

WHAT ARE THE CHARACTERISTICS OF SPECIFIC DRUGS?

Hallucinogens control the mind and affect the nervous system. They are naturally found in various cactus plants and wild mushrooms and when ingested they cause illusions and fantasies. They can also be synthesized in the laboratory using chemicals. Frequently this chemical is placed on a piece of blotting paper which is subsequently cut up and sold as acid "tabs".

The most common chemical hallucinogen is **LSD** Lysergic Acid Diethylamide which is made from the Morning Glory flower and a fungus called Ergot. While it has been claimed that LSD is not physically addictive, it is mentally addictive. It is frequently used as a prescription drug when needed to treat criminals suffering from sexual disorders, schizophrenic children, psychotics, and alcoholics. LSD has been used to treat terminally ill cancer patients. The normal dosage of LSD to produce any type of effect is 0.028 mg. (one millionth of an ounce!) The purity and strength of LSD has raised questions about whether or not it causes cellular and chromosome damage. Current evidence shows that small doses do not cause fetal damage or birth defects. It has not as yet been proved to cause cancer or detectable genetic damage. However, impure, or illicit, LSD can cause these effects and increase the rates in which they occur. LSD excarnates you, it affects your relationship to both time (etheric) and space (Astral). Hallucinogens create a gap between your etheric and physical bodies.

Marijuana, on the other hand, has an active ingredient (THC-Tetrahydrocannabinol) that LSD does not have, thus "pot" can be addictive when used in large doses for periods of time. "Pot" is taken from the female Hemp plant and is sometimes used to make Hashish. The hemp plant is also a source for rope which is used for tying things up! Marijuana has the same quality of tying up the psyche of users. It creates a dream consciousness, logical thinking recedes and willpower fades. The main chemical constituents of "pot" are stored in the fat cells of human beings and is now understood to paralyze the short term memory and cause long lasting effects upon the central nervous system. It creates gaps between your astral body and your etheric body, and between your etheric body and your physical body.

It is often used medically to help cancer patients overcome the severe nausea caused by chemotherapy.

The **Analgesics** are a large group of drugs that covers everything from "Ben-Gay" and aspirin to Novocain and cocaine. While "Ben-Gay" is a topical ointment used to numb localized areas of skin, Novocain is used as an analgesic in minor operations and dental surgery. Mild analgesics are used to treat headaches, the most common of which is aspirin. It has many side effects such as drowsiness, and stomach discomfort (it can eat a hole into the stomach lining and cause an ulcer). Overdose can be a common problem. Allergic reactions and a thinning of the blood are other common side effects. Cocaine can be called the drug of the 90's. It can cause a rush in circulation strong enough to cause heart failure, such as in the case of basketball star Len Bias. It can be inhaled through the nose, thus destroying the cilia, injected directly into the vein (mainlining), or swallowed. A reduced form of cocaine called "crack" can be smoked. It has been found to arouse severe anti-social tendencies and violence. It is strongly addictive. Addiction means to "surrender oneself to something habitually or compulsively."

The strong Analgesics are called **narcotics**. They are used medically to relieve intense pain. Usually, they are illegal in their purest form and must be broken down into a compound that is legally usable. Examples of these narcotics in their purest form are: Opium, Morphine, Codeine, and Heroin. Three of the later mentioned are extracted from the first. When broken down, they are used in cough syrup, pain killers and tranquilizers. As drugs they are strongly addictive and personality altering. These drugs also excarnate you. They create gaps between your ego and astral body and between your etheric body and your physical.

Tranquilizers and sedatives are used to calm and relax. Other uses are to tame anxiety and psychotic problems. They are proven useless when used for long periods of time. The withdrawal symptoms are extreme, even fatal. Both are addictive physically and psychologically and both build up a tolerance after a period of time.

Drug abuse and drug addiction in our society is a very scary ordeal. They tend to speed up life experiences artificially, and then, in the long term, leave individuals dried up in both body and spirit.

— David Mitchell

Velicitas Vogt has spoken several times in North America on this subject. What follows

is a rough transcription of some of the points made in her lectures.

There is an increasing senselessness and emptiness in our modern life. This can cause people to seek artificial fulfillment through the ingestion of alcohol or drugs. Often this leads to addiction.

What are the seeds of addiction? What is it? What needs to be strengthened in a person to overcome addictive tendencies? How do we recognize how we need to change ourselves to combat this problem?

Can working with high school age students on the subjects of drugs and alcohol be done voluntarily? It can, but only when the youths have questions; not when merely treated in matters of health. If the etheric has been well-developed, they can carry the astral battering of drugs. Youngsters are looking for how they may come to a spiritual experience.

Drugs admit dragon forces to bear on the physical body to break it down, paralyzing the will and weakening one's grounding on the earth. Evil is the experience of the Fifth Post-Atlantean epoch; we must confront it inside ourselves. We must remember that we have no right to force others to hear truth.

Most of us have tendencies towards addictive behavior. Even Ghandi was addicted to sugar in his boyhood.

SUBSTITUTES

Dependency drugs come from gaps in the thinking, feeling, willing. These gaps are common, and need to be recognized. Perhaps student doesn't experience warmth with others. The teacher needs to recognize this gap.

We live in a society where we commonly substitute a material substance for a soul-spiritual hunger. Addiction can arise in this way. Some persons decide to become addicted. It can come from the past life experiences. A German study showed that children who were not welcomed by their parents had addictive behavior.

ARTA's book "Rock Bottom" is about drug addiction and I highly recommend it.

We are coming into the time in evolution when we can begin to work out of the developed ego forces to work against addiction.

1. One needs to freely choose therapy, mandatory programs don't work!

2. The therapist needs to be genuinely interested in the other
3. Help only comes through sacrificing one's self interest and developing an interest for the other and their condition
4. "When did you decide to step out of your life?" This is the kind of question that arises when working with addicts. We can accompany someone who is involved in substance abuse by entering into their pain, but we must let the patient go through the process of overcoming the crisis; this is a transforming process; the counselor leads astral/ego forces temporarily.
5. New communication with the world needs to be opened up.

The four stages of ritual are:

Annunciation,
Offering,
Transubstantiation.
Communion

Therapists observed after 10 years that these were the practical steps being taking their work with addicts. Drug addicts allow us to see that these steps are what are lacking in our society!

A new level of encounter amongst human beings is taking place in this therapeutic process, (see "Awakening to Community" by Rudolf Steiner).

The comments most heard by drug addicts are: "No one acknowledges me!" "I want to be seen" "I just want to get rid of my body!" The problem is that their lower senses were not well-developed during their early childhood.

Felicities suggested the following:

- don't talk too much about drugs - this represents an addiction mentality.
- problem of T.V./walkman/electronics is much worse than drugs (in her experience).
- it is neither needed or helpful to speak to High School students about drug abuse
- it is more important to look at social interaction between the teachers.
- conception brings these tendencies - if not consciously.

(See Rudolf Steiner's *From Symptom to Reality in Modern History*, GA 185, 9 Lect. Dornach, 18 Oct. - 3 Nov., 1918.)

Drug Prevention is about educating young children. It is the following:

- conscious conception,
- good social interaction among adults,

- teachers speaking to middle school classes only when asked and in small groups,
- prevention during class teacher phase.

It is not good for students to see adults get panicked about drugs, the adults need to be strong and willing go through the experience.

Rudolf Steiner said, "We will experience the etheric Christ only when we experience evil first." One must apply this statement to be able to reach teenagers.

We teachers need to recognize small addictions in ourselves in order to understand their desire to take marijuana and LSD (this is different for cocaine and heroin). We must observe the students' stages of development based on *Study of Man*.

The ages 14-15 is a dark time; we need to support them through this period. "I trust you to go through it, you have strong healthy senses, and have experienced true authority."

Drug substance is Ahrimanic!

Lucifer	Ahriman
Emotional Effect	Physical Effect
High	Crash

In Europe there are 10-12 drug recovery centers based on Anthroposophy. The average length of stay for patients is 1 1/2-2 years.

Age of Development	Drug
Indicates deficit in first 7 years. Makes you feel carried, helps you trust. gives you a sense of will.,	Heroin
Gives feeling - I am great, beautiful think quickly, make rapid connections, indicates lack in second 7 years. Where student wants to be the best the hero. Movement of thinking is lacking.	Cocaine
Gives special imagination, the ideal behind the thought sense of the spirit, feel dissolved from all problems of puberty while taking them.	LSD Marijuana

ANTIDOTES

The overall antidote is to take care of the 12 Senses. Also, Waldorf Education is prevention through curriculum.

During the first 7 years one must pay attention to the care and development of will. The baby comes in with 4 senses - touch, balance, life, movement. These four make it possible for the child to come into the physical body. The senses of balance and movement are attacked today.

An essential moment is when the baby tries to straighten up - to pull itself up. This occurs three times: first in the body between 1 and 7, the second time in the soul between 8 and 14, the third in the spirit between 15 and 21. If it is interrupted as a baby, it prevents the other two from happening. The will is then attacked.

The sense of balance is attacked by the overuse of the automobile - we need walk more to feel our own sense of balance.

The feeling senses make the child feel welcome to life. Saying YES to life is important. If the child's authority figures are not able to say YES with their being, the child will not be able to say YES. You need sympathy in early years to carry you through life. Forces of sympathy act like a life-saver for life.

We must try to keep the forces of antipathy from coming to the child too early in life. With antipathy comes the negative forces of life- soul pain is created, and they could seek a pain-killer like heroin.

In the Middle years the following four senses are important to develop: Smell, Taste, Sight, and Warmth. All need high sensitive activity. Are we tasting real or synthetic food? The sense of smell is so sensitive it will adapt quickly - open the windows, let fresh air in the room.

The sense of Warmth is most important with relation to drugs. Do the children have the right clothes on? Pay attention to, though, that they are not too warm.

The best drug prevention is to make children move, be active, in a physical way, a soul way, and in a spiritual way. Why? Because the Ego is movement, not fixed.

Passivity induces the tendency to drug addiction. TV watching does the same, TV fixes the eye. Eye movement involves both the nerve-sense and blood processes. The eye must be active to perceive; the eye moves at a certain

rate,, the bright spot on a TV screen moves at two times that rate, so our eye cannot grasp it. Our eye gives up, sits back, stays open, inactive while all the pictures happen in front of it.

This is analogous with drug use. One takes a drug, sits back, and watches the pictures.

A new attack on senses is a special reality called "cyber-space" (Virtual Reality).

This experience takes away our judgment which is the function of the Ego.

A *Gameboy* is a great attack on the development of thinking in ages 7-14. Forces mold the organs in ages 1-7; the same forces develop thinking in ages 7-14. The *Gameboy* attacks the Etheric Body directly.

A solution for parents is not to say NO's, this is too dogmatic. Rather the parent should be able to explain why things are harmful.

Also there should be no access to computers before the age of 9 because the etheric body is forming.

Waldorf teachers bring soul pictures in the first school years - these strengthen the etheric forces for life.

CONTRADICTIONS

A "pure" Waldorf child became a heroin addict at the age of 14. Why? All parents and teachers do is only part of what is going on. Destiny is at work as well. The therapy for this 14 year old was easy because of background and education.

A question lives within me, do some youths seek to experience drugs as a way of pursuing an initiation they left incomplete in a past life?

We are all in struggle for liberation. We need to acknowledge we are all struggling human beings. Do we really love this century? Children incarnating now with a Melancholic look (I don't want to be here).

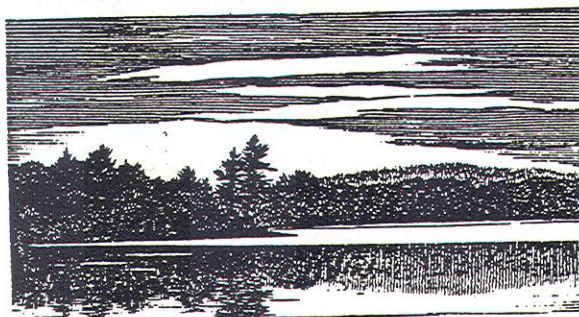
In my opinion the disposition to addiction in early childhood all come down to not being engaged. They are the passive watchers, the ones not playing.

Creative fantasy play for children, which takes place in a calm space is a form of meditation and promotes the capacity to meditate in adulthood.

The task of Waldorf Kindergarten now-a-days is to be a therapeutic center.

Those of us born after 1949 need 100% sense-stimulation in order to make our brain react. The curve of addiction increases along with use of TV.

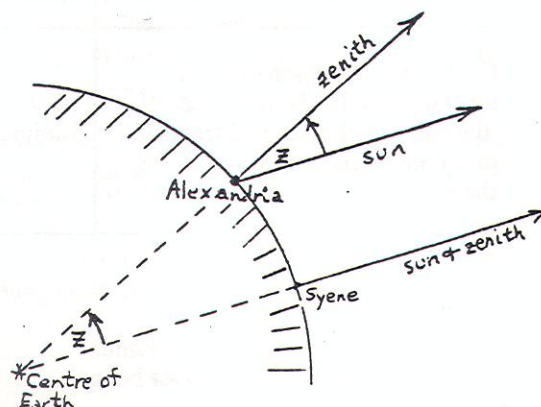
Why is it that Huck Finn never become addicted? The answer is simple, because he really enjoyed and was engaged in the realm of creative fantasy in early childhood!



Eratosthenes Revived A very large scale grade 10 Surveying Project

In November, 1993 Joe Proskauer, who was teaching a block at the Washington Waldorf School, phoned me at the Toronto Waldorf School and proposed that together we repeat the experiment of Eratosthenes (276-195 B.C.) who measured the circumference of the Earth.

Eratosthenes lived in Alexandria and knew from travelers' reports that the city of Syene was approximately 5000 stadia due south of Alexandria and that the bottom of the well in Syene was lit by the noonday sun on the day of the summer solstice. On the summer solstice, he measured the angle of the sun from the zenith in Alexandria. This angle would equal the differences in latitudes between the two cities, since the sun was directly overhead in Syene at the time.



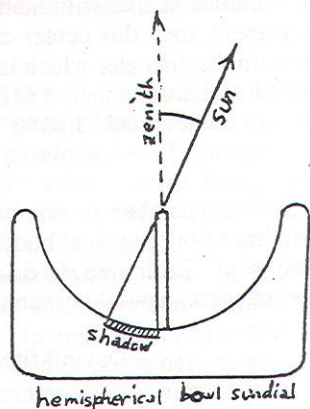
Actually, to be more precise, he measured the arc length of the sun's shadow on a hemispherical bowl sundial (a device which tells time at any latitude) and also the circumference of the hemisphere. Then using:

$$\frac{\text{circumference of earth}}{\text{Syene to Alexandria}} = \frac{\text{circumference of sundial}}{\text{shadow length}}$$

he calculated the circumference of the earth to be approximately 250,000 stadia which translates into the remarkably accurate figure of 25,000 miles. (Although the exact value of the stadium is uncertain.) It is interesting to note that less accurate estimates made later became widely accepted and thus led Columbus to underestimate the distance to the Orient.

To reproduce the experiment we kept in touch by phone to find a day when it was sunny both in Washington and in Toronto. It just so happens that when I was courting my wife I lived near the Toronto Waldorf School and she lived a few blocks from the Washington Waldorf School. So I knew very well indeed the driving distance between the two schools. It is 500 miles exact to within a couple of miles with Washington almost due south of Toronto. By a charming coincidence this is almost exactly the distance from Alexandria to Syene. However, to account for the drive around Lake Ontario and the winding of the road through the Appalachians, we took 400 miles as an estimate of the north south distance from Toronto to Washington.

Joe Proskauer, Bob Zelenka, and the grade 10 class in Washington fashioned a 16" diameter clay bowl hemispherical sundial. (After an attempt to make a portable one failed, they successfully made one in place.)

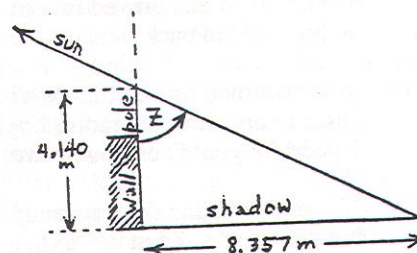


They found the longest shadow to have an arc of 8". This meant that the angle of the sun to the zenith in Washington was:

$$Z_W = 8" \times 360^\circ / (16" \times \pi) = 57.3^\circ$$

In Toronto the grade 10 advanced mathematics class tied a broom handle in a

vertical position to the railing on the top of the link to our new wing. (See diagram below.) We marked off the tip of its shadow on the ground below every few minutes from about 15 minutes before local noon until 15 minutes after. (The tip of the shadow was blurred due to the sun having a significant diameter. It would probably work better to use a large board with a small hole in it instead of the stick.)



This meant that the angle of the sun to the zenith in Toronto was:

$$Z_T = \arctan(8.357 / 4.140) = 63.65^\circ$$

From this we calculated that the two schools have a difference in latitude of $Z_T - Z_W = 6.35^\circ$, and that the earth has a circumference of $400 \text{ miles} \times 360^\circ / 6.35^\circ = 22,677 \text{ miles}$. This was not as accurate as Eratosthenes' result. It helped us appreciate the greatness of Eratosthenes' achievement and made for great fun besides.

Reference: Cleomedes "De Motu Circulari Corporum Caelestium." in *Greek Astronomy* by Sir Thomas Heath, Dover, Mineola, New York, 1991.

— Marty Levin

PLANE GEOMETRY

(our second takeoff based on Lewis Carroll's *Jabberwocky*)

"T was Euclid and the theorem pi
Did plane and solid in the text;
All parallel were the radii,
And the angles convexed.

"Beware the Wentworth-Smith, my son
And the loci that vacillate!
Beware the axiom, and shun
That faithless postulate!"

He took his Waterman in hand;
Long time the proper proof he sought –
Then rested he by the XYZ
And sat awhile in thought.

And as in inverse thought he sat
A brilliant proof, in lines of flame,
All neat and trim it came to him.
Tangenting as it came.

“AB, CD,” reflected he –
The Waterman went slicker snack
He Q.E. D.'d and proved indeed
He trapezoided back.

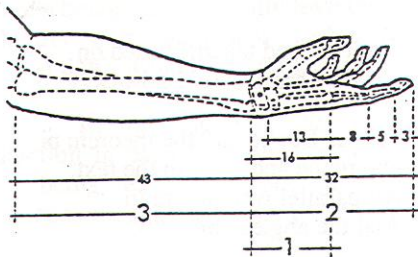
“And hast thou proved the 29th?
Come to my arms, my radius boy!
O good for you! O one point two!”

“T was Euclid and the theorem pi
Did plane and solid in the text;
All parallel were the radii,
And the angles convexed.

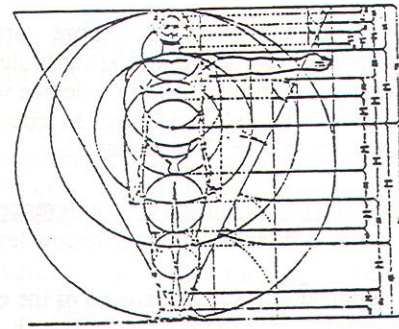
– Emma Rounds

THE GOLDEN NUMBER

God did not neglect the divine proportion in his masterpiece, mankind, who is a little cosmos joining all creation to it's God. In the temple of our body, God locked the blueprint of creation, as He locked within our soul the Living Image of the Trinity. The human body, with legs and arms outstretched, may be encased within a pentagon. In the human hand, the length of the first phalanger (the first bone up to the joint) in our fingers multiplied by 1.6180 gives approximately the length of the second phalanger. The length of these two bones gives approximately the length of the third phalanger.

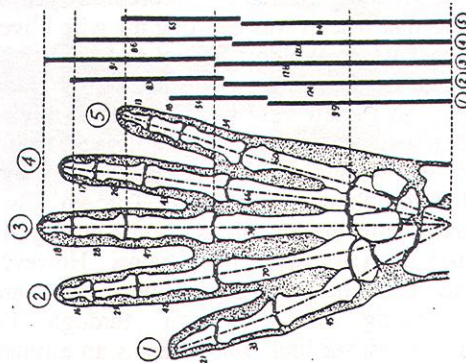


The length of the hand up to the wrist joint multiplied by 1.6180 gives the length of the forearm.



When a man stands erect, the distance from the ground to his navel, multiplied by 1.6180, gives his total height.

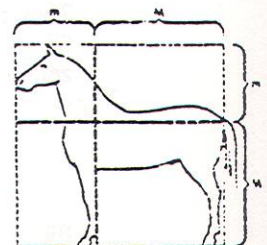
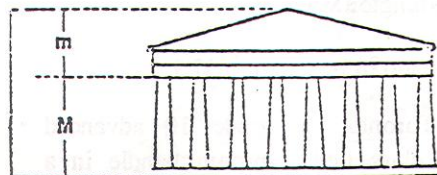
The human face may also be analyzed harmonically into many golden rectangles.



Even our blood carries the “golden imprint,” for it is capable of imposing when in a supersaturated solution of copper sulfide in the process of crystallization, a form in which a center appears. If the person from whom the blood is taken is in good health, and with neither alcohol or drugs present, then this center can be located at a point on the diameter which is .6180 of the whole width. This number “.6180” is of course the golden number and “1.6180” is its ratio.

The golden number is not only as it were, the “number of our physical body,” it penetrates our very soul. Each time we discover the golden number at work, natural or man made, we recognize it.

– David Mitchell



The following is an excerpt from *Foundations of a Phenomenological Approach to Chemistry* by Frits Julius, Book II. It is being translated by a teacher from New Zealand and should appear soon from Lanthorn Press in England. Meanwhile, perhaps this can serve as a stimulus to a better understanding of how our Waldorf approach extends right into dealing with technical subjects and yet preserving the living aspect of nature.

— John Petering

IV. EDUCATIONAL GUIDELINES FOR A CHEMICAL FORMULA LANGUAGE.

1. FORMULAS IN CHEMISTRY AS A PROBLEM.

As soon as we take account that everything we do with the students works on them formatively or mis-formatively, then particular methods and forms of thinking, which are usually viewed as self-evident, become a serious issue.

Learning about chemical formulas, for example, has a deep influence on the concepts which people develop about the nature of matter and material processes. This also works indirectly on the perceptual life and thereby generally on the whole inner life. A very far-reaching process of abstraction must be accomplished before we can express a chemical transformation in terms of a formula or a chemical reaction equation. This easily leads to ruining the living connection which the human being ought to have with the processes of nature. An extensive and diverse activity of nature is expressed in a rigid and all-to-simple conceptual schema.

If we study Steiner's curriculum plan, it is quite evident that he placed the greatest value on the *development of concepts about material substance, which are as living as possible*, and above all about what occurs in the realm of each substance. His indications in the Conferences¹ show that he viewed it very favorably if no formulas could be used in school lessons. In most cases this would be unavoidable since formulas are widely used in other schools. And a compromise is already available here.

In order to resist them somewhat, we should allow them to be developed from well-evaluated viewpoints. Then it is not too difficult to find a good side to the formulas as we introduce them. We can practice the skill of abstracting, which plays a major role in modern life and

which many students can only acquire with great effort. Naturally, we must take care that the abstraction process is carried out step by step, and that each step is completely understood before we go further. Each step should be practiced so that each student can grasp it with confidence.

It does not appear possible to me, if we wish to follow the curriculum indications, to utilize formulas in their decisive form and with their associated quantities before the 11th grade. This conviction has several bases. First, the syllabus content for 9th and 10th chemistry lessons do not afford us time to build a basis for the formulas. Second, before the students have reached the level of maturity of 11th grade, they are generally not in a condition to form completely clear concepts of the basis of the formula system on their own. Third, the particular [dynamic] forms of thought which we have learned to be of special importance for the 10th grade, and which can be expressed in a particular formulation, would be eliminated or at least rendered less effective [by spending a lot of time using formulas].

The curriculum for 10th grade gives us initially the task to create a systematic foundation for chemistry as a scientific edifice. We have to begin with salts, and through their decomposition and dissociation, develop the acids and bases. We are firstly bringing the students in contact with a particularly characteristic *process* of analysis [breakdown], and we are careful that they receive a living concepts of it. Afterwards, as we bring acid and base together for the first time where salt will arise again, then the concept of chemical combination can arise. Also, we are following a methodology which starts out from the members of a whole, a whole *as we find it in nature*. To bring the parts together again is the next step. With the dissection [analysis], there remains in addition to the whole, the foundation for our concepts and explanations. The analysis, in our conception, does not cause the elimination of the whole, but *occurs within* the whole. The whole becomes even fuller and more living through analysis; it spreads itself as an ordering principle over all the various substances which arise thereby.

In this view, if we now want to introduce formulas at the beginning, then we would be considering everything from the basis of the final decomposition products. And, we would be sacrificing the whole, with all that we are able to observe in it.

We have here an especially clear instance of a problem, which we referred to in our introduction. In such an abstract approach,

¹ Conferences, Volume 7, March-December 1923; see 4/24/23

we would be placing our own capacities [of analytical thinking] and our human methods of thinking into the foreground, putting Nature in the background and allowing her to speak too little.

If for example, we say "CuSO₄," and mean 'copper sulfate' [or better yet 'blue vitriol,' the older common name rather than the formal IUPAC chemical binary name], then in so doing we bring to expression that we are not focusing on seeing the well-formed, blue, transparent crystals which lie before us, but rather orienting our attention to the fact that we can build this substance out of three chemical elements in certain weight relationships.

Now, in my treatment of the lesson content for the 10th grade lessons I have not only used simple word equations, where the substances were referred to by name, but I have also even introduced a certain kind of formula. On the other hand, when in this way we refer to a salt as 'BA,' someone can also object that writing it this way no longer expresses the whole. The advantage, however, of the overview this provides overrides this problematic aspect. If we write the formula in this symbolic way and compare it to the usual formula with subscript numbers, we can see that it affords a much clearer overview.

If we start out from base replacement:

copper sulfate + soda lye → sodium sulfate +
copper alkali (copper hydroxide)

then the following symbolic formula can work to clarify things by its simplicity:



In the usual chemical formula equation, in contrast, so many conditions and thoughts are included, that initially it doesn't contribute much to clarifying anything:



A formula such as BA is not an indication of a particular substance anyway, as is the case with CuSO₄ but rather much more a shorthand indication of a natural law [bases react with acids].

2. ABOUT THE ESSENCE OF CHEMICAL COMPOUNDS AND THE PRINCIPLE OF IMPERMEABILITY

Textbooks often begin with the formation of iron sulfide out of sulfur and iron powder. We start with a warm, yellow powder

and shiny, metallic granules. These are mixed in a definite weight relationship. Then we heat a part of the mixture to glowing heat. The glow spreads, and so to speak eats its way throughout the entire mass. As long as we have a mixture, we can still separate the two powders from each other without much effort. Each has its own characteristics: iron is magnetic, sulfur easily melts and even becomes volatile. After they have chemically reacted, we have an indivisible mass with entirely new characteristics. All the characteristics of iron and sulfur have disappeared, except the weight. If we pour dilute sulfuric acid over the iron sulfide, hydrogen sulfide gas is liberated, which is recognizable by its incredibly bad smell. This is a new characteristic. The magnetic and ease of melting are no longer present.

The principle of impermeability, in my opinion, is valued too little in everyday physics and chemistry, since it points to one of the most significant, distinguishing marks of matter. One defines 'matter' as "that which fills space."² "Our sensory perceptions are based upon an extension in space, which we call matter."³ "That which fills space, which acts upon our senses, we call matter or substance. A 'body' is anything of substance which fills a definite space."⁴

A contemporary formulation of the principle of impenetrability related to the above runs: "...at that place in space where one body is, no other body can be at the same time."⁵ There is a correction which Steiner made which is especially important for our work. "One should say: those bodies or beings which are of such a nature that where they are in space, no other body of the same nature can simultaneously be, they are impermeable."

In this way Steiner indicates again and again how in the fundamental definitions and formulations of scientific statements, we can either pursue a direction which leads irrevocably to materialism, or a direction which leaves the possibilities open that there are still higher realms where other laws hold sway.

In general we can say: impenetrability applies for matter; penetrability for everything which is of a spiritual nature. For things which take place on the spiritual plane it is noteworthy

² R. Steiner, "World of the Senses", Hannover 1911-'12, GA 134, Lecture IV

³ R. Steiner, "Goethe the Scientist" (Goethe's Natural Scientific Writings), Vol. IV, 2, p. 209

⁴ Lommel, Textbook of Experimental Physics, 1913, Leipzig.

⁵ R. Steiner, "Study of Man" end of Lect. III

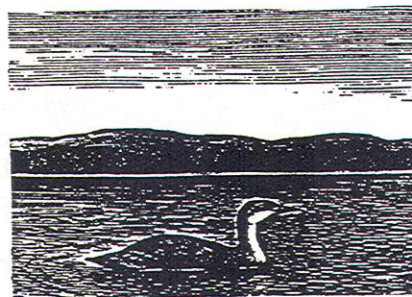
that it is possible for two different beings to occupy the same place.

That which occurs with chemical combination is an occurrence in the physical world which appears to follow spiritual laws! Something takes place between two material bodies, which otherwise usually occurs between spirit- or soul-beings. We will see that this understanding has far-reaching consequences. Here we have found a clue which ought to lead us further into deep mysteries of creation.

In any case there exists a difference in level [planes] between the occurrences in the mechanical domain, in which impenetrability plays a large role, and those in the chemical realm, where we already find that mutual penetrability of being and character of substances comes to the fore.

Before we go further into the essence of [chemical] combining and reactions, we want to show that the fundamentals we have developed up to this point are already sufficient to develop a clear insight into the principles of the formula-language. One can forthwith employ the topics which follow in 11th grade lessons.

In the next sections, Julius describes how we can use the Cannizaro method as a phenomenologically-based way of establishing the 'elemental' weights of the 'elemental substances.' But, even though this is an abstracting, analytic process, this method is still based on actual phenomena, not on theoretical smallest entities. Certainly we will discuss the various underlying philosophical issues and viewpoints in 11th and especially 12th grade courses, but at least this method 'leaves open the possibilities.'



THE PROPERTIES OF ACIDS AND BASES

The following properties are of a general nature. Not all substances considered to be acids or bases do necessarily exhibit all of these characteristics. They are meant as guides by which one can determine what kind of substance one is studying.

CHARACTERISTICS OF ACIDS

1. Properties of "air" and "fire"
2. They have a sour, burning taste.
3. They have a prickly pungent odor.
4. They form watery mists (acid rain)
5. They turn blue litmus paper red.
6. They are found in our stomachs.
7. When we exercise our muscles create them.

PROPERTIES OF BASES.

1. Properties of "earth" and "water".
2. They have a soapy, bitter taste.
3. They are almost odorless.
4. They tend to dry things out.
5. They turn red litmus blue.
6. Most are insoluble in water.
(exceptions - Na, K, Ca, Ba, NH_4^+)
7. They are found in our intestines.
8. When we sit still and think we create them.

DSM

The following article by Walter Lebendörfer which follows is a shorter version of what Julius discusses in the remainder of Chapter IV. For those who did not have the pleasure to meet Dr. Lebendörfer at the science conference in 1990, he works at the teacher training institute in Jarna Sweden, and knew Frits Julius personally. Thus it is appropriate for his indications to follow this introduction.

- John Petering

1. CHEMICAL EQUIVALENT

Acid + Alkaline (* Hydroxide) $\rightarrow$ Salt + Water + Warmth
(* We have translated hydroxide in the Swedish to Alkaline.)

The above formula describes qualitative changes.

Acid and Hydroxide disappear - Salt and Water and Warmth are freed.

Quantitative Relationships:

One can do it so that 1 litre of acid neutralises 1 litre of hydroxide solution. Acids and hydroxide solutions then have the equal or equivalent concentrations.

1ltr nitric acid neutralises e.g. 1ltr potassium hydroxide solution, by volume.

if nitric acid contains 63.05g nitric acid/1ltr solution

and potassium hydroxide solution contains 56.16g pot. hydroxide/1ltr solution.

This quantity of potassium hydroxide neutralises as well 1ltr of solution containing:

36.46g hydrogen chloride/1ltr of solution,

or/

49.04g of hydrogen sulphate (sulphuric acid / litre of solution), or

36.46g hydrogen chloride (hydrochloric acid) is equivalent to:

49.04g hydrogen sulphate

63.05g hydrogen nitrate

and 56.16g pot. hydroxide

In this way, you can spin a web of equivalent weight relationships.

Equivalent Quantities

Acids

HCl	36.46g
H ₂ SO ₄	49.04g
HNO ₃	63.05g

Alkalis (Hydroxides)

NaOH	40.06g
KOH	56.16g
Ca(OH) ₂	37.07g

These quantities are within this system equivalent.

2. The Stoichiometric Laws

One can destroy copper oxide and get copper and oxygen. If one weighs the quantities one can, for example, get the following quantities:

copper oxide	50.00g	
copper	39.95g	= 79.91%
oxygen	10.05g	= 20.09% (i.e. these weights can be gained experimentally)

Another example of weight analysis:

1.750g carbon dioxide	gives up 1g oxygen, 0.750g carbon
1.875g nitrogen oxide	gives up 1g oxygen, 0.875g nitrogen
1.126g water	gives up 1g oxygen, 0.126g hydrogen

If one works with just these quantities or with other quantities - there will always appear the same weight relationships. This is also true for combining substances - they unite in the same particular weight relationships.

This phenomena is summarised in the law of constant weights proportions:
(1st Law of Stoichiometry)

"Different substances combine and unite to form new compounds in certain fixed weight proportions."

Both with synthesis and analysis, the weight of the participants (reactants) equals the weight of the products, as far as one can weigh them. This is described as the Law of Constant Mass in chemical reactions. (In nuclear chemistry a part of the mass is lost and warmth appears).

3. Equivalent Weights

The proportion of weight (e.g. 8:1, 16:2) can be substituted with fixed equivalent numbers. The lightest substance, hydrogen, has been chosen as the standard or basis for equivalent weights. So Hydrogen has been given the equivalent weight of 1. (Later this figure has been changed to 1.008. One did this so that oxygen could be given the whole number equivalent weight of 8).

Equivalent weights of a substance in grams is that weight which can bind or substitute or drive out 1.008g of Hydrogen.

Example:

1.008g Hydrogen unites with 8g of oxygen.

8 is the equivalent weight for oxygen.

The equivalent weight of hydrogen chloride is 36.46g, because such a weight mass frees 1.008g of hydrogen, when the acid reacts with the metal.

Mercury unites with oxygen in the proportion 100:8.

Mercury's equivalent weight in this compound is then 100.

Mercury in its turn unites with Sulphur in the number relation 100:16.
Sulphur's equivalent weight becomes then 16.

1.008g Hydrogen unites with 35.45g chlorine.

35.45 is chlorine's equivalent weight.

4. Multiple Proportions

Nitrogen builds with oxygen many different compounds. All of them are nitrogen oxides, but they have different specific qualities. One of the oxides is a colourless gas, another a brown-red gas, a third works anaesthetically and is called laughing gas. Quantitative analysis shows the weight relations between nitrogen and oxygen are different between the different nitrogen oxides.

Oxide	I	II	III	IV	V
Nitrogen	63.64%	46.68%	36.85%	30.44%	25.93%
Oxygen	36.36%	53.32%	63.15%	69.56%	74.07%

The above number relationships can be simplified.

In the first case, the relationship is:- $\frac{63.64}{39.36} = \frac{1}{x}$

$$x = 0.572$$

In the same way, the others can be simplified:-

$$\frac{1}{0.572}$$

$$\frac{1}{1.14}$$

$$\frac{1}{1.71}$$

$$\frac{1}{2.29}$$

$$\frac{1}{2.86}$$

The oxygen amounts (numbers) relate to each other with the following relationships: 1 : 2 : 3 : 4 : 5

i.e. $\frac{1}{0.572} \quad \frac{1}{1.14} = 2$

$$\frac{1}{0.572} \quad \frac{1}{1.71} = 3 \quad \text{etc.}$$

If you take oxygen as the starting point (standard) with its equivalent weight of 8, then the equivalent weight of Nitrogen can be calculated.

With oxide 1, the weight relation is:-

$$\frac{63.64}{36.36} = \frac{y}{8} \quad Y = 14g$$

Nitrogen's equivalent weight in oxide 1 is 14g.

For the second nitrogen oxide (no.2) one can calculate Nitrogen's equivalent weight as 7g etc.

Oxide	1	11	111	1V	V
oxygen equiv.	8	8	8	8	8
nitrogen equiv.	14	7	4.67	3.5	2.8

The Englishman, Dalton, summed up these experiences in the second Stoichiometric Law.

Law of Multiple Proportions (Second Stoichiometric Law)

The elements can sometimes make compounds in more than one weight proportion. If that is the case, the reacting weight amounts of the same elements are related to each other as small whole numbers. (the highest is 1 : 7)
The following number relationships exist:-

$$1 : 2, 1 : 3, 1 : 4, 1 : 5, 1 : 6, 1 : 7, \\ 2 : 3, 2 : 5 \text{ etc.}$$

A consequence of this Law is that one and the same element can have different equivalent weights in different compounds.

5. Dalton's Atomic Hypothesis

Equivalent weights are directly taken from the perceptions of the chemical reactions. They repeat (review) the quantitative chemical reality and do not represent any other hypothesis or theory. They are, however, impractical because one and the same element can have different equivalent weights in different compounds. For example, Carbon in Carbon Monoxide has equivalent weight of 6g. (6g Carbon unites with 8g oxygen)
Carbon dioxide - carbon has equivalent weight 3g (3g Carbon unites with 8g oxygen).

The Englishman, Dalton, tried in the beginning of the 19th century to form a mechanical model mental picture, which was to 'explain' the Stoichiometric Laws. He thought of a gas mass made out of many small, in principle, indivisible, but concrete particles. These unchangeable particles were thought to enter into bonds with other particles of another character and, more importantly, another weight. Dalton thought that through a chemical reaction the atoms were bound together into aggregations.

Dalton didn't know how many atoms existed per volume unit. Due to this, he couldn't decide the atoms' absolute weight in grams. Instead, he tried to create the relative atomic weights. He put the lightest element (Hydrogen) as having an atomic weight of one. Then he tried to decide how much another atom of another element was in relation to a hydrogen atom.

Important Points of Dalton's Atomic Hypothesis 1803

- Atoms are completely unchangeable and particulate.
- Atoms' form and weight are different for each element.
- Atoms of the same element are alike.
- Atoms are bound together as aggregations without changing.
- The weight of a certain compound is the same as the combined weights of the participating atoms.

The modern atomic theory diverges from Dalton's in many important ways. Dalton was the first researcher to picture the concrete atoms and also the first one to interpret the lawfulness of chemical reaction an atomic way.

The concept atom has its origin in the Greek Philosopher, Democritus, but with him, the atom was a principle - a pure concept - which he won from pure thinking. He imagined that all bodies, even those of the Gods, consisted of atoms which are indivisible.

"A - tomos" means 'impossible to divide'.

(Individuality is related to the atoms - What do you think of that?)

6. Volume Relationships in Chemical Reactions

Guy-Lussac did research on volume changes in chemical reactions. He showed that:-

2 volumes of Hydrogen + 1 volume of oxygen → 2 volumes water vapour
1 volume Hydrogen + 1 volume Chlorine → 2 volumes hydrogen chloride (gas)
3 volumes Hydrogen + 1 volume Nitrogen → 2 volumes ammonia (gas)

Guy-Lussac summarised his results in the law:-

Law of Guy-Lussac (1808)

Gases unite always in simple rational volume proportions. If in a reaction of different gases, the resulting compound is a gas, in that case, the volume of the new gas is in a simple ratio to the volumes of the reacting gases.

Guy-Lussac and Boyle found in their research that all gases change their volume in the same way if temperature or pressure are varied.

The above law is only true if temperature and pressure are standardised to 760mm Hg. and 0°C (so called normal conditions).

7. The Formula of Water

Experimental Measurements:

volume relationships : 2 vol hydrogen + 1 vol oxygen $\rightarrow$ 2 vol water vapour
weight relationships : hydrogen combines with oxygen in the relationship
1 : 8.

Problem: To make a reaction formula out of weight and volume relationships.

A way to write the formula:

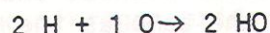
The symbol O means oxygen, and H means hydrogen.

The number in front of the symbol means gas volumes.

The small numbers behind the symbols refer to weight quantities of that element.

The symbol without a number refers to one weight quantity.

If we write the reaction formula only with respect to volumes, it is written as follows:-



$$\begin{array}{ccc} (2 \times 1.008) + (1 \times 8.000) & \neq & 2 \times (1.008 + 8.000) \\ 10.016 & & 18.016 \end{array}$$

This was a problem where one possible solution was offered by Avagadro's Theory.

8. Avagadro's Hypothesis

The Italian, Amadeo Avagadro, interpreted (1811) Guy-Lussac's Law atomistically. He postulated that:-

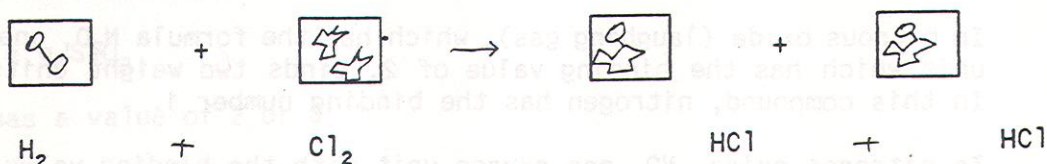
"Equal volumes of gases contain the same quantity of free moving particles if they have the same temperature and pressure."

Guy-Lussac had also imagined particles, yet he could not understand why out of one volume of chlorine and one volume hydrogen, he got 2 volumes hydrogen chloride instead of one volume of hydrogen chloride. He had another picture of it and thought that the particles in hydrogen and chlorine were atoms.

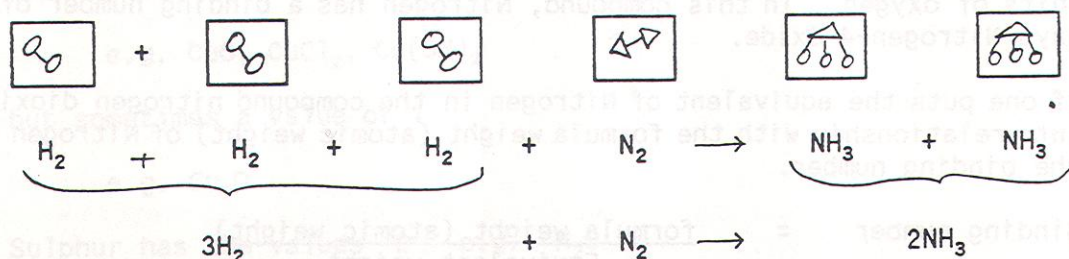
Guy-Lussac's interpretation:-



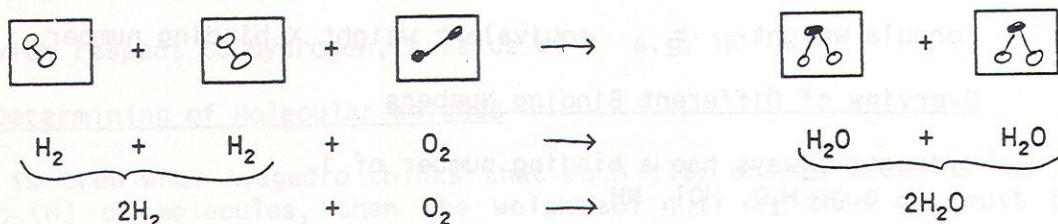
Avagadro believed that the particles in the gases should not be simple atoms, but larger combinations which he called molecules:-



Avagadro's interpretation of the synthesis of ammonia:-



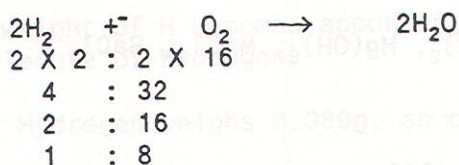
Avagadro's interpretation of the synthesis of water:-



By this interpretation, the symbol H_2 means one molecule of hydrogen and the symbol H means one atom of Hydrogen, the coefficient 3H_2 means 3 volumes or 3 molecules of hydrogen.

If we accept Avagadro's postulate, we can write the formula of water as H_2O .

Dalton tried for a long time to understand the formula of water as HO (of course he used another formula language than ours). Dalton also searched for a standard weight for oxygen and other elements instead of the variety of different equivalent weights which we find empirically in analysis (see Multiple Proportions). Now it was possible to think such a standard and one called it atomic weight or formula weight. It became 16 for oxygen and 1 for hydrogen.



10. Binding Value (Valence)

When water is synthesised out of Hydrogen and Oxygen, one weight unit of Oxygen combines with 2 weight units of Hydrogen and we get the formula H_2O . One says Oxygen has a combining value of 2 with respect to Hydrogen whose combining value is 1.

In nitrous oxide (laughing gas), which has the formula N_2O , one oxygen weight unit which has the binding value of 2, binds two weight units of nitrogen. In this compound, nitrogen has the binding number 1.

In nitrogen oxide, NO , one oxygen unit with the binding value 2 unites with one nitrogen weight unit with the binding value 2. For this reason, one says Nitrogen 2 Oxide. In Nitrogen Dioxide, NO_2 , Nitrogen unites with 2 weight units of oxygen. In this compound, Nitrogen has a binding number of 4. One says Nitrogen-4-Oxide.

If one puts the equivalent of Nitrogen in the compound nitrogen dioxide (3.5) into relationship with the formula weight (atomic weight) of Nitrogen one gets the binding number.

$$\text{Binding number} = \frac{\text{formula weight (atomic weight)}}{\text{Equivalent weight}}$$

$$= \frac{14}{3.5} = 4$$

$$\text{Formula weight} = \text{equivalent weight} \times \text{binding number}$$

Overview of Different Binding Numbers

Hydrogen always has a binding number of 1.

e.g. H_2O , HCl , NH_3

Oxygen as a rule has a binding number of 2.

e.g. H_2O , Cl_2O , H_2O_2

Alkali metals

Na

K

Li

always have a value of 1.

e.g. K_2O , KOH , $NaOH$, KCl , $NaCl$

Alkali earth metals

Mg

Ca

Ba

always have a value of 2

e.g. CaO , MgO , $Ca(OH)_2$, $Mg(OH)_2$, $MgCl_2$, $BaCl_2$

Aluminium has a value of 3.

e.g. Al_2O_3 , $Al(OH)_3$, $AlCl_3$

Carbon has as a rule a value of 4

e.g. CO_2 , CH_4

but it can also have a value of 2

e.g. CO

Silica has as a rule a value of 4

e.g. SiO_2

Iron has a value of 2 or 3

e.g. FeO , FeCl_2 , Fe_2O_3 , FeCl_3

Copper has a value 2 normally

e.g. CuO , CuCl_2 , Cu(OH)_2

but sometimes a value of 1

e.g. Cu_2O

Sulphur has the values 2 e.g. H_2S

4 e.g. SO_2

6 e.g. SO_3

The Halogens: fluorine chlorine bromine iodine

have with respect to hydrogen, a value of 1 e.g. HCl

11. Determining of Molecular Weights

If it is true what Avagadro thinks that each 1ltr of gas contains the same number (N) of molecules, then the weight of 1ltr of this gas must be N multiplied by the formula weight of the gas.

In other words:

The weight of a molecule (molecular weight) is according to Avagadro is proportional to the weight of a litre of the gas.

1ltr of oxygen weighs 1.429g

1ltr of hydrogen weighs 0.089g

It could be possible to take the litre weight of hydrogen as molecular weight and to choose 0.089g as the standard molecular weight, but as one had earlier chosen 1.009g of H as the standard for equivalent weights, one chose 2.00 as the molecular weight of H. i.e. 2g. of H as the gram molecular weight.

The atomic weight of H becomes according to Avagadro equal to 1. (2 H atoms make one molecule of Hydrogen)

Now 1ltr of Hydrogen weighs 0.089g, so one needs:

$$\frac{1 \times 2}{0.089} = 22.4 \text{ ltrs Hydrogen gas}$$

to get 2g of Hydrogen.

One calls the volume of 22.4ltr the mole volume for Hydrogen. according to Avagadro's Hypothesis, we need 22.4ltrs of all other gases to get one mole (or gram mole) of the different gases, i.e. equal amounts of grams as the molecular weight.

If we know the weight of a litre of gas, we can determine the molecular weight:

$$\text{Molecular weight} = \text{litre weight} \times 22.4$$

$$\text{Litre weight} = \frac{\text{Molecular weight}}{22.4}$$

12. Modern definition of the concept "mole"

Loschmidt's number or Avagadro's number; N_A . Earlier, when a mole was spoken about, it meant that it was the molecular weight of a substance in grams. Since the 1960's, the mole has been defined differently and based on the calculations which the Austrian physicist, Loschmidt, first did in 1865. Loschmidt looked for a certain number of particles (atoms, molecules or ions) per molar valence, i.e. 22.4 litres of a gas under normal conditions (0°C , 760mm Hg.). He remained satisfied with determining the molecular number of air. According to Avagadro's Hypothesis (equal volumes of a gas contain equal numbers of particles), the result would be true for all gases.

Later he confirmed more exactly the measurements for this particle number per mole volume. This verification relied mainly on two methods which gave the same result.

The First Method

One decides the electrical elementary charge with Millikan's experiment. Then, with the help of the laws of electrolysis, one can decide the sum of the charges in one gram of substance, then only 1 or 2 or 3 elementary charges are connected with one atom and then one gets a value for the number of ions. Avagadro's number. The precision of the measurements depends on the precision of the determination of the elementary charges.

14. How to determine an empirical formula

It is particularly important for the chemistry of Carbon.

a) Purification of a Substance by distillation crystallisation etc.

b) Qualitative Analysis of the Substance

What element can we get off the substance, for example, by burning? If we get CO_2 , it indicates that we had a carbon compound, if we get some condensation of H_2O , it indicates that we had a hydrogen compound.

c) Quantitative Analysis

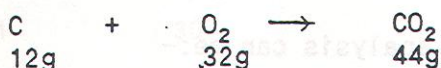
A weighted amount of a substance is to be burned in O_2 . The burning takes place in a combustion tube or in a burning oven. The gases evolved should be circulated in the presence of glowing CuO . If H is evolved, it will form H_2O , which absorbs in a previously weighted amount of CaCl_2 . CO_2 reacts with weighted amounts of potassium hydroxide or other bases in a test tube. The weighing must be very accurate. For modern times, one can do micro and ultra micro analysis. One can determine proportions of very small amounts. A substance by chromatography and by x-ray diffraction analysis.

d) Determination of the Empirical Formula

For a given compound, one has obtained the amounts (weights) of each element that made up that compound. Now we can determine the proportions in which these elements combined to make the compound. These proportions are expressed in the number of moles. One mole is the amount equal to the formula weight (atomic weight or molecular weight).

Example 200g ethanol has been analysed into 374g CO₂
235g H₂O

Carbon and O₂ react in the following way:



374g CO₂

If 44g CO₂ → 12g C
374g CO₂ → X

$$> \frac{44\text{g}}{374\text{g}} = \frac{12\text{g}}{X}$$

$$X = \frac{(374\text{g})(12\text{g})}{44\text{g}} = 102\text{g of carbon}$$

Using the similar calculation for H₂ we get 0.261g of Hydrogen. The rest is oxygen since no other elements were found.

The % composition of ethanol is:-

52% C
13% H
35% O

The atomic weight of Carbon is 12

1 mole of carbon = 12g

100g of ethanol is composed of 52g of Carbon. How many moles of Carbon are represented in 52g Carbon?

$$\frac{52}{12} = 4.33 \text{ moles of Carbon}$$

$$\frac{13}{1} = 13 \text{ moles of Hydrogen}$$

$$\frac{35}{16} = 2.2 \text{ moles of Oxygen}$$

Carbon	:	Hydrogen	:	Oxygen
4.33	:	13	:	2.2 or about
2	:	6	:	1

The Empirical Formula could be:-

$C_2H_6O_1$ but multiples could also be appropriate, for example:-

$C_2H_{12}O_2$ or $C_8H_{24}O_4$ etc.

Which of all of these possibilities correspond to the right value?
We cannot choose until we find the molecular weight.

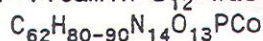
e) Determination of Molecular Weight

Using Victor Meyers or determination of the lowering of the freezing point or raising of the boiling point methods one can determine the molecular weight to be 46. Therefore, the formula must be C_2H_6O

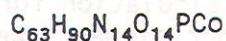
Practical difficulties in the analysis can be:-

- i) one has made a mistake in the recognition of an element.
- ii) one has not fully isolated all the elements that make up the compound.
- iii) too large a molecular weight.

Example: in 1950 the MW of vitamin B_{12} was found to be



in 1955



15. Determination of Atomic Weight

One and the same element can have different equivalent weights depending on the compound.

Dalton could not conceive of multiple combining weights between two substances. He could only conceive of one combining weight between two substances. Empirical results show, in fact, that multiple equivalent weights exist.

The ratio of atomic weight to equivalent weight, we shall call the combining number.

$$\text{Combining number} = \frac{\text{Atomic weight}}{\text{equivalent weight}}$$

One method used is:-

- a) determination of weight relations between the elements that form compounds.
- b) determination of molecular weight.
- c) the lowest quantity of the element in question is the atomic weight of that element (provided that we know all compounds formed by this element).

Example: the determination of the atomic weight of Carbon

<u>weight relations of</u> <u>Carbon compounds</u>	<u>molecular weight</u>	<u>lowest quantity</u>	<u>formula</u>
C : O _a 3 : 4	28	C _a = 12 O _a = 16	CO
C : O _b 3 : 8	44	C _b = 12 O _b = 32	CO ₂
C : S 3 :	76	C _c = 12 O _c = 64	CS ₂
C : H _a 3 : 1	16	C _d = 12 H _a = 4	CH ₄
C : H _b 12 : 11	26	C _e = 24 H _b = 2	C ₂ H ₂
C : H _c 12 : 1	78	C _f = 72 H _c = 6	C ₆ H ₆
C : H _a 4 : 1	30	C _g = 24 H _d = 6	C ₂ H ₆

The lowest value for Carbon in all compounds was 12. Therefore, we can assume the atomic weight of Carbon to be 12.

Other methods give similar results.

POSSIBLE POINTS FOR CLASS DISCUSSION

What do the inventors of the following have in common?

- Radioactivity • COBOL
- terramycin • nuclear fission
- radium • apgar score
- rabies vaccination
- smallpox inoculation

Who was it that

- founded ecology as a science?
- was known as the foremost industrial engineer in the world in the year 1972
- figured out the necessary calculations that allowed the atom to be split?

What all of the above have in common is that they were all women.

If you would like to enrich the history of science in your classrooms by having more material on the contribution made by women you can write for a packet of information from:

National Women's History Project
7738 Bell Road
Windsor, CA 95492

I especially enjoyed the brief biographies which included astronaut Judith

Resnick, theoretical physicist Shirley Jackson, my great aunt astronomer Maria Mitchell, primatologist Dian Fossey, anthropologist Margaret Mead, geneticist Barbara McClintock, and nuclear physicist Chien-Shiung Wu, to name a few.

Posting these biographies for the students to read generated confidence and discussion amongst the girls in the class, especially.

— David Mitchell

BOOK REVIEW

When teaching life science in the high school, as well as the grades, it is valuable to be able to quote directly from naturalists to give the students a picture of how they expressed their observations.

The Princeton University Press, 1988, has published *THE BOOK OF NATURALISTS, An Anthology of the Best Natural History*, ISBN # 0-691-02408-1 which adequately fits these needs.

Some of the contents include:

Aristotle – *Fishing-Frogs, Cuckoos, and other things.*
Pliny – *The birth of Pearls*
J. Arthur Thomson – *About Tadpoles*
John Muir – *The Water Ouzel*
Jean Loius Agassiz – *The Aims of an Expedition*
Alexander von Humbolt – *The Jungle River*

John James Audubon – *The Wild Turkey*
Rachel Carlson – *The Odyssey of the Eel*
Vilhjalmur Stefansson – *Foxes, Owls and Polar Bears*
Thomas Belt – *Driver Ants*



This book should be in every school's faculty library.

– David Mitchell

The editors would be grateful to receive books, together with a brief synopsis, that you have found helpful in your science preparation.

The following article was kindly submitted by Mark Rigner, and could serve as food for thought as to how we can foster a better awareness of this important aspect of our relationship to the cultural and natural environment. See also the current issue of *Orion* magazine, Volume 14, Number 2, Spring 1995.

What is Home?

by Doug Hulmes

Tell of what Home is – snow and fir forest are Home.
from the first moment they are ours.
Before anyone has told us that it is snow and fir forests,
They have a place in us, and since then it is there,
always, always. Come home. Go in there bending branches –
Go on 'til you know what it means to belong.

Norwegian Poem by Turgei Vesaas

To the Seri Indians living along the west coast of Sonora on the desert coast of the Sea of Cortez, Home is not a building, it is more a sense of place, it is the land, the plants and animals that live there. It is the sea, the desert, the wind, the stars, and the ancestors whose spirits live among the desert plants and speak to them in dreams. It is generations of wisdom handed down through the centuries of how to survive in a harsh arid landscape. It is the knowledge of plants that ripen during different seasons providing a steady source of food, of secret water sources hidden in remote desert canyons. To the Seri Indians, Home is where The People have lived and died, and where their songs, dances, and myths reflect their closeness to the land.

To most Americans, home is a house, the people and possibly the animals that live in the house, and perhaps the yard around the house. For most Americans, they have lived in many houses, in many places. Most Americans live far from their parents, and even farther from their grandparents. Few Americans know much about the lives of their ancestors, and perhaps do not even know where they originally came from. They have few stories handed down from generation to generation, and have at best a very superficial knowledge of the place where they live. Unfortunately, most Americans have little sense of place, and very little that reflects a closeness to the land.

It is possible, that due to technology, television, automobiles, airplanes, and even spaceships, that American are broadening their sense of place and Home to the Earth. Many young people, when asked to draw their Home draw the Earth. Perhaps the loss of wisdom and knowledge of a particular place is evolving to something larger. Perhaps.

I believe it is the ultimate role of the environmental educator is to help remind us of the place we live ... our Home. I believe it is the role of the environmental educator in our culture to remind us of the wisdom handed down by past generations of people who have seen the changes, experienced the hardships and blessings of the land, and remind us of the mistakes made by a culture struggling to survive in a new land that they knew little about. The 19th Century myth that rain would follow the plow caused the death and suffering of thousands of people during the dust bowl and numerous other drought cycles of the Great Plains, and arid Southwest. The Americans who moved there know little about the land and how to survive without water. Technology has helped against the odds, but for how long? History repeats itself, and there are too many examples of past civilizations who have fallen because they exceeded the carrying capacity of the land.

Environmental educators are the teachers of the wisdom given to us by Ecologists, who in the words of Aldo Leopold are the doctors of the land, who "see the marks of death" or sickness, and are beginning to understand how the land stays healthy. Environmental educators must also understand the relationships of history and culture, science and politics, economy and ecology.

Our culture has forgotten that the words ecology and economics come from the same Greek root *ΕΧΟΣ* (ecos), which means Home. Ecology is the study of the Home, while economics is the management of the Home. How can we possibly understand the relationships of ecology and economics if we have lost the meaning of Home?

The following outline could be viewed as a way for us to discover our home. It could be a thematic unit or entire school curriculum. It is a way of seeing the connections between subjects that for too long have been taught without seeing their relationships to each other, and to Home. It is the role of the environmental educator to help us find our Home.

I. What is Home?

*[Possible subject areas in the
Waldorf High School Curriculum]*

1. Geographical and Ecological Overview *[9th gr. Geography]*
 - a. How was the landscape formed? *[9th gr. Geology]*
 - b. What is your home's watershed? *[9th gr. Geology]*
 - c. How does the climate and weather influence the land? *[10th Geology]*
 - d. What plants and animals live or have lived there, and how did they adapt to the land? *[Gr.11 Botany] [Gr.12 Zoology]*
2. Cultural Overview
 - a. Who lived here before us? *[10th Native Americans block]*
 - b. How did they live?
 - c. What was their impact?
 - d. Why did they leave? *[10th Ancient History?]*
3. European/Historical Overview
 - a. Who came to this region? *[19th Century American History]*
 - b. Why did they come? *[language classes]*
 - c. What was their impact?
 - d. How did their attitudes towards the land differ and how did they change?
4. Contemporary Cultural Overview *[Gr.9, Gr.12 Cultural Geography]*
 - a. Who lives here now? *[Composition, essays]*
 - b. Why are they coming? *[language classes]*
 - c. What are their impacts?
 - d. How do they view the land and their Home (Anthropocentric, Biocentric or Ecocentric?)
5. What will happen to our Home? *[Gr.12 Cultural Geography]*
 - a. What do we want to happen to our Home? *[Composition, essays]*
 - b. What can we do to take care of our Home?

II. How can we as environmental educators help to integrate a sense of place and Home into our educational systems?

1. How can we show the relationships of subjects taught in school to better educate about our Home?
2. How can we teach people to care? *[undertone for all Waldorf classes]*

The hope for our culture may lie in the understanding that Home is not just our house. Home is also our neighborhood, community, bioregion, state, country, and the planet Earth. We have much to learn. In the words of Barry Lopez,

"Whatever evaluation we finally make of a stretch of land, no matter how profound or accurate, we will find it inadequate. The land retains an identity of its own, and still deeper and more subtle than we can know. Our obligation toward it then becomes simple: to approach with an uncalculating mind, with an attitude of regard. To try to sense the range and variety of its expression – its weather and colors and animals. To intend from the beginning to preserve some of the mystery within it as a kind of wisdom to be experienced, not questioned. And to be alert for its openings, for that moment when something sacred reveals itself within the mundane, and you know the land knows you are there."

—Barry Lopez, *Arctic Dreams*, p204

Doug Hulmes teaches in the Environmental Studies program at Prescott College, and coordinates the Environmental Education Curriculum.

WALDORF ENVIRONMENTAL CURRICULUM

Subjects from the Waldorf Curriculum in Relationship to Environmental Education

	KIND.	1,2	3	4	5	6	7	8	9	10	11	12
STUDY OF MAN	↑	↑		Developed out of the animal kingdom	History	Nutrition and hygiene	Man as synthesis of the animal kingdom, nutrition, health	Inner organs, sense organs skeleton (overview)	Muscles, skeleton, homeostasis	3-Fold process in man, Embryology and the development of the infant	Cytology (Microcosm) History	12-Fold animal kingdom in relationship to man Zoology, (Metamorphosis) Evolution
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
ZOOLOGY	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
BOTANY	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
GARDENING/ AGRICULTURE	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
ENVIRONMENTAL STUDIES	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
PRACT. SKILLS FIELDTRIPS	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
GEOGRAPHY	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
CHEMISTRY	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

WALDORF EDUCATION / ENVIRONMENTAL EDUCATION

The following is a synopsis of an program developed at the Rudolf Steiner School in Zürich on the environment and environmental education. Thanks to Arthur Auer for bringing this article to our attention.

– David Mitchell

The following subjects in the Waldorf Curriculum have a direct relationship to environmental study:

The study of man ought to describe man and women in a step by step way (coming from an understanding of the whole and pictorial) in detail. In the 8/9th grade we study the skeleton, in the 10th grade the organs and organism.

The study of Geography holds the counter-point. The child learns first about his closest surrounding and knowledge is expanded to countries, continents, physical geography of the earth (10th) and the earth in the cosmos. (11th). Here, Mankind and Earth, two pillars of knowledge, are woven together. Earth and man always relate, depend, interact. Both subjects (Man/Earth) lend itself to the discussion of environmental problems, especially in grade 10. The physiology of man and the ecological cycles are main topics. For example toxins/poisons and ecological balance are connected to the quality of our food and health. The bruised "skin" of our earth will bruise our skin.

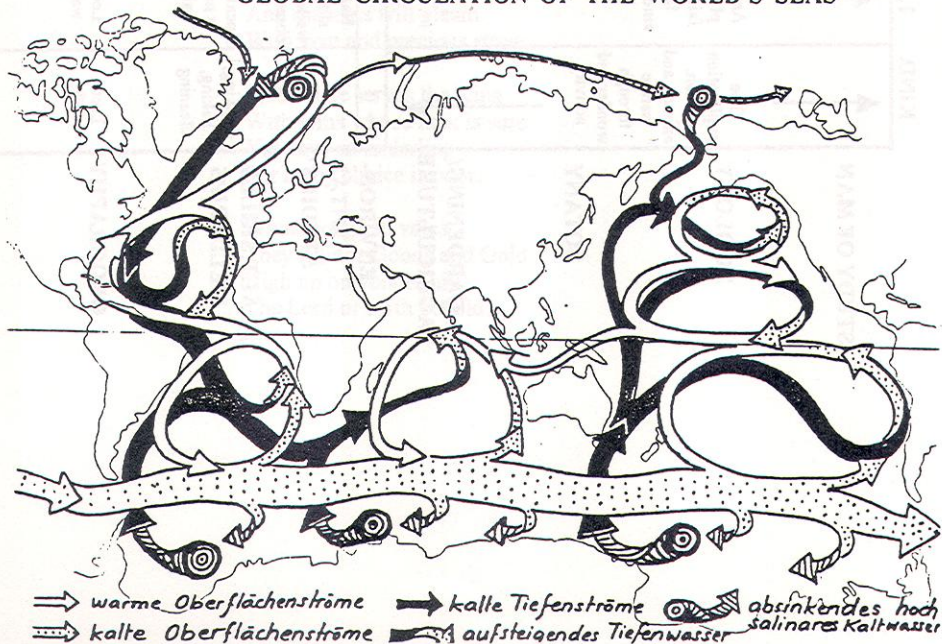
Chemistry provides an opportunity for further discussion as well as a more concrete examination of the substances which make up the earth and our own bodies. The study of Botany and Zoology should be taught in connection with the subject Man/Earth in the elementary school. In grades 6-10 it should be taught with emphasis on the practical; gardening and the care of the earth should be emphasized. In High School we look beyond the school environment. We do practical work on field trips: 9th - farming; 10th - surveying and forestry; 11th - industry; and 12th - ecology.

All Waldorf students should take part in the care of the immediate surroundings. They should be provided with the opportunity to care for indoor plants and have a garden.

In 9th grade Geography a goal of the teacher might be to develop a model of the physical geography with examples from: Atmosphere, Hydrosphere, Lithosphere, teaching that earth is a large living organism. This should not be a theory, backed-up and proved by example, but should develop from the observations and thoughts of each individual student.

Another example could be the study of Tropical Currents. The Pacific, Atlantic and Indian Oceans all show characteristic patterns of circulation. The Atlantic and Pacific have individual patterns which mirror itself at the equator. The Indian Ocean, however, changes its spin twice in the course of a year. This is only to be grasped if one has undertaken a previous study of wind emanating from the tropics, Plate tectonics and the rotation of the earth. Water temperature holds certain laws, which should bring up further questions. A closer look at the deeper ocean currents is the key to finding answers. Deep currents develop very differently; the cold/heavy salt water sinks in the polar regions and flows back to the equator on the bottom of the ocean. The currents are guided by the shape of the bottom of the ocean as well as the continents and are forced to the surface. The connection between topical and deep currents is a complex exercise in spatial imagination and - simply put - is a world-wide circulation system of five spatially twisted (turned) lemniscates. The water quality continuously changes from: warm/cold; CO₂/O₂; salt/non-salt, which are the result of the sun and its orientation to earth that changes position rhythmically between the northern and southern hemisphere yearly.

GLOBAL CIRCULATION OF THE WORLD'S SEAS



Oceanographers estimate that the water of all 3 oceans circulates the earth once in 10 years. All this is determined by the tides which is connected to the monthly rhythms of the moon. Finally, the water circulation between oceans and atmosphere, i.e., evaporation, rain and the system of rivers and streams should be integrated into the knowledge of the currents of the earth. The entire atmospheric water is exchanged within 10 days. We gain here a picture of a multi-leveled system of circulation, an organism of the currents of the earth.

Teaching about the human circulation, its rhythms and organs will reveal amazing parallels and can be discovered by the students themselves. The earth is not a warmth-energy-machine, but a living and very sensitive organism. This can be the lesson beyond the material and can lead to further discussion about environmental prognoses.

The pollution of the earth can be studied parallel to the human body and one can propose - as in human illness - that there is a hope for the forces of self-healing. Many ecologists find this to be amazingly the case. This should not, however, encourage or be an excuse for further exploitation of the earth. The forces of self-healing can only begin if toxins are stopped and a "doctor" will support the life-forces. We humans are the only possible "doctors". It is hopeful that many Waldorf graduates have incarnated with the purpose of fighting for this cause.

The following is an example of forestry in grade 10 and how one looks at the environment. Three aspects are of importance for this block:

1. Man has had experience working in unison with nature and understands our capacity to strengthen nature's life-forces. Such study is the most concrete answer to questions about acid rain and the dying forests. Do not exclusively stress this point (man working in unison with nature), but discuss society and its values as well. Approach this study consciously taking into account the age and crises of the students.

2. Develop in the students a new understanding and perception as they relate to the passing of time in history; they are sensitive to the earth's "biography" through the awakening of their own and vice versa. When we cut down an ancient tree we interrupt a process of maybe two hundred years. We harvest a natural resource-transformed sun-force - which renews itself (if taken care of). From cradle (wood!) to coffin (wood!) it accompanies us through our lifetime. Wood can "warm" us physically and spiritually. Plow, wheel and ships, all made from wood, are landmarks in the cultural history of man. Today we do not only fell trees to exploit nature, but to rejuvenate life itself.

We plant young trees and clear areas to plant more. These saplings lead us as far into the future as our old mans/woman's stories lead us into the past. We stand in the present, actively forming the earth. Such understanding at this age will present a life-help/orientation and can help student's to grapple with the stress of environmental problems.

3. The third aspect is the solidarity between men. Helping a community by volunteering to care for "their" forest should be experienced, especially by young city people. This also teaches social responsibility and respect, particularly to those youngsters who merely "consume" the country and mountains as a vacation/resort area.

Method of Teaching

Using the development of the leaf-structure/shape (leaf metamorphosis) can illustrate how the process of becoming can be recognized in the manifested form. Through exact (precise) observation the student can re-experience the development of the plant and inwardly take part in the process. If the student follows the life-process both with sensitivity and with consciousness it will soon become clear that there is a lawfulness to be found in all living (things) plants. The students can only come to recognize this if they stand back, take their ego out of the observation and begin to "listen" very carefully until the plant will "reveal" its secret. This method, of stepping back, a method Goethe utilized consciously, is in itself a moral-ethical one. It is a fundamentally Christian orientation - "not I, but the other being in me" (not I, but Christ in me) which deeply influences how one relates to the world around one. As contrast, the teacher can quote Francis Bacon (17th century) who envisioned a yet unheard of power of man (over nature): "Let us dissect and torture nature, so that she may reveal her secrets to us," in order to create anew a paradise on earth.

Outlook

Modern science has and is following Bacon's views, not Goethe's. Nature has pulled back, retreated from man, and kept her secrets guarded. We can only begin to change this through an education which acknowledges the creative forces in both man and nature, and which can see the connection between the spiritual in man and nature. If one listens to youth today, one will hear a new tone - new forces are emerging: there is emerging a new brotherhood with nature, and a new sense of fairness toward the

"weaker" creations can be seen. The arrogant approach of the contemporary scientist is a relic of the last century. Education must create the circumstances in which courage is fostered and furthered.

Courage and joy of life can grow if teachers and parents do the following:

- Restore trust in the spiritual and moral capacity of man.
- Make visible the wisdom of nature and enable to become sensitive to the life forces of the earth.
- Teach responsibility for the development of the earth as a whole living being.

This work begins with the education of the parent/teacher themselves. It is an interesting fact to note that those students who had to care for small animals or/and were taught to take care of their daily surroundings were much more willing to act on environmental problems. A study done on a grade in Zürich showed similar results. Family life in general had a significant role to play in environmental awareness.

The fundamental question is, Can one teach "Environmental Studies"? One first needs to develop holistic thinking. It is generally agreed that holistic thinking is undermined by virtue of the school structure itself – subjects, ages(grades), aptitude, performance, general studies, specialized studies, all are separate and divided.

These structures may be useful for an educational system. However, we must ask ourselves what is missing in order to foster a healthy relationship to nature and the environment. Two fundamental abilities are necessary:

1. The ability to empathize with our environment leading to a true stirring of our souls. The ability to be deeply touched which leads us to love the beings of nature.
2. The willingness to act and the capacity to act – in other words the transformation of our feeling and thinking into willing. This process is nothing less than the manifestation of the moral forces of man, for not in speaking but in doing is his morality revealed.

The actual question then is: Can one teach love, morality (ethics, action, deeds) through insight?

Environmental Studies Through "Inner world" Studies

Today love and morality (ethics) are not teachable in the traditional sense, because the development of a human being is an individual matter. These values can be awakened at the right age out of the personal inner world of each, can slowly grow into a sense of self and can then grow into the experience of the world. We can conclude then that "Environmental Studies" can only be successful if it has a human dimension, taking into account the inner world of the student. The body, soul, and spirit must be nourished according to appropriate age. We must therefore go deeper and ask, what does the child/student need to develop in as harmonious way? We must not ask, what must I teach so that the student acts environmentally conscious? The answer can only be found in a realistic study of man. If the child's development is harmonious and he or she is not alienated from nature, it can be expected to become environmentally conscious. It is important on the one hand to experience a relationship and connectedness to nature and on the other to recognize man's special place within nature that carries responsibility for nature. We must also find a world view which does not see the world(earth) as a coincidental, mechanistic dead thing, but a being which speaks to the child through its various kingdoms.

Both the method and the content must be contemplated and be appropriate. The analytical method may be right for physics but is inappropriate for the living, soulful or spiritual realm.

The child must experience three fundamental things before entering puberty:

1. (0-7) Trust in the world, imitation should lead to the subconscious expectation: "the world carries me - it is good."
2. (7-14) Discovering the own inner realm which holds pictures of the world around but is larger than just a mirror image. Living pictures can be re-enlivened through the imagination, and remembered. Living pictures can be transformed and brought to expression. In relating to the being of the earth a higher principle can be subconsciously experienced which then awakens the love for the earth/world/environment/surrounding.
3. The artistic realm in doing and observing must be cultivated so it will lead one to a dialogue with the world.

The Task of Education with Respect to the Environmental Crisis

In puberty the students step back from their "old" relationship to the world. They begin to judge and observe with criticism. Things can be seen more negatively and the world as it is (i.e. not ideal) must therefore be rejected. This awakening is painful but necessary and often leads the youngster into loneliness and distress. The "old" view is fading and yet still found to be true –youngsters begin to realize that in order to create a more ideal world, human beings must act in ethically/morally sound ways. The tension between inner(ideal) and outer(real) world will lead to a search for truth. It is now very important what the teenager finds within himself as real substance. Being entirely thrown back on himself the soul-realm of childhood is crucial.

These inner conflicts stand side by side with others such as the environmental problems. The environmental crisis, however, bears within it a fundamental problem: the death of nature and life forces leave a picture of hopelessness and an empty future. It is dangerous to confront students at a young age intellectually with negative subjects. If they are pressed into being critical and distant they are denied the opportunity to experience a positive emotional connection to the world. They then cannot act out of this experience but also cannot come to sound objective judgments which often leads them to disinterest and inactivity.

If the youngsters find within themselves and trust that "the world is good" and can also find the correct experiences (jewels of childhood) then they can come to realize: "the spiritual within me can find a way to the spiritual in the world - I am not hopelessly separated from the world." By teaching a so-called "enlightened natural scientific" world view, we hasten this isolation. Science today harbors separateness as a philosophical dogma since Kant. The dichotomy of subject/object, inner/outer world is a basic criterion of scientific correctness. This world view essentially communicates that a deeper insight into the wonders/secrets of nature is an illusion. It thereby undermines the youngsters' search for truth.

Three tasks must be accomplished if one is to teach Environmental Studies including its crisis:

1. The students must feel competent to recognize the mysteries and laws of being through their own observation and thinking. Their search for truth must be supported through the creative, not the abstract and lifeless, or ready-made theories. Students must experience nature as a "dialogue partner". They can come to concepts and broaden their understanding as well as keeping their interest awake. Trust in the capacity to think and enthusiasm is strengthened. The method of teaching is crucial for establishing a relationship to nature.

2. All elements of the soul life which enabled a positive connection with nature must be tended to: love for others (and other creatures), love for beauty and the experience of creativity in harmony with the outer world. Artistic activity and a loving and artistic approach toward all elements in every subject can guarantee this.

During the phase of development when analytical thinking takes place, art can be used for its curative value and can help heal loneliness and a desolate soul condition.

3. Finally, educating the adolescent must provide a practical field of activity, because of the students' tendency to be critical and the inability to direct action and will application, it becomes crucial to guide practical work beyond the school community into the "real" world. They must come to realize: "I cannot only complain about the bad world around me, I can contribute to a better world; I am able and needed."

The task of the teacher is to be a guide for the way as well as to be a true contemporary. The teacher's own mentors and their wrestling with a path ought to be visible to the students. This shouldn't happen by being a buddy, but rather by sharing life-experiences and insights. Students should be encouraged to question and think in a way that may open-up new perspectives. This is only possible if the teachers themselves are concerned with the wisdom of both the human being and the world, if he or she has found a point of view which is not rigid.



EXPERIMENTS

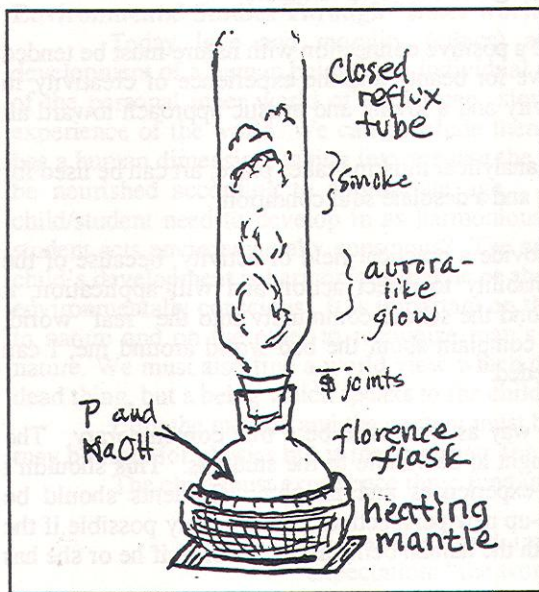
Gr11 - Phosphorous

IMAGES OF THE STARRY SKY WITH PHOSPHORUS

As always when working with dangerous materials, wear safety goggles and protective apron; use a fume hood and famaliarize yourself with the experiment beforehand. These experiments could be used in Gr. 11 survey of the elemental substances.

Phosphorus is a very labile, unstable substance, especially the more interesting white form (allotrope). This form melts at only 44°C , just a bit above body temperature and burns at 60°C still below boiling water temperature!

The first demonstration experiment uses a large 1,000 ml beaker. Carefully place 2-5 g white phosphorus in the beaker with tongs and begin gently heating it under 10% NaOH solution in the beaker. As the mixture exceeds 60°C , bubbles of phosphine gas will be produced, which can be captured under water and bubbled up in another flask. There they make little flashes as they burn in contact with the air.



Then, allow the bubbles to break on the surface of the large beaker, and they will form splatters on the wall of the beaker. After cooling the beaker and lye solution, and darkening the room, we can observe tiny speckles of glowing phosphorus on the beaker wall; it creates an impression like a bit of the starry night sky.

For a second experiment, we could attach a glass reflux column to a 500 ml boiling flask, and allow the phosphine fumes to boil up into the tube. As the oxygen is used up, some of the phosphine will form a region of glowing vapors, appearing somewhat like the northern lights.

Notice how the light created by phosphorus is a kind of cold light, in contrast to the brilliant light given off by burning magnesium. Phosphorus is a kind of 'fixed light.' Yet this is a very ephemeral phenomena - only the yellow phosphorus allotrope will do this; the red phosphorus form has lost this capacity to glow in the dark, and is much more stable, i.e., dead.

Again, in doing such experiments **exercise thoughtful care**, and perform the experiment with proper safety equipment and clothing!

EXPERIMENTS

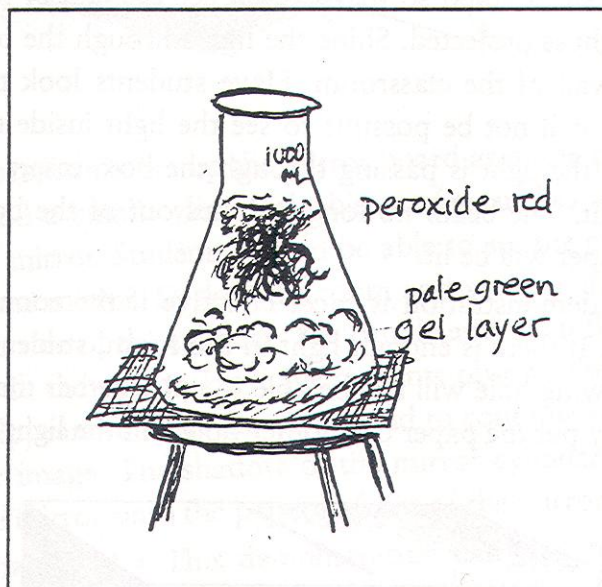
Gr 10 - Salts

IRON SALTS

Walter Lebedörfer contributed the following experiments. In order to live into the process of solution, we could observe the variations in color and crystal forms in the following, reminding us of various scenes and locales in nature. Iron is a very changeable substance, and its salts can take on a variety of colors and appearances.

In a 1,000 ml flask, make a saturated solution of lead (II) chloride, and as it cools, observe the tiny crystals which descend, like snowflakes.

In a 1,000 ml flask, prepare a 20% (wt) iron (II) sulfate solution; then slowly add hot 2M soda lye; observe the globular pale yellowish green gel formed (a metal hydroxide). Then, add dropwise, 5-10ml of hydrogen peroxide, and observe the color change as iron is oxidized to the ferric (III) form. Observe the overall triple color layer: red, pale green, darker yellowish-brown. Here we can see the red active form of iron, the darker basic form below, and the calm, green gel balanced between them.



EXPERIMENTS

The following six experiments were taken from Roberto Trostli's wonderful new book *Physics is Fun*. This book has over 400 demonstrations, 50 illustrations and is an invaluable source book for Waldorf teachers, and public school teacher in grades 6, 7, and 8. It is available for \$25 plus \$3 postage and handling (\$4 Canada) by writing to:

Roberto Trostli
The Harstbrook Waldorf School
173 Bay Road
Hadley, MA 01035

4. DEMONSTRATION

The Black Box

If it is difficult to have a blacked-out or dust-free room, the phenomenon demonstrated above can be demonstrated on a smaller scale.

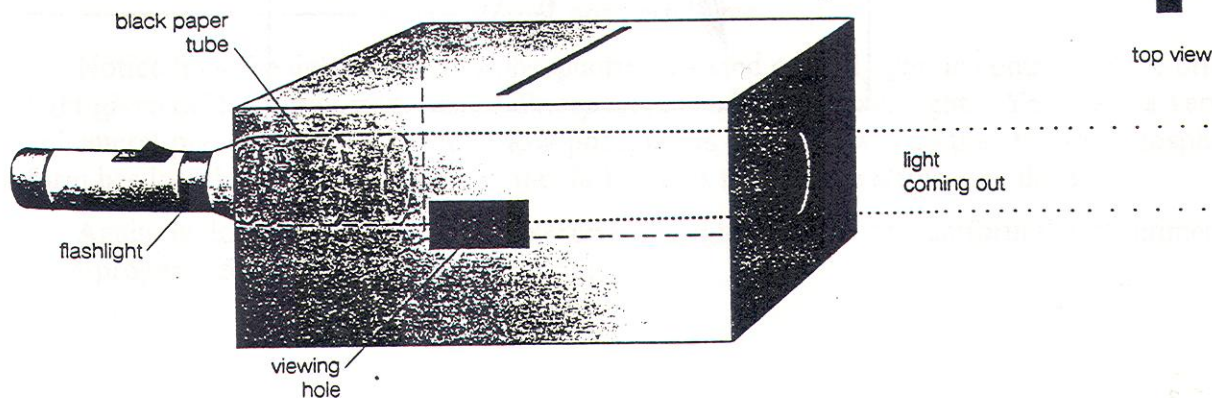
Procedure • Prepare the box by cutting circular holes through both ends of the box. Insert 3" of the tube into one of the holes and seal the joint between the tubing and the box with tape. The hole opposite the tube should be large enough to allow the light projected through the box to go through the opening and not shine on any part of the inside of the box. Cut a slit in the top of the box large enough to insert a slip of paper. Cut a rectangular viewing hole in the center of the front of the box.

Students should sit or stand so they cannot see the end of the tube out of which the light is projected. Shine the light through the box and illuminate the far wall of the classroom. Have students look through the viewing hole. It will not be possible to see the light inside the box itself. To show that the light is passing through the box, insert the slip of paper into the slit. The beam no longer shines out of the box onto the wall, and the paper will be lit.

Comment • This demonstration is most effective if the room is not totally blacked out. If there is enough light in the room, students looking through the viewing hole will not be able to tell whether the light is on or off unless they put the paper or another object in the light's path.

Materials:

a cardboard box painted flat black on the inside
a tube of cardboard or heavy paper
black tape
a flashlight or projector

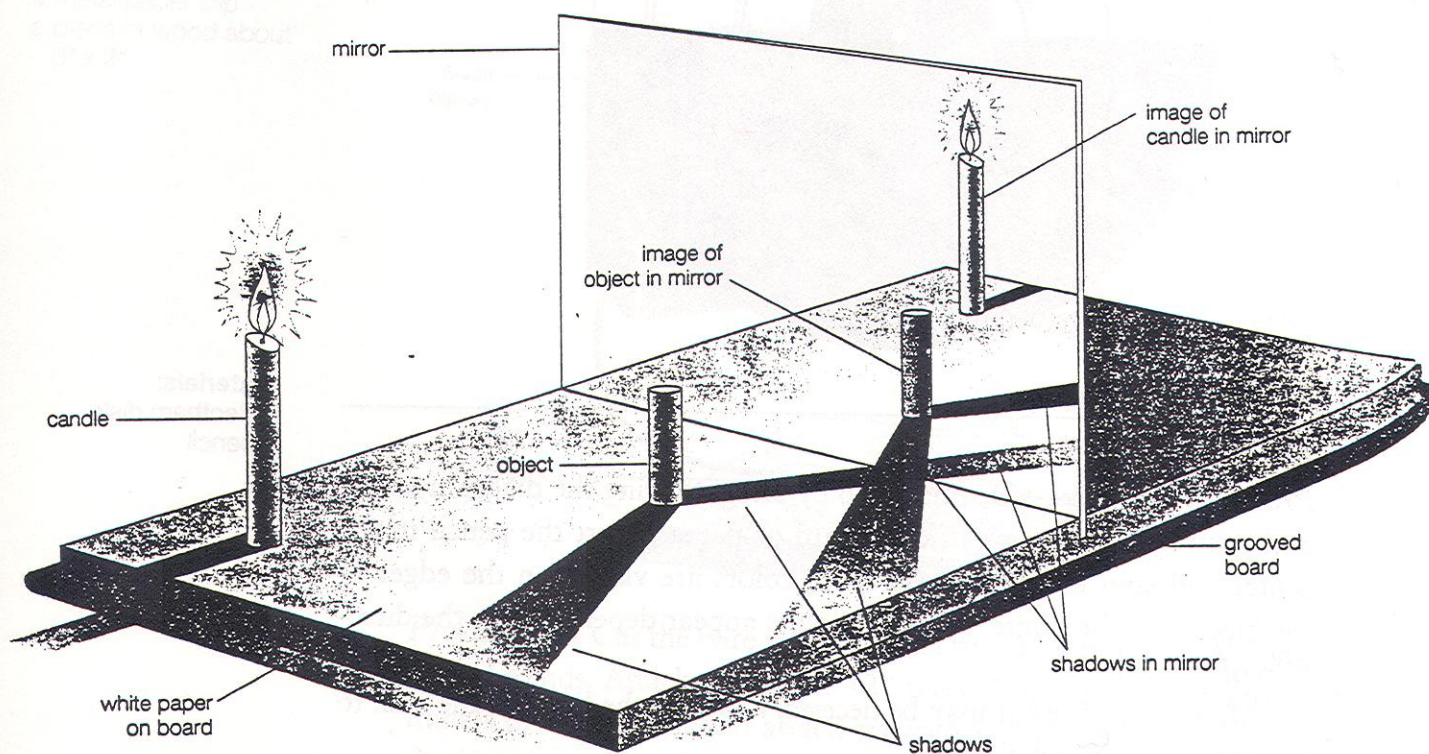


Materials:

a grooved board
a plane mirror
a piece of paper
a candle
matches
a small object

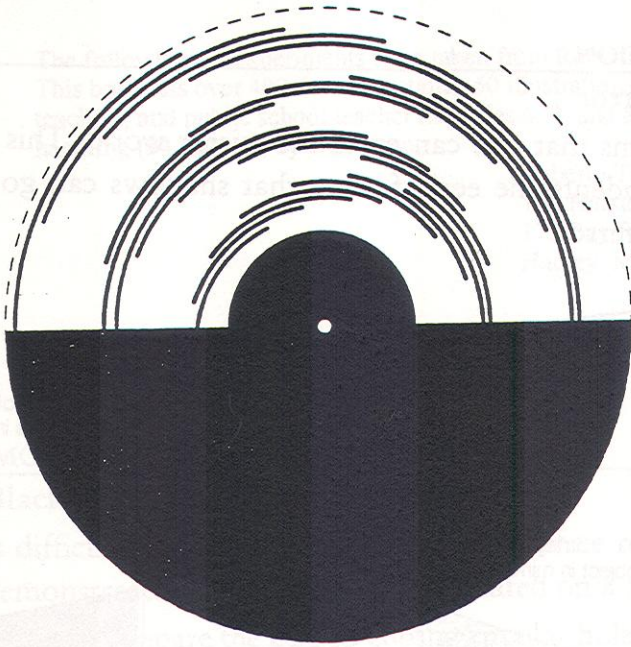
36. DEMONSTRATION**Shadows in a Mirror**

Sometimes it seems that one can enter the mirror world. This demonstration gives students the eerie feeling that shadows can go into or come out of the mirror.



Procedure • Set up the mirror board as in the previous demonstrations. Stand a small cylindrical object a few inches away from the center of the mirror. Students should be able to see the cylinder and its reflection in the mirror. Darken the room and set a lighted candle behind and to one side of the cylinder. The candle and the reflected candle will be visible in the mirror. Have the students observe the shadow of the cylinder. It appears to enter the mirror and to continue onto the paper in the mirror image. The shadow of the mirror cylinder appears to come out of the mirror onto the paper in front of the mirror.

Comment • This demonstration can lead to interesting discussions about the mirror world and serves as an introduction to the more formal laws of reflection.



24. DEMONSTRATION

The Bentham Top

Procedure • Make a Bentham top by photocopying the diagram above and pasting it on a disk of cardboard or paper. Insert the pencil in the center and spin the disk. As it spins, colors are visible on the edges of the black and the white. Different colors appear depending on the direction of the spin.

After a bit of use it may be necessary to tape the back of the disk to the pencil to prevent slippage.

Materials:

a Bentham disk
a pencil

25. ACTIVITY

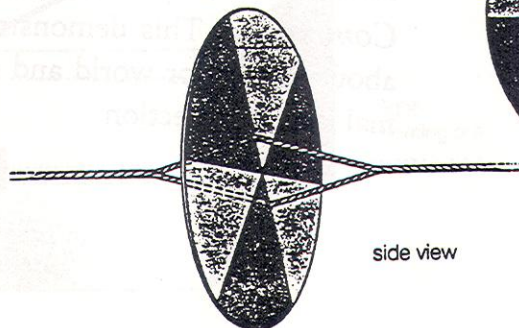
Making Simple Chromotropes

Procedure • Mark several 3" circles on the poster board and cut them out. Shade the circles in two or three colors on each side. The colors can be combined in various types of designs. Use the compass point or a sharp pencil to make two holes $\frac{3}{4}$ " apart from the center of the circle. Thread a 3 ft. piece of string through the holes and tie the ends of the string together.

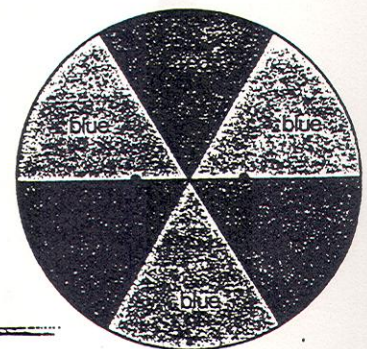
To spin the chromotrope, hold each end of the string loop and gently twirl the disk away from you. When the string is wound fairly tight, pull both hands apart, and the disk will begin to twirl. Alternately pull and slightly release the string as the disk nears the end of the twirl so that it will continue to spin. Observe how the colors mix to form secondary colors.

Materials:

pencil compass
white poster board
or oaktag
scissors
crayons or magic markers
string



side view



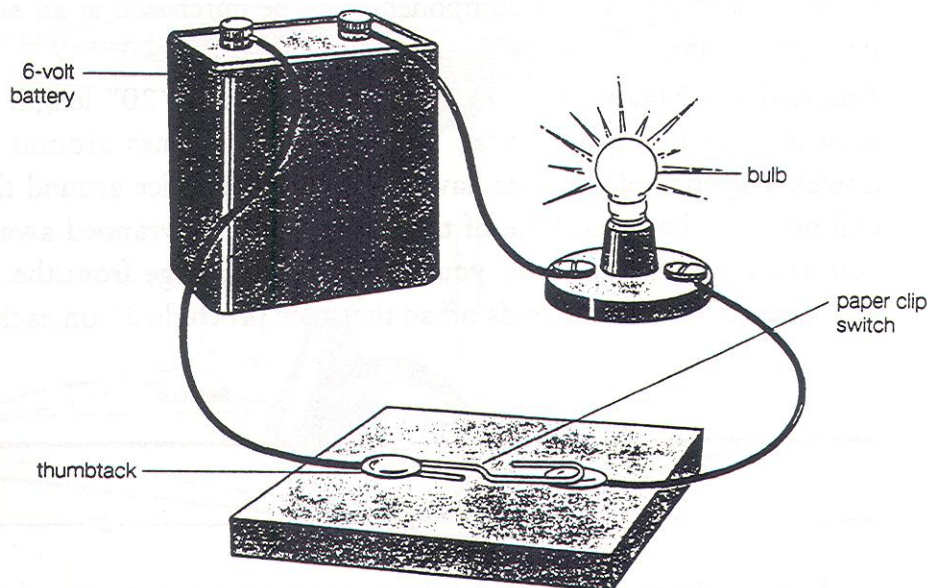
top view

Materials:

a 6-volt battery
insulated copper wire
a bulb
a bulb holder
two metal thumbtacks
a metal paper clip
a piece of wood about
3" x 2"

42. ACTIVITY**Making an Electric Switch**

Electrical switches control electricity by allowing electricity to flow or by stopping its flow.



Procedure • Cut the wire into 3 pieces, two 12" and one 24" long, and strip the ends. Attach one of the 12" pieces and the 24" piece to the terminals of the battery, and attach the two 12" pieces to the terminals of the bulb base. Test the circuit by touching the free ends of the 12" and the 24" pieces of wire. The bulb should light when the wires touch.

Open the paper clip so that it is in an "S" shape and wrap the free end of the 24" piece of wire around one end of the paper clip. Push one of the thumbtacks slightly into the wood; hook the end of the paper clip with the wire underneath the tack and push the tack the rest of the way so that it holds the paper clip firmly. Twist the free end of the 12" piece of wire around the end of the other thumbtack. Push in the tack underneath the free end of the paper clip. The tack might have to be slightly raised so that when the paper clip slides over it, there will be good contact.

To operate the switch, slide the paper clip so that it touches the second tack. When the paper clip is touching the tack, the circuit is complete and the light goes on; when it is not touching, the light goes off.

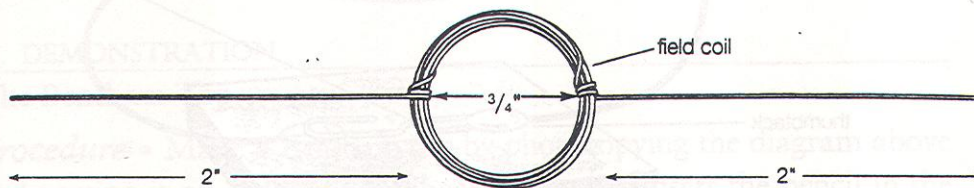
Comment • Instead of a light you can use a bell, a buzzer, or a small motor.

41. ACTIVITY

The World's Simplest Electric Motor

This simple motor, described by Robert Ehrlich in *Turning the World Inside Out*, is a delightful project. It can be constructed quickly and works beautifully. All the components can be purchased at an electronics supply store.

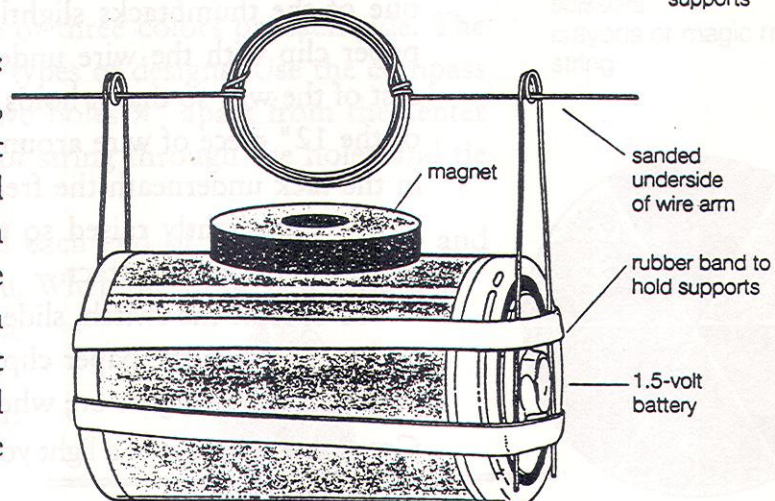
Procedure • Making the field coil: Hold 3" of the 20" length of #22 wire in your hand, and wrap the remainder 5 times around the $\frac{3}{4}$ " dowel. The ends of the wire have to be wrapped twice around the field coil on opposite sides. One of the ends should be wrapped away from you, the other end towards you, so that they emerge from the coil on opposite sides. Trim the ends off so that they protrude 2" on each side.



Making the supports: Wrap the support wires twice around the nail or the piece of wire hanger, making loops in the center of each of the support wires. Straighten the ends so that they come down from the loop.

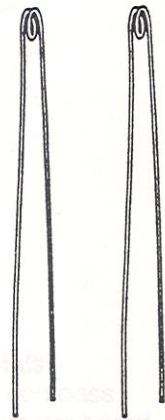
Assembling the motor: Wrap the rubber band twice around the battery and insert the supports so that they make good contact with the metal end plates of the battery. Put the magnet in the center of the battery and raise the supports so that the field coil can swing freely. Trim the ends of the field coil so that they protrude about $\frac{1}{2}$ " from the loops of the supports.

Stripping the field coil's arms: As the field coil sits in the loops, note which surface is in contact with the loops. Take out the field coil and sand off the insulation from half the circumference of the surfaces of the arms that were in contact with the loops. Do not scrape the insulation from all around the arms, otherwise the motor will not run.

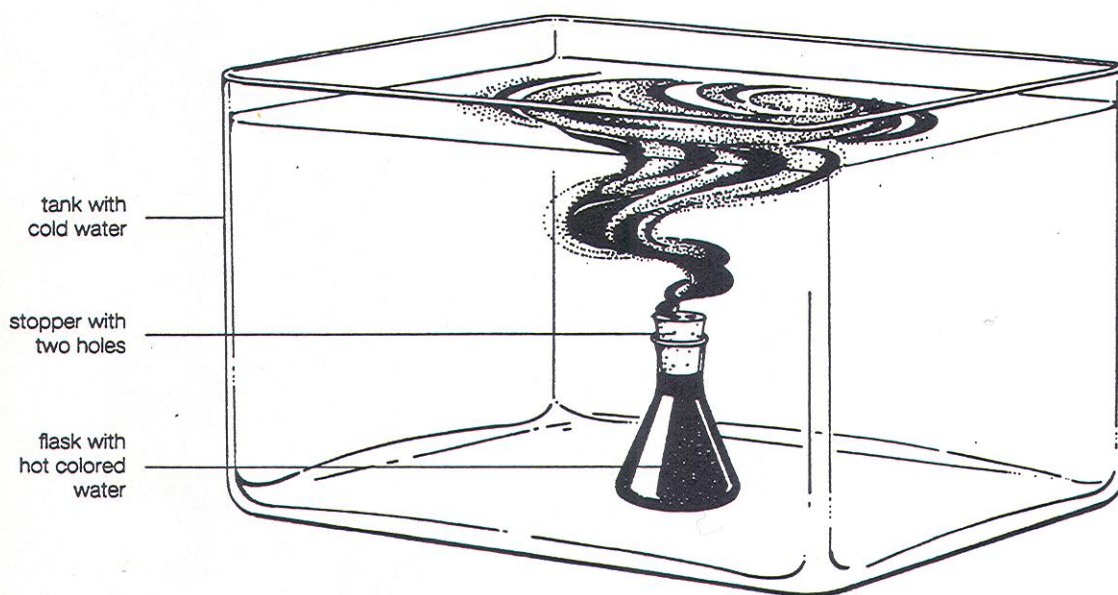


Materials:

- a "D" size 1.5-volt battery with metal end plates
- a small disk-shaped refrigerator magnet
- a 20" length of #22 magnet wire
- two 6" lengths of #18 uninsulated aluminum or copper wire
- a thick rubber band
- a $\frac{3}{4}$ " diameter dowel or candle
- a nail or straight piece of coat hanger
- sandpaper
- scissors or wire cutters



supports



29. DEMONSTRATION

Convection in a Tank

This is a fitting final demonstration for the week's work in heat.

Procedure • Fill the aquarium with very cold water. Heat a small amount of dyed water and fill the small bottle almost full. Stopper the small bottle and cover the holes as you place it on the bottom of the aquarium. Uncover the holes, and the colored hot water will slowly begin to rise out of the bottle, revealing the beautiful convection currents.

Materials:

an aquarium
water
a small bottle
a two-holed stopper
a beaker
a stand
a gentle heat source
matches
paint, ink, or dye