrate the sphere model by using a mix of "balls" with different diameters, such as peas and mustard seeds that flow through a funnel.

Appendix

Chemically, fats are combination of glycerol with usually three molecules of fatty acids (triglycerides). Fatty acids are chain-like molecules consisting of carbon and hydrogen atoms that carry an acid (carboxyl) group. Glycerol is a trivalent alcohol.

Glycerol reacts with fatty acids to form fats – with elimination of water (condensation reaction).