Phenomenological Organic Chemistry

An Introduction Based on the Inner Nature of Substance in the Plant World

Class 9 Chemistry
Main Lesson Demonstration /Classroom Material
and
Laboratory Projects

Included are experimental descriptions, Discussion of Deeper Themes and Methodology for Carrying Out a Student Laboratory Project in Home-Medicine making

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Mt Barker,
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and unrevised by the Author.

The translation was made from the original:

Vom Kohlenstoff zum Aether
Materialen fuer den Chemieunterricht der 9. Klasse, mit Versuchsbeshreibungen und Vertiefungen von Einzelthemen, zugleich eine Einfuhrung aus phaenmenologischem Ansatz unter dem Begriff innere Naturen.

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1.1 The Curriculum Indications and its Epistemological Direction

The outline for the chemistry block curriculum in class 8, based on Rudolf Steiner's indications, is as follows:

> *"... extend the simple chemical concepts so that the child learns to understand how industrial processes are connected with chemistry. Using chemical concepts you try to develop a link with substances which build up the organic bodies: starch, sugars, proteins and fats."*[1]

And, for the 9th class, he has suggested:

> *"Chemistry: That which we have established for class 8 -- the first elements of an organic chemistry, what an alcohol is, what an ether is -- these should now be carried further in the 9th class."*[2]

The First Elements - Organic Chemistry. The conventional textbook approach to chemistry introduces so-called "organic[3] chemistry" by considering the completely non-living hydrocarbons of petroleum; however, Steiner clearly placed great value on the block having a truly organic, living architecture, specifically connecting to the substances indicated for study in 8th class (starches, sugars, proteins and lipids). However, the class 8 students didn't just learn about these substances as mere names for isolated substances, but rather as members of a series, by experiencing the intimate connections between natural forces and human nutrition.[4]

So also in class 9, it is not our task to learn to understand the "chemistry of the organic" as separate from life, or systematized according to formulae, nor to treat the substances as a series based on "homologous structures" or "functional groups;" rather, the goal is to pursue the traces of life. For, the imprints of life we see on the earth's surface always flow out of higher organizational principles, by which they must be understood, not only (in an additive sense) out of lower, non-living precursors (substances, molecules) which [are thought to be the cause of] the living substances and so explain them.

Certainly, it is also clear that by "first elements" of organic chemistry, Steiner did not mean chemical elements (constituent substances); in that case, we would have to study elemental analysis and inorganic chemistry in general. This, however, is deferred until grade 11. It is not material elements which are meant, but the elements of understanding.

The block should not be fashioned out of a mere sequential treatment of the properties of substances, nor from an examination of manufacturing-industrial processes, nor technical applications. Rather, we should examine just a very few phenomena, and therefore really study them thoroughly. The students should practice a thoughtful consideration of the qualities chemically interwoven in each substance. Thereby, the more factual knowledge developed in class 8 can be understood in retrospect in the light of new questions and new activities of soul in the students at this age.

Plainly, these 'new elements of understanding' (going beyond the four food substances indicated for class 8, perhaps) are given preference by studying the transformations of the substances indicated by Steiner for the 9th class: alcohols, ethers (esters), and the like [aldehydes, carboxylic acids]. So, if we take up sugar and starches from the class 8 syllabus, then

1 *Discussions with Teachers, Lect. II, on 9-6-1919, pg. 167 (in German edition); GA No. 295.*

2 *Conferences with Teachers, 9-22-1920; Vol I, pp. 223, GA No. 300; 4th Ed. 1975.*

3 *Today, meaning carbon-based, rather than products of living organism, as was its meaning in antiquity.*

4 *Compare the section introducing the Class 8 chemistry block in my book: Chemistry blocks in Classes 7 and 8, 1976, p. 107*

we deal with a clear series from most solid to most volatile. [emphasizing transformations of qualities]

We must note that when Steiner speaks of "an ether," right up to the beginning of the 20th century, esters were still termed "ethers." Thus, a chemist of that time writes "It is quite deplorable, that although it is on the best grounds that we now think of these as esters, nevertheless many of them are still called ethers."[5] Even today, the aromatic branch deals with various 'fruity ethers', which are systematically arranged as esters of lower fatty acids and simple alcohols. So it is not entirely wrong if we introduce the preparation of strong-smelling esters out of acid and alcohol, in order to focus our gaze from that starting point on the variety of fragrant/aromatic etheric oils, which we typically obtain from the plant world.

2. On The "Inner Nature" of Substance

The "inner nature" of a substance has three aspects in the way it moves our thoughts: metamorphosis, uniqueness, and overall imprint of the four elemental qualities from the whole world of Nature.

2.1. Metamorphosis

The first aspect is metamorphosis or transformations of qualities; e.g., an increase in the characteristic we could call "the watery-nature" can be seen in the sequence from wood to sugar (clarity, solubility, ease of melting). This is also shown in the large quantity of water vapor given off with thermal decomposition of sugars. With sugars, the carbon nature (solidity, structure, form) decreases a little, although a carbon residue and soot still persist. The chemist can now play with these inner qualities: imagine an increase in the flammability (the fiery-volatile quality) of sugar -- we come into the domain of "fire water", the alcohols. Now, remove its watery nature in our imagination, and we come to something like an ether -- a fire liquid. (A more precise treatment follows, below). In this way we work in our thinking with qualitative principles which can metamorphose one with the other; not as a mere additive juxtaposition in the manner of summary-formulae of organic chemistry, nor assembled in a material-spatial arrangement like structural formulae.

Such a type of thinking-in-metamorphosis is indicated by R. Steiner by the word "is" ("... what an alcohol is ..."). Therefore, we should not simply go through a mere sequence of the occurrence, preparation, characteristics and commercial uses of a family of substances, say, methyl alcohol, then ethyl alcohol, etc., in order to extract those characteristics which occur repeatedly, and in general explain 'alcohol' [i.e., the term 'alcohol' as meaning a combination of all the characteristics common to this group].[6] Rather, in the above metamorphic sense, it is a question of conceiving of each alcohol as one particular example or a step in a series of transformations from solidity (wood, starches) towards volatility (ether, aromatic substances) - alcohol as movement. The idea of a 'substance' should arise out of such a transformation, inwardly grasped, not just outwardly defined. In what follows, it is important to show how this step-by-step path in thought, from rigidity to volatility, reveals itself to the students in worked-through experimental observations, initially unconnected; but later, demanding connection. For it is essential that the students can look back later on their mastery of clear steps in learning and pithily formulated connections cannot be left out of schooling.

2.2 The "Inner Nature"

The "inner nature" of a substance is a phenomenological measure, a way of characterizing. Initially this 'nature' is something physical which doesn't disappear but remains in physical space. The "inner nature" is however, more than a material component, and should not be thought of in a mechanistic sense. It is not matter, but rather a type

5. *Lassar-Cohn, Methods for Organic Chemistry Laboratories, Leopold-Voss Publisher., Hamburg, 1907.*

6. *See Bortoft on "Authentic and Counterfeit wholes."*

of activity which can be transposed from one space to another.

Such a notion is foreign to our way of speaking nowadays. But, still, we could change the words we use to describe things; but as a teacher, we will simply speak about the subject as we have experienced it in our own perception. Some words which might be used to stand for the impressions of the "nature" of substances are: "aspect, quality, inclination, characteristic tendency, affinity, relationship, impression or 'imprinted by', action or activity."

So that the mobility in thinking which has been achieved, isn't allowed to run away into uncertainties, when we put up descriptions on the black-board, with a more schematic presentation of the transformations of a substance, or in comparing various substances, we can make sure that each particular 'nature' is always written with the same color; for example, the "solid-burable" (as in carbon-nature) written in black-gray or brown, the "balanced, extinguishing" watery-nature (of sugar) written in green, the "fiery-volatile" nature, in red.

2.3 Uniqueness

A second aspect of the transformation of the "inner natures" of plant substances is their uniqueness according to their origin. The simple diethyl ether with its recognizable smell and physiologic effects, and still more the aromatic substances found in all sorts of plant organs, are each unique; they could never be derived definitively from a mere intermingling of the "solid" and fluid" natures discussed above. Here a connection with the (unique) wholeness of the individual plant must be brought into consideration: its location, environment, cultivation, season it ripens, etc. Then, chemistry leads to individual plant species and to new botanical questions.

2.4 Imprint of the Whole of Nature

The substances studied here, are arranged from wood to etheric oils, relating to the growth and development of plants and how qualities like the various Greek elements interweave, from moist earth up into the warm air. From this arises the third aspect: the four elemental qualities, an idea which gives a real picture of the overall process of Nature over the surface of the earth. Warmth and light indicate the region of Nature in which a sugar or an ether (ester) is 'at home.' Individual substances are representatives of the cosmic working of nature-processes. The precise, thoughtful penetration of chemical activities in the laboratory (which is important for young people at this age), is therefore combined with a comprehensive, experiential understanding of Nature.

So, we have the three main points:

- The *transformation of qualities*, like solid, volatile, fiery, etc. in the laboratory; the overall 'inner nature;'
- *The originality* of individual substances and individual plants, the uniqueness of the aroma of a substance, the therapeutic action etc.
- The *'impulse'* or imprint given by outer nature through the whole cycle of seasons in forming substances.

3. Possible Approaches to the Block

3.1. Transformations in Living Nature

The introductory topics could build on a discussion of the environment, or raw material issues; e.g., about burning fossil fuels, or the waste heat from atomic reactors. From this whole cluster of issues about how the human being rightfully stands within nature (and how he is imperiled), we take up the idea of breathing. Various gaseous components of the atmosphere are demonstrated and named (carbon-dioxide tester experiment). The carbonic acid which arises from carbon compounds (charred) leads us back to class 7 where we considered burning, albeit in a much more imaginative manner, and which we now interpret at a new level. Oxygen is mentioned, but comes in with the experiments (see below) simply as a

component of the air, initially. For only then can we enter into the chief theme of the block: the transformations of plant substances arising from building-up, constructive life-processes; and, we won't get lost in the chemistry of oxygen, which by itself leads to tearing-down and decomposition processes, to oxidation agents (and explosives) [themes for class 10 and 11]. The theories of burning, from phlogiston to the stoichiometric (weight analysis) ideas of Lavoisier have, in short, followed a path towards the inorganic-mechanistic. We should not pursue these in this block, but rather work on the qualitative transformation of substances in the fertile, pure realm of plant life. We could learn a preliminary classification of the substances of interest into: 'enkindling' (able to ignite things, promote burning), 'burnable', and 'balanced'. All substances in the world are, finally, various interweaving and aspects of these three principles (three natures).

The class 9 main lesson block primarily takes up "burnable" substances, class 10 focuses on the "balanced" (salts), and the 11th or 12th class main lesson blocks investigate the "enkindling" ones, experimenting with pure oxygen, nitrates, explosives, or halogens.

3.2 Origin of Combustible Substances

Now, we have to ask: how do burnable substances arise in Nature? The rigid crust of the earth is sealed up, stony, chemically stable and in equilibrium with the conditions at the surface of the earth. Only where the enlivened loose earth turns toward the mantle of air, can a mantle of plants begin to grow, and it is their remains that provides us with combustible materials. All aspects of the growth of plants are an image of the cycly of the year i.e. an occurrence outside on the earth's surface. And together with humankind, they stand in a reciprocal relationship to the air. True, they do not have a sentious consciousness, no reaction from an inner life (e.g. with lack of air), and no ability for self-movement provided by appendages. Rather they move gently in the wind with all other plants, and give themselves over to the free air outside and to the rhythms of the environment. Just this makes them able to supply combustible material (class 7) and nutrition (class 8).

Thus, it is even less thinkable that we would enclose the plant mantle that covers the earth in a glass jar, than we would enclose our own breathing. To plants belong the above-mentioned openness to the environment. Indeed, we may decide to intervene in this way and demonstrate rising oxygen concentration. We shouldn't go too quickly into the usual study of carbon-dioxide assimilation which, in the final analysis, views the plants as a chemical machine. The reality of assimilation is the illumined plant leaf, is seasonally given multitude of forms, which grow and become larger. Systole and diastole, in growing aloft, developing/maturing in the course of the year – this we experience in an eternal rhythm of densification and out-streaming. Certainly, assimilation is a sort of densification process, but of such a kind as leads back again in rhythmic transformations to an out-streaming in the blossom's fragrance. The whole path of plant development from leaf right up to blossom and fruit is the reality of assimilation, not concepts of gas-exchange or bio-mass accumulation. All the substances we work with (wood, resin, sweet sap, aromatic oils) simply portray this path in nature in an image of true assimilation, as we enhance one or another aspect of it by manipulating one or another of these substances in our laboratory. The capacity to transform, not to accumulate mass, characterizes the "activity" of carbon substances (the 'carbon principle'). ***Here lies the field of study for this main lesson block; experimental realities, which through concrete, qualitative thinking, can be led over by the feelings into a deeper participation with processes of nature.*** For, there could be no

plant world without these perpetual transformations of phenomena and organs from stiff and dense below, to fluid/volatile above. Within this field of transformations is presented to thinking a field of activity, which can open up a spiritual, yet content-rich, reality based chemistry. Schematics and diagrams of environmental cycles of a mere material assimilation theory cannot accomplish this. They hold the thinking rigidly in mere concepts and abstractions, and thereby, finally in non-understanding. Only in the end would it permit us to clearly reflect on how, out of the growth of plants, the air can possess a gentle increase in its stimulating/enlivening quality, its refreshing character, and how these qualities are connected with the up-building course of the yearly cycle of plant growth.

A very accessible arrangement of topics for the main lesson block is provided -- as indicated above -- by starting from carbon and carbon dioxide and the question of the special appearance of burnable substances including wood, and then on to sugar, alcohol, ethers & esters.

3.3. Earth Coal vs Sugar

If we took our starting point from hard-black coal, or soft-brown peat from the earth, then we would have the consequences of a one-sided process on our hands. Although coal arose from plants which–albeit over immeasurably long time–had their fiery-volatile nature and watery-balanced nature reduced or removed, natural coal now shows only the slightest trace of these two natures. However, if we ourselves bring this process to completion with distillation (coking) of wood, to achieve the transformation in a shorter time, then we get **charcoal**, which is practically pure carbon. When heated anew, this wood-coal (in contrast to mined coal) no longer produces any water vapor as a secondary combustion product. On the other hand, we can isolate a related plant substance by pressing the fluid sap out of the solid plant fibers, and allow something with a more watery-balanced nature in this sap to come to expression: **sugar**. We encounter sugar as transparent, water-soluble solid crystals, which, however, combine within it the solid-burnable and the fiery-volatile. Through various technical means, we can increase or suppress each of these natures. One of these processes is fermentation, which leads us to alcohol. With alcohol (and its subsequent products ether and esters), the carbon-nature is so intensively transformed through either the watery or the fiery-volatile, that with heating a sooty residue is no longer formed. Remnant influences of carbon-nature are shown by the more or less yellow or sooty flame. The products of burning too reveal which 'natures' are to consider in the reactions. For example, if a great deal of water vapor arises, which is lighter than air (upward cloud formation), the fiery-volatile nature is correspondingly strong (hydrogen-nature). With this study of decomposition products, we attempt a truly chemical concept formation. We don't merely view together outer qualities, but rather take hold in a clear way of natural processes, leading them to accelerated and intensified new phenomena, such as distillation, coking, combustion, or fermentation.

Refinement. The plants themselves – next to the solidifying process leading to wood – provide an example of such a "refinement" (c.f. Goethe), as the watery-leafy middle part of the plant leads up to the flower. There we find, above all, the fiery-volatile fragrant substances, which barely have any mass. If we imagine the refinement process carried so far that every trace of both of the other two qualities is overcome, then we would arrive at hydrogen as the quintessential fiery-volatile. It is not the basis, but only a variation of 'hydrogen-nature' taken to the extreme. Again, the study of combustion products (pure water vapor) makes this

inner nature manifest but, in this case, in its one-sidedness. [See class 11 syllabus; hydrogen as an element in the Human Being and in the World]

If, in contrast, we consider the formation of fruit, we can recognize a kind of about-face into the watery forming realm, or also transformations of the solidifying type in the formation of skins, acids and oils. In the fatty oils, the fiery-volatile has been seized by a new variation of the carbon-nature, so that volatility has disappeared and there remains only a muffled-fiery quality: the fats and waxes.

Petroleum & Life.

In contemporary petroleum chemistry, usually treated as "organic chemistry," we can also discover all these tendencies and specialization of characteristics. We also find here more or less volatile, gaseous, fluid, and even solid black or aromatic products. These facts, mirror the origin of petroleum oil from the living kingdom. Still, won't all these characteristics only act like ghosts of the archetypal, living qualities, which in petroleum will be awakened to a 'transplanted' virtual-life, only through an out-of-joint / dislocated technology? Students should certainly be offered a glimpse into this virtual-world; nevertheless, petroleum chemistry such as the homologous series of the alkanes cannot serve as the starting point for our main lesson block, for then we would find ourselves with the deadest substances without any images from nature, and would understand nothing of the living connections.

Four Elements.

If to the carbon-nature (solidity), to water-nature (non-flammability), and to the fiery-volatile nature (hydrogen), we add a fourth: an airy-nature, making a non-flammable but volatile gas (carbon dioxide), then these inner natures can be thought of as images of the four elements. The activity of the Elements over the whole earth is indicated in further detail by Steiner in Lecture 6 of the "Supplementary Course"[7] [*Here Steiner contrasts the modern, abstract image of the human being proffered by natural science, with the Greek conception of things, which still incorporated an inner conception of the Life of Nature, and the importance of a living image for the growing youth. Translator's Note*]

It is interesting that in the Conferences, immediately following the above indication about the chemistry syllabus, Steiner continues on unprompted to speak about the Study of Man: "Anthropology – continue the study of the human being in order that a true anthropology is taught to the students. This must grow in concentric circles from class to class and the usual natural sciences be arranged about it." So, chemistry too orients itself about the central study of the human being, and needs no systematic of its own – but is connected into an existing order. As teachers, we ask ourselves how we should grasp the way hydrogen-activity (as a non-material "force") takes effect in the whole of Nature and in the human being. Deeper explanations by Steiner in the Agriculture Course,[8] in the workman's lecture on Bees,[9] and in the medical lectures[10] will prove useful The same applies for carbon.[11] There, in addition to the simple material interconnections, much is said about the effects on and within living beings, and in the whole of nature. We could also say that the substances discussed there are those that approach the etheric, or still more the spiritual. In contrast, in the chemistry main lesson block, we initially keep our focus completely on the physical substances and their outer characteristics, and the reaction-principles which appear in the laboratory.

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7 *Waldorf Education for Adolescence; Supplementary Course - the Upper School; Stuttgart, June 1921, GA 302*

8 *Agriculture Course, Lecture 5?; 11/06/1924; GA 327.*

9 *Nine Lectures on Bees, GA 351-a; Lecture on 10/20/1923.*

10 *Spiritual Relations in the Human Being, Lect. 2, 10/22/22; Mercury Press, 1978; Science & Medicine, 1st Medical Course, Lect 12, 4/01/20, GA 218; Steiner Press, London, 1975.*

11 *Agriculture Course, GA 327; Bees, GA 351; 1st and 2nd Medical Courses, GA 312 & GA 313*

However, it can still warm the teacher to consider the wider aspects, even if at first, it is expressed in a form which is not immediately suitable for the lessons. An absolutely beginning consideration might be the following: we meet the fiery-volatile in our upwelling warmth; we live in it. We live in the solidifying-permanence, in our solid body. The watery streams through us, from the mouth inward. We experience it with every wound and also, in the plasticity of our body. The point is not to arrive at a 'perfect analogy,' but rather to return to the human being by thinking about such qualities.

4. Overview of the Syllabus

Main Themes.

If we survey the preceding thoughts, we can arrive at the following themes for this block:

- *carbon dioxide* and combustion (total oxidation), as a balancing of 'enkindling' with burnable qualities;
- *Coking* (enclosed destructive distillation) as liberation of the volatile-burnable from the solid-burnable;
- *sugar,* treated in class 8, and here again by liquefaction (making-watery) and thereby *activation to alcohol,* so-called 'fire-water;'
- formation of *ethers* as a loss of the watery-nature;
- acetic acid (vinegar) *fermentation*, a partial oxidation, i.e., the onset of a balancing out and aeration;
- formation of *esters* as another variant of the overcoming the watery-nature;
- etheric oils and the resins of plants.

Background to Practical Work. The prelude could form a fundamentally inorganic theme (carbon-dioxide and combustion). Although that does not yet resonate with the actual theme of the block, namely the delicate metamorphosis of the inner nature, it has still proved useful to a certain degree as an entry point for the beginner. Probably this has more to do with teacher and students finding the right mood together about the more objective, merely material aspects (occurrence, characteristics, composition in the air, etc.) and how they work together. The feeling of meeting something concrete and learning something important (e.g., the components of the air) is beneficial for the beginning of the main lesson block. The specific steps in thinking the transformations of the inner qualities of the organic, where the will must penetrate the thinking more vigorously, are then recruited into an already begun learning process . With well-defined concepts we stimulate a spiritual mobility, which *then* is led over via the subsequent delicate phenomena into investigating and dealing with more open-ended concepts.

Each teacher will have to decide whether this sequence is necessary. Where it isn't, I have begun directly with burning and then coking (closed distillation, charring) of wood. The composition of the air is then tied in without any sort of special experiments, and carbon dioxide is briefly characterized as a waste gas of burning charcoal.

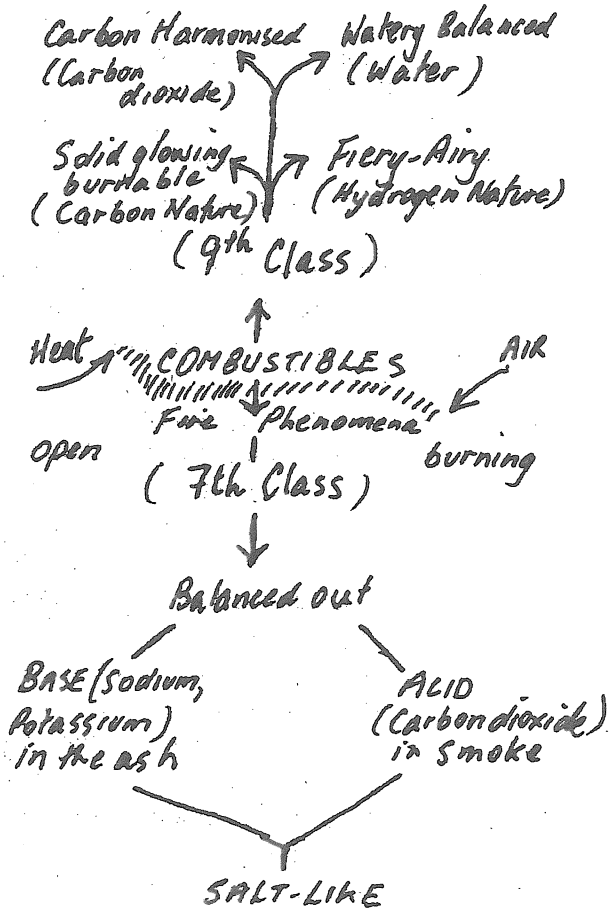
Consider carefully the sequence of introducing the three 'natures.' Perhaps it is advisable to shift the emphasis in stages from day to day. The smoldering-solid nature is developed initially along with the various combustion residues of carbon; the watery-nature is investigated after the coking-water [very watery initial distillation product from wood coking]; with the fiery-volatile nature, we show the 'wood-gas' [flammable gases produced in the middle part of a wood distillation run], and then back to the wood. For the transition cellulose to sugar and sugar to alcohol, all three qualities are available, as they are for the transformation to ether

etc.

If exceptionally little time is available for the main lesson block or for preparation, it could start with fermentation and alcohol. The smoldering-solid and the watery nature investigated in sugar and also with wood are related in afterwards. We must then be careful that the concepts are formed rightly - the teacher has a more difficult task. This jump right into the center of the main lesson block can, however, be a great stimulus for the students!

The diagram below, again indicates the path:

We see how the themes of classes 7 and 9, both begin with combustibles but then develop differently. In the class 8 main lesson block, the



theme of combustion is totally taken up within the theme of nutrition. The images presented by the phenomena of starch and protein, sugar and fats are researched there. In the 9th class, these same combustibles are now placed within a polarity of rigid and volatile, and from carbon, followed through the plant world, to hydrogen.

But, we should be cautious of too much inorganic chemistry. The causal-materially oriented path of development taken by modern science has made all chemistry inorganic, actually physical, at least in the way we actually understand it. In contrast, chemically poorly-defined substances are the most important for life. They originate in the living-organic and re-enter life processes again (food stuffs and medicines, etc.). A chemistry which aims to foster the growth and development of the whole *human being* should *not* develop its basic concepts from molecular mechanics or chemical technology. Technology, being based on finished, inorganic concepts, inserts itself into the world as something independent of the cosmos. It keeps the world and life outside. Mechanistic foundational concepts, especially when they are technically powerful, do not belong as the basis of a chemistry which strives for qualitative concepts of the living-organic world. A purely inorganic chemistry is never indicated for any class by Steiner. (And nevertheless, the chemistry teacher often tends to base everything on inorganic chemistry, since they were trained that way. From this we ought to extricate ourselves.....).

5. Pedagogy & Methodology

The task given for the young person in class 8 and 9 is to connect to society and the world, their awakening independence (through which they become free) and also strengthened – that is, to integrate them in a socially productive way with the community. At first, they may wish to emulate the outer, visible deeds of others, and understand how they master things. These young students want to penetrate such things with their own power of discernment, so that in this way they learn as a first

step how to grasp the most external aspects of the world–the world of technology. As Rudolf Steiner says in the curriculum lectures of September 6, 1919, "An interest for everything worldly and for everything human" comes to life. Young souls feel a newly awakened power to exercise control and are also completely given up to the forces of personal desires (the urge towards power and eroticism—see Rudolf Steiner's lectures on June 21 and 22, 1922). Such young people exhibit a new physical strength, independence, and resistance to the established order of previous generations, as well as a desire to try new things. If the school and home do not harness these forces and attempt to integrate them into life, then, depending upon the student's natural tendencies, it is possible that depression or even suicidal tendencies arise in boys' young souls, while girls escape into an external, superficial world.

The help that teaching can offer consists at least partly in *providing a thorough understanding* of technology, transportation, and business. How have these things changed our life together, that is, the way one person interacts with another? We think of the telephone and the locomotive in physics. Here we encounter a world made by human beings. In this case, intellectuality and cleverness act in the service of comfort and make human beings independent of the limitations of nature. Technology arises from technically specialized but outwardly highly effective human thoughts, and today is maintained only by such thoughts. Although, in relation to the phenomena of nature, these thoughts may be very incomplete and restricted to the quantitative, nevertheless they *are* a very accessible sequence of thoughts; and have in fact become decisive in the events of the external world!

Whereas in physics, the discussion revolves more around finished technical devices, in chemistry our concern is more with technology in the laboratory, for instance working with gases or simple devices such as a fire extinguisher or a pressure relief valve. Our discussion in the ninth class is much less connected with the chemical industry–which we might present in twelfth grade chemical technology. The entire way we perform experiments undergoes a characteristic transformation in class nine in comparison to class seven. In the class 7, we present large, open experiments, ones in which air plays an unhindered role–like an unlimited sea of air in these experiments, e.g., in combustion, or in dissolving lime with acid, or in its re-solidification in mortar. Even in class 8, things are still cooked or decomposed while exposed to open air. We begin quite simply by growing grain and go on to grind it, sift it, and rinse out the starch, which we then make into paste. Open smoldering experiments such as caramelization, vapors from boiling fat, and boiling coagulated egg white, belong to this series of open experiments. However, in class 9 the vessels are closed up. The distillation flask forms a small hollow sphere, the setup of condensers and receiving flasks look more like labyrinths. Unknown vapors, neither the air nor a smoke from our world, fill these chambers and tubes. The students should live into them through their feeling. This occurs in numerous new variations from simple distillation and reflux heating to rectification and steam distillation.

The transformation to the volatile oils, the freeing of "spirit" from murky, watery brews, pictorially shows the students a purification and enrichment, a sublimation. Something like an inner soul process can thereby be seen externally. Such distillations also occur through smoldering/charring, during which, especially in class 9, we catch and contain the gases thus released. The situation is similar for fermentation, in which we collect carbon dioxide.

During puberty, young people have an impulse to learn about objective things without taking the

circumstances surrounding them into account. Thus, they penetrate into their surroundings only through their own conceptual images (as technology generally does). At first, the student can comprehend only the separated part, that is, the technical aspect; through that they then come to their own judgements. Students are somewhat passive when presented with the broad pictures of nature; their will cannot yet draw together those pictures into a self-sufficient thought-framework. Thus, what they seek, runs away.

If you present only nature-pictures, then the result would be a chaotic discharge of the students' energies of will. On the other hand, much in the details of the apparatus of conventional school experiments, amounts to giving children of this age a bone to chew on—which we are supposed to get them to gnaw on, but it is still only a bone. The teacher needs to continually guide them towards the deeper and softer phenomenological connections. At first, they are kept in mind, but left unspoken; then later, mentioned in a short overview. And, finally presented in the way the teacher illuminates objective science on the basis of the phenomena, and never by means of [theoretical] model-concepts of particles and their "bonding," which only provides an inventory of the object and how and where specific elements exist within it.

6. Literature

The following books may be useful for obtaining a deeper and firmer understanding as part of your preparation [many are specific to German-speaking countries].

Fritz H. Julius attempts to give a comprehensive phenomenological description of chemistry instruction in Waldorf schools in his booklet "*The World of Matter and Human Development*," Book I, Stuttgart, 1978, 2nd edition; English translation by Steiner Schools Fellowship. See also, his book II, "*A Phenomenological Study of Chemistry*," translated by AWSNA Publications, Sacramento CA.

Gerhard Ott gives a number of good experiments and interesting thoughts in his 2-volume work "*Outline of Chemistry by Phenomenological Methods*," Basel, 1960 [not translated].

You can find a discussion of carbon and hydrogen similar to that presented in this volume together with a complete overview of chemistry in Rudolf Hauschka's, "*The Nature of Substance*," Frankfurt, 1976, 6th edition.

For its clear, systematic presentation and the amount of reference information it contains about chemistry, we should mention Beyer's standard university textbook of organic chemistry: Textbook of organic chemistry). [see also, Seyhan Ege's *Organic Chemistry*, UofM text, Houghton-Mifflin, 2000]

You can find a broad description of the chemistry discussed in this book in: Winnacker-Küchler, Chemische Technologie (Chemical technology), vol. 3, Munich, 1972, 3rd edition. [Often a valuable resource is older editions of "industrial chemistry" texts which give details of processes, no longer mentioned in the more theoretically-oriented modern texts.]

Exact descriptions of experiments, particularly for presenting specific materials can be found in Arndt-Dörmer, Technik der Experimentalchemie (Techniques of experimental chemistry), Quelle & Meyer Verlag, Heidelberg, 1969, 8th edition.

The following two volumes contain interesting information about nutrition and intoxicants:

F. Hauschild, Pharmakologie und Grundlagen der Toxikologie (Pharmacology and the basic elements of toxicology), Georg Thieme Verlag, Leipsig, 1960, 2nd edition;

and also in J. Schormüller, Lehrbuch der Lebensmittelchemie (Textbook of nutritional chemistry), Springer Verlag, Berlin, 1974, 2nd edition.

You can also use the following books for learning about how to obtain essential oils, their characteristics and uses.

H. Janistyn, Handbuch der Kosmetika und Riechstoffe (Handbook of cosmetics and fragrances), vol. 2, Alfred Hüthig Verlag, Heidelberg, 1969;

and in K. Bournot, Rohstoffe des Pflanzenreichs: Ätherische Öle (Raw materials from the plant kingdom: Essential Oils), J. Kramer Verlag, [place not given] 1968.

Concerning the themes presented in class 8 and 9 chemistry, I have developed two projects.

The first one is for producing alcohol—distillation, rectification—with the resulting cologne or mellisengeist using raisins as a starting point.

The second project is soap-making, coloring, and perfuming of the soft soap.

Both of these projects are in my volume "Laboratory Projects in Chemistry" [See PART 2 in this volume for the first project. The second project has not been translated yet.]