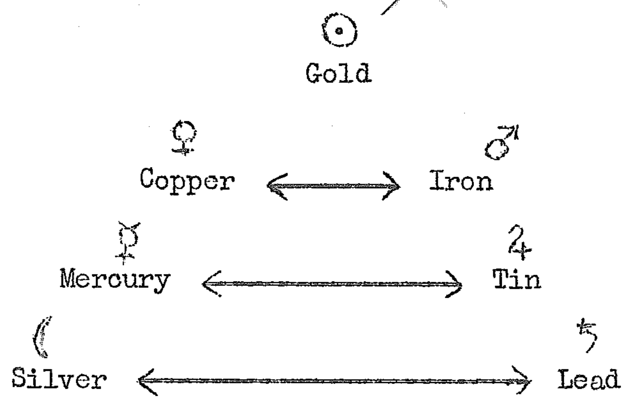
It can, however, be said that these are closely related, broadly speaking, to the motifs indicated.

In Wilhelm Pelikan's "Sieben Metallen", an excellent and detailed survey of these connections is given. Many other things are to be found there as well, e.g. a consideration of the role metals play in the earth's crust.

In the following diagram the connection of the metals to the planets is given. The mighty contrasts existing always between two planets and their metals are also indicated.




F. H. Julius "The World of Matter and the Education of Man"

## WORK IN THE 8TH CLASS.

Occasionally almost the same themes are given in the syllabus for Class 8 and Class 9. At first glance this can be confusing but when one is faced with the task of actually taking the lessons one soon notices that the teaching matter can be subdivided and organised, and that the chief aspects of the work are so different that not the slightest muddle need arise.

In the syllabus for the 8th class attention is particularly directed to the carbohydrates, fats and albumen as foodstuffs. Elementary organic chemistry is spoken about in the 9th Class. This is a very broad subject to which the carbohydrates, fats and albumen also belong.

During the work one notices that all manner of things can be done and handled for which no time remains in the 9th Class. If the starting point is well chosen, the work in Class 9 can even be supported and well grounded through that preceding it. Above all care must be taken not to deal too early with isolated separate parts of the teaching matter and definitions. Usually this kind of "being very learned" is the result of a certain awkwardness for want of guidance, or through not being master of the subject. In a way, it is the greatest art, to make something out of simple things. And exactly through this, one succeeds in fostering and protecting the children's fiery enthusiasm and faculty of deeply immersing themselves in the phenomenon right on into the higher classes.

This epoch is best begun with sugar. One observes, e.g. how sugar reacts to water. First its great solubility is presented, through bringing water to the boil in a beaker, and then slowly adding sugar, taking care that only a little ever lies at the bottom. Meantime the rising of the liquid's surface is noticed. Finally the solution will occupy more space than the original pure water. The liquid is then allowed to cool. It becomes first like syrup and then viscous. After a little while crystallization begins, so that the whole mass hardens. One now does something which is more important than ever for children of this age; one lets them consider how these phenomena are utilised. Children of this age are extremely interested in the prosaic sphere of everyday life. We can satisfy them particularly well in this subject. The girls chiefly know the substance in question from cooking. Now they learn to understand, through thinking, what most of them for a long time already knew from experience. In some cases we can even give them a few practical tips.

The dissolving of sugar and then allowing it to set again is used, among other things, in making icing, confectionery, syrup, jelly, jam, etc.

Now sugar is brought into contact with fire. First a little is heated in a test tube. The sugar melts and if done very carefully the liquid remains colourless. Otherwise it quickly turns yellow and changes into a beautiful brown, pleasantly smelling state. This is called caramel, which is used among other things in preparing caramel pudding and certain sweets.

Stronger heating makes it boil furiously, while the colour of the liquid becomes darker, almost black. Simultaneously great quantities of smoke and inflammable vapours begin to escape. This experiment can be heightened through placing a lid on a greater quantity of sugar in an iron beaker. When the beaker is heated a mighty puffing, blowing and flaring up results. The swelling mass pushes up the lid, and drips over the edge. In the end only shiny-black, crunchy and porous carbon remains. Sugar can also be blown into the gas flame. Each grain then produces a small flame. The heating of sugar on an iron spoon is also quite effective.

Then one can deal with the forming of sugar in the plant leaf.

The presentation now of the role played by carbon dioxide and the formation of oxygen would not be out of the question. In any case this must come in the 9th Class. One will, however, definitely notice that the work on a substance can be much more intensive when its academic aspect is not immediately pushed into the foreground, but when, from its reactions to external influences, from its relationship to the four elements, that is from the "Deeds and Suffering" of the substance, its character or even kind of biography is developed. If this is done, abstractions become superfluous, and one develops instead a full and living view of the processes in nature. In this instance the accent is placed on the connections between air, water and light. The opportunity must never be lost, of referring to the Above and Below in nature, which appears so clearly again here. In sugar, that which comes from above as warmth, air and light and from below as the watery element, are woven together into a wonderful unity.

We can now give a sort of explanation for the way sugar behaved in the experiments. Its great solubility is connected with having been born out of the watery sphere. Its relationship to water is also demonstrated by the fact that it is always found in nature in a dissolved state. The crystallising, that is the emerging out of the liquid, is even comparatively difficult to bring about. Every plant is more or less permeated by sugar in a very dilute solution. In animals and men sugar circulates with the blood.

Another of sugar's traits is to give off gases when heated. Its relationship to the air is thereby evident.

When sugar burns so much that it bursts into flame, thereby producing warmth and light, it owes this to the sun-fire captured by it, and now set free.

In sugar a great contrast becomes a unity: sugar is related to water as well as fire. It is therefore understandable that sugar can be absorbed into our blood without any change. The same can be said of the blood as of sugar; fire and water unify in it also. However, we differ from the plants in what is done with the sugar in our bodies: it evolves into warmth, whereas in plants the greater part of it condenses and hardens into solid substances like Cellulose. The plant builds up its immobile form with the help of sugar, while the sugar builds for us the foundation of our mobility and production of warmth.

The various kinds of sugars could be differentiated when dealing with this substance, although I'm of the opinion that a general treatment of it could be stressed in Class 8, and then the different sorts defined in Class 9.

Probably it will mostly be necessary to differentiate Cane-sugar from Glucose, in certain circumstances also Fructose. This is the case above all, when the Fehling's solution test is already being introduced.

After sugar we can take starch. We take some potato flour, and other kinds of flour and let the children rub it between their fingers. Certain differences are experienced. Flour looks a little like sugar at first, but feels much drier.

Now we sprinkle some potato flour on to a glass of water. At first it floats, and then sinks without dissolving.

Then we heat dry flour. It doesn't melt, but carbonises. It flares up less than sugar; but burns much longer.

At this point we can insert a few remarks about the burning of food during cooking. One demonstrates, how e.g. such a half-carbonised mass is easily removed, after boiling with a soda solution.

Then we take the appearance of starch in the plant. Sugar is actually always in circulating, flowing movement. In contrast to this, the superfluous sugar on arising through assimilation, is already pushed out of the sap stream, in the form of insoluble grains of starch, and so to say put on one side. Small grains can be proved microscopically in the leaf. In poor light, or at night these starch granules are changed into sugar again, and dissolved. The plant, however, puts starch in places where life in the plant has temporarily come to a standstill, and where in connection with this, coarsening and hardening processes appear. Especially tubers and seeds often contain much starch. The trees also store up great quantities of starch in their trunks during the summer, which are kept through the winter, but when life begins to unfold in spring, all these grains are unlocked again, and taken up as sugar into the sap-stream.

While it is characteristic of sugar to flow through the plant in diluted form, the characteristic of starch is that it appears resting, separated into countless grains. When one of these grains is observed under the microscope, it shows a self-contained unity, centred around one point, and built up in layers. From every aspect starch brings to expression expulsion from the unity-building forces of life, and the continual stream of fluid. The plant as a whole depends mainly on the surroundings in the widest sense. In contrast, each grain of starch seeks its own central point.

We now add some starch to boiling water. We must first carefully mix some flour with a little cold water. This is poured into the simmering water. One sees then, how the grains quickly disappear to be replaced by a smooth, translucent, half stiff state. It is quite gripping, to observe the movement of the steam bubbles growing slower in the porridgy mass. After cooling, the mass becomes even stiffer. Starch paste is prepared in this manner. When the children are then told that actually in porridge and certain puddings, paste is cooked, it often causes a sensation. One can point out that bread-baking is based on a similar process.

In the making of paste it is evident that starch only allows itself to be partly dissolved, even in hot water. The boundary is disposed of between the original starch and the water. Each grain takes in water, and begins to swell, so that its structure is lost. Very soon all the free water has disappeared, and has been replaced by a jelly-like mass.

We can also deal with the way the transformation of starch into sugar is used. In nature this happens for example in the germination of seeds. We can let grains of corn germinate by bringing them into contact with moisture under certain conditions, and then get a mass of grains, after heating and drying these, which has both a starch and sugar content. We call this malt.

This change of starch into sugar is disturbingly noticeable in the potato, the life process of which ceases on freezing. A slight but constant production of sugar takes place in the potato, which continues even when frozen. Under normal circumstances this sugar is consumed through the scarcely noticeable life process which is retained even by the stored potato. In the frozen potato this sugar mounts up. This accounts for its unpleasant, sweet taste.

The children might even try to change bread or flour with the help of the saliva into sugar, by chewing it. Together with this it can be told that all the starchy food that we eat is completely transformed into sugar and absorbed into the blood in this form. It seems better to me to deal with the details in Class 9.

Now comes something which in my opinion can be taken in the 8th Class as well as in the 9th:- Proving that a substance contains starch or sugar through certain tests. In either case the children find this very stimulating. I believe it is good, when doing the Fehling's solution test, not to use it directly in its completely finished form. It is better to let it arise step by step. I now mention these steps:

(a) It is shown, how a solution of copper-sulphate and sodium hydroxide forms a blue precipitate.

(b) The same experiment is done in the presence of a sufficient quantity of dissolved sugar. The blue colour is now much deeper, but there is no precipitate.

(c) This deep blue solution is carefully heated. If cane or beet-sugar has been used, there will be no change. However, with Glucose a change of colour appears. The blue wanders through to green, to yellow and then orange. Finally there is a strong yellowish-red opaque precipitate. This experiment is strikingly effective when a flask is used. Not many chemicals are required either.

(d) For the usual laboratory experiments this deep blue liquid is prepared beforehand with the help of a substance, which is not a sugar, and which shows no change in colour when heated. Tartaric acid is chosen for this, or one of its alkaline salts, e.g. Rochelle salt. The solution to be tested is heated with a little of this blue liquid. This method is also used in testing urine. The so-called Fehling's solution is therefore prepared by mixing copper sulphate solution with a solution of tartaric acid or one of its alkaline salts, and later adding sodium hydroxide.

Flour or starch is most simply proved with iodine. A few iodine crystals are dissolved in some concentrated alcohol, or what is cheaper, in a potassium iodide solution. The resulting brown solution, called tincture of iodine is added drop by drop to a starch solution. A deep blue colour results, which completely disappears on heating, but returns when again cool.

All kinds of things can be demonstrated by these iodine and Fehling's solution tests in connection with food constituents. e.g. When a few pieces of carrot are cooked in water for a few minutes in a test tube, the resulting liquid cooled, mixed with Fehling's solution and heated, the wellknown colour change is achieved, proving that carrots contain sugar. In contrast to this, if a few drops of tincture of iodine are put on a cut carrot, at the most a few tiny blue spots appear. Carrots therefore contain very little starch. However, a cut potato, or a piece of bread, is turned a strong blue colour by iodine.

The following could also be demonstrated: One first shows that ordinary cane or beet sugar don't react with Fehling's solution. Then the sugar solution is heated with some acid. It will definitely react with Fehling's solution now if the acid is previously neutralised by the addition of a little alkali. In this way the fact can be made clear to a certain degree that other sugars, glucose or fructose, can arise from cane sugar. This fact is again particularly important in cooking. Sugar should be added to sour dishes only after they have cooled, as it otherwise decomposes and the sweetness is greatly diminished.

It is very important to present the children every now and then with clear broad summaries. In the sugar household of the Plant, certain great structures can actually be proved. We have seen how the sugar, in as far as this is the foundation of life, really only travels through the plant as a thin solution. It adopts thereby a kind of middle position. On the one side it is constantly being rejected from the stream and condensed into solid starch. This is, in a way, packed up and stored away. On the other side it flows in the form of Nectar right out of the plant altogether. It becomes scent and is sprayed out into space by the insects.

The baking of bread is especially important. I once saw how a farmer did it in the following manner: He first took his bowl of flour; then a basin with a little water into which he put a little yeast, as well as salt and honey. Having stirred this well together, he mixed it with the flour and kneaded the dough. In the meantime the fire in the stove blazed away merrily and now the dough was put into tins on top of the stove to rise. After this the burning wood was scratched out and the tins pushed in. This old recipe is as universal as it appears to be simple. Bread is one of the chief foods of man. His body is to be looked upon as the central point, as a combination of the whole of nature. In such an old farmer's recipe, a combination of the whole of Nature is found and thereby it expresses the attempt, already in the preparation, to pave the way towards building up the human body. One can consider how the flour is at first earth, and then takes up the water; how the air enters through the fermentation and lastly how fire concludes the process. When one reads the story of Prometheus who created men, one again encounters the same path through the four elements. Then we have the trinity: salt, water and honey. These are the representatives of the whole plant, of the root, the stem and the flower. We must know for ourselves that the three principles - salt, mercury and sulphur - are clearly expressed here. And then the grain itself. Grasses are those plants which are the tallest with the least matter. They are wonders in the art of construction. In grass each scrap of weight, so to say, serves the task of overcoming weight and holding that which is really heavy, the corn, as high as possible up to the sky. The grasses continually celebrate a great victory over the downward-pulling earth forces.

The grandeur of grasses and corn is most recognisable through a comparison with the potato. The potato tuber is actually a stem and therefore meant to be upright, but it bends back to push into the earth. It not only follows the direction of weight, but also grows into a plump mass.

The upright position, which is only possible after overcoming gravity is typical of man. We owe the possibility of kindling the light of consciousness to this position. Corn assists us in achieving this. It is an example to us of uprightness. It points so clearly to the overcoming of the earth, that it has always been regarded as a symbol of Christ's risen body. The potato seeks out weight and darkness; we therefore take into us through eating potatoes something that is the absolute opposite of that which the corn brings.

As a variation the children's enthusiasm for the potato can be aroused again by demonstrating the simplest way of preparing potato flour. A potato is grated on a large grater. Some water is run through the resulting mass and allowed to stand. A snow-white layer is discovered on the bottom after a while. This is potato flour.

Although it is not a food, it seems appropriate to me, briefly to draw attention to cellulose. Like starch, it is formed from sugar. It is absolutely insoluble, but burns well. It is interesting to see how the plant treats it quite differently from starch. Cellulose is also expelled from the living sugar stream, but never becomes grains. It is always built into the whole of the plant; and therefore never has its own form but is constructed so as to serve the plant.

We are here dealing with the actual building material of the plant. As this substance is quite indigestible to us, it presents us with great limitations with respect to plants as nourishment. Herbivorous animals however are able to break down and digest the cellulose.

For us, cellulose is a substance which is eaten in great quantities without its being nourishment.

We now come to albumen. We can introduce it by taking a hen's egg, breaking it, and separating the yoke from the transparent white. The children are given as strong an impression as possible of the sticky sliminess of egg white.

Then we put some of the white in cold water, and show how it spreads out, more or less dissolving. Afterwards we put a little of this in hot water, and the coagulation is visible. In a dilute acid solution coagulation also takes place. Then we can cook the set egg white with an alkali and see how it dissolves again.

To be quite thorough one can also heat the white directly with a flame. It is not inflammable, but is carbonised black and is crusted. During this the same smell is noticeable as with burnt hair, wool or horny nails. All these substances are hardened and transformed albumen.

The egg white particularly lacks form and is in a very subtly balanced state, as is evident from the experiments. Owing to these characteristics it is the actual life-bearer. When it hardens, as in the formation of horn, it achieves in contrast an especially dead, set form.

Further experiments can be done; e.g. letting the albumen in milk coagulate through the addition of acid. This is the cause of the forming of the curds in buttermilk and sour milk.

Also coagulation by means of alcohol can be demonstrated, followed by the explanation of how dead animals may be preserved in alcohol.

Lastly we shall discuss fats and oils. We let a piece of fat float on water and show how the water runs off it when it is pushed under so that it rises again. When oil is squirted on to water out of a pipette one sees a wonderful display of golden yellow drops, rising up as small balls. The pipette can also be blown out under water, whereby a ray is to be seen, which soon dissolves into rising drops. Should water happen to fall on oil, small clear balls are visible which sink down. When water with a thin layer of oil on the surface is shaken up, a cloudy, milky mass results of water and fine drops of oil, which slowly rise to the surface to join together, recreating the original state. This experiment can also be varied using distilled water, oil and a piece of soap. When this mixture is shaken, a much finer distribution of oil drops results and it takes the oil much longer to separate from the water again.

If one begins with a fairly concentrated soap solution in distilled water or has put a synthetic wash powder into the water, something very surprising happens when oil is added. No large oil drops are formed, but the mixture disperses, shooting apart in tiny particles. From such experiments it will be understandable that it is difficult to wash fatty articles with water. The role played by soap and other washing powders, becomes clear in this way.

We now allow fat to melt and reset.

Then we pour oil into an iron crucible and try to set it alight. Only when the oil has been heated does a bright yellow, very smoky flame appear. If the burning oil is heated to boiling point one can produce wonderful effects. When poured out e.g. the falling stream remains alight, so that one has a splashing mass of fire below. Mighty fire phenomena are achieved when drops of water are splashed on to hot burning oil, or even more so when water is just poured on. In this manner flames can be conjured up a few metres high! Immediately the warning is added that exactly the same thing can happen when water is carelessly poured into fat when meat is being fried.

It is somewhat calmer when oil is heated with some water. This is the well-known braising. It can be demonstrated with some very nice things, e.g. sliced potato baked with oil in a beaker or test tube. One hears again the crackling, and also sees how the slices slowly become brown. From the sizzling during heating one hears that butter and margarine contain a considerable amount of water.

From all these phenomena it is apparent that oil is penetrated through and through by the fiery element and has very little relationship to water. The result is that fatty foods are very heavy and difficult to digest. With butter the case is different, because fat and water appear there very finely interwoven.

The fat that we absorb is burnt for the most part by our bodies to produce warmth and energy. We therefore require fat especially in the cold and when doing strenuous work. Furthermore it serves as a lubricant, among other things.

Animals need fat to ward off water. Water birds, e.g. have a fat gland in the rump with the help of which they smear their feathers. The whale and seal even protect themselves from the cold, with a thick layer of fat.

In plants we find oil above all in the seeds which have been subjected to the greatest influences of warmth.

Through taking milk last of all, one can conclude this period in a very practical way. As milk is the only nourishment for some time for the small child and young animals, it must naturally contain all the necessary nourishing substances.

Sugar is easily proved again with Fehling's solution. It serves for nourishing, but also plays an important part in turning the milk sour. Depending on the extent to which the acid appears the sugar and accompanying sweet taste vanishes. We not only know this from sour milk, but also buttermilk, yogurt, etc. When milk is allowed to stand, a layer of fat, the cream, separates off. This process is hastened, by turning the milk centrifugally in the separator.

Through shaking or churning the milk itself or the cream, lumps of butter separate out. Although cream contains much fat, still other constituents of the milk are in it also. Butter contains chiefly fat and water. This water appears at first glance to be a sort of thinning or even an adulteration of the butter, but it is actually an indispensable ingredient. It gives the butter the consistency through which it is so easily digestible, and which the margarine factories likewise try to give to their products.

With milk the fat floats in the liquid in the form of small drops. In butter a fine mixture of water and fat is still always present.

The albumen of milk is noticeable in various ways. On heating only a certain part of the albumen coagulates - which forms the 'skin'. The whole amount of albumen can be coagulated by adding acid. When milk turns sour by itself, as with the usual sour milk or buttermilk, this coagulation also naturally takes place. Gradually a thick white mass separates from a light liquid, the curds and whey. When this coagulation is not yet noticeable with the cold milk, because it hasn't formed enough acid, but then appears on heating, we speak of the 'turning' of milk.

This coagulation of the albumen is used in the production of various things. Through draining buttermilk through a linen cloth it thickens into cream cheese. For thick cottage cheese this mass must be wrung out.

In the making of cheese the milk first has to curdle (that is, the albumen coagulate) through having rennet added - the juice from a calf's stomach. When the liquid has mostly been drawn off, processes can take effect in the coagulated solid mass, by which it becomes cheese.

Nearly all these processes depend on fermentation. It might even be referred to as the beginning of decay, or a particular type of it.

It may be possible that, after all these things, a list of constituents of a number of plant and animal foods can be made. Furthermore directions for the treatment of these substances and a sensible preparation of the food could also be given.

In the syllabus Rudolf Steiner pointed out the importance of dealing with industrial processes on a chemical basis, and there are many possibilities for this in the production of foodstuffs. Something about making soap might also be suitable. Perhaps there are even other possibilities in quite different directions.