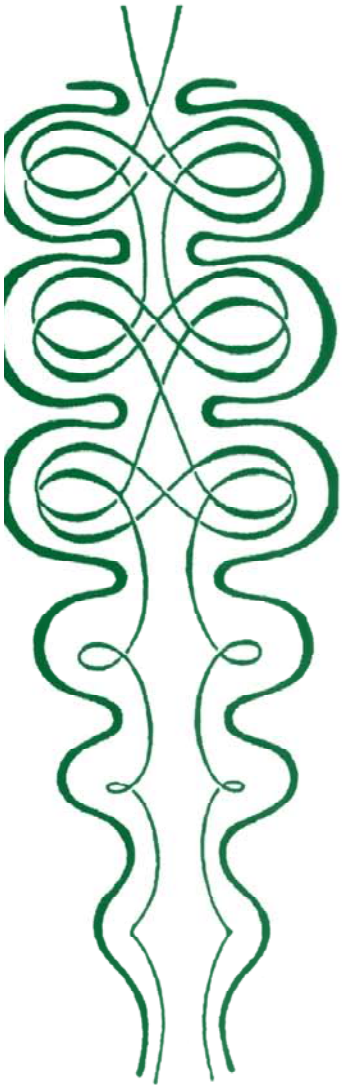
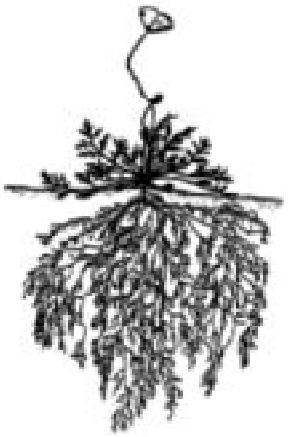
Volume 9, #18
Spring 2003



WALDORF SCIENCE NEWSLETTER

Editors: David Mitchell & John Petering
1158 Quince Ave.
Boulder, CO 80304
FAX 303 / 541-9244



Waldorf Science

Explorations in Phenomenology as Practiced in Waldorf Schools

A Science News Roundletter

Editors: John Petering & David Mitchell
1158 Quince Ave.
Boulder, CO 80304
FAX 303/ 541-9244
E-mail – davidm@awsna.org

VOL. 9, #18 **Spring 2003**

NOTE FROM THE EDITORS

The goal of this newsletter has been to support the deepening of science classes in Waldorf schools by promoting the sharing of teacher's notes and research, and by making interesting, thought-provoking ideas available. Thus far, we have not really succeeded in having a wide selection of teachers share content with us; most of the material is researched by the editors. We are always conscious of the many ways we could deepen and improve our science curriculum, but need to prioritize our limited resources on the most effective things; thus we welcome your feedback (as well as contributions!).

Recently, we have examined the analysis of some Waldorf teacher comments and empirical data compiled and designed by Professor David Jelinek of the California State University in Sacramento. A draft is published and available as a PDF file on the web at: http://www.csus.edu/indiv/j/jelinekd.

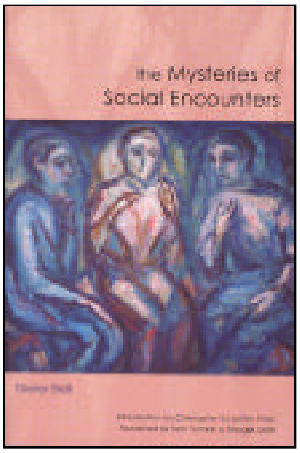
A response has been written by David Mitchell and is available to anyone interested. Write to him at davidm@awsna.org and he will send an electronic copy. We invite your views and comments on Jelinek's paper, as well; he has asked for input on the accuracy of the information in it, on Waldorf educators' perspectives on the issues raised, and any recommendations for practical steps to address reform.

In the true spirit of science we continue to try to improve the subtleties of our Waldorf methods and materials, and that was part of the driving force behind the workshops and colloquia on science teaching sponsored by the Waldorf High School Research Project. Some of these produced materials that may help the teacher, and several new books have appeared recently (see the AWSNA Publications catalog). But, we are also aware of some existing booklets which are of dubious quality; however, we have not felt it our role to determine which books were "approved" and which were not. Generally, we feel that anything that attempts to guide Waldorf teachers in science, must at least be,

1) scientifically literate and accurate about the facts,
2) based on an in-depth knowledge of Waldorf pedagogy and classroom practice, and
3) clear about what is appropriate for the developmental stage of the children being taught

(continued on page 7)

Books of Note



The Mysteries of Social Encounters

by
Dieter Brüll

Introduction by
Christopher Schaefer

AWSNA Publications

Reviewed by

Scott Olmsted

In few situations is the old saying, "a little knowledge is a dangerous thing," more easily proven than in the social organization and functioning of many of our Waldorf Schools. The enormous good will and promise of a new way of social working inspired by Rudolf Steiner's work too often translates into many plaintively wondering "why is this so hard?" while many others simply throw up their hands and walk away from the movement. Yet those who have felt in their hearts the wisdom of anthroposophical social ideals can also carry on confidently, sure that greater social learning will be found on this path, and that each new insight is a step towards a better world.

In the spirit of gaining new insight, we are given a powerful tool in the recent AWSNA Publications translation of Dieter Brüll's book "Der anthroposophische Sozialimpuls—ein Versuch seiner Erfassung" under the title, *The Mysteries of Social Encounters*. This book could have a profoundly positive effect on our English-speaking schools and other anthroposophical institutions, and lead us further on this path to a socially harmonious world. Brüll's scholarly work not only takes us on a survey of Rudolf Steiner's social theories, but also gives practical examples of how these theories are often misunderstood and misapplied. He shows quite clearly how, in such cases, they are indeed, "a dangerous thing." The danger here is that we take Steiner's theories and implement them without regard to other practical social realities.

A central theme of the book is precisely this: that we must work to make our thinking about ideas such as, for example, "the threefold social order" flexible enough that we stop using it as jargon and start applying it practically in the organization of our institutions. To apply it practically in our own community requires further insight into the stage of our community's development, its social dynamics, and the social abilities of the community members. In other words, we have to get to know each other! Brüll is clear that most of Steiner's social theories carry an implicit warning, often ignored: "This is a theory. Effective practical results require practical organizations." He further states that the most forward thinking theories, applied before there are social conditions that can accept them, often result in a counter-productive discrediting of the very ideas one is promoting. So it is that organizing institutions based strictly on theory can result in experiences not very satisfying—somewhat akin to biting into an unripe pear. The appearance of both is so promising, but careful handling and patience lead to far better results.

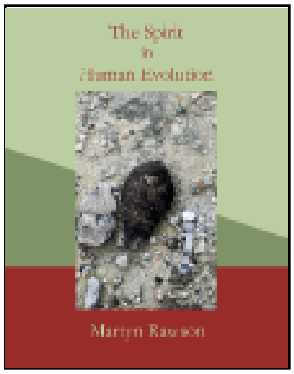
The Mysteries of Social Encounters also explores the basis for positive social interaction and offers key insights into what "careful handling" might look like in any institution, but especially in those built on anthroposophical foundations. Brüll begins by looking at the basic phenomena of social interaction with a depth of insight that illuminates three-fold social ideas as they pertain to the different aspects of society. Not only as these ideas relate to the wider societal or "macro" level of government—about which Steiner spoke frequently after 1917—but also as they apply in our personal lives and in the life of institutions—about which Steiner spoke surprisingly little. Each of these three spheres of social activity—the personal, the institutional, and the societal—requires a different application of these ideals. Have most people working with threefolding made this distinction? I suspect not. Luckily, Brüll offers us precision and clarity on these concepts. Yet as long as we work with them as mere concepts they will fail us. Or as Steiner put it: "Today it is not a matter of looking for theoretical solutions but rather to seek conditions in which humans can live in a social manner." GA 81, 1922. And, going further, "To the degree that human beings regulate their social life together from their ordinary consciousness, forces intervene which work against the sense of development salutary for mankind. " GA 1917

Instead we are called on to "make new our ways of thinking," and to become flexible and practical in our application of social theory.

Those interested in transforming the social relationships in their community should seriously consider a study of this book.

Starting with an in-depth survey of Steiner's social thought in the introduction by Christopher Schaefer, *The Mysteries of Social Encounters* is an invaluable mirror for any group, and a necessary path of study for those groups who consider themselves anthroposophical. As communities we must come together and realize that the social condition must be created together, not imposed by experts. In this era of pronounced intellect and ever-deepening individualism we must take up the work of community building with the new thinking of anthroposophical social science. This new thinking is based not on theory but on action; not on what I work out for myself, but what the other reveals to me; not on preaching a new world order, but on listening to what is living and, with patience and love, helping it grow. Brüll makes a convincing case that shows how too often, social theories that were intended to support the freedom of the individual are brought forward as moral imperative, forced into situations that are not ready for them, and thus forced to live a malnourished existence, if they survive at all.

Now, as in Steiner's time, world events show us how far we have to go in our social development. The tragedy and weight of world events, of local conflict and personal struggle must be confronted, however. Steiner encourages us to say to ourselves: "I am, in any case, called to look at everything without illusion; I must neither be pessimistic nor optimistic, so that forces may awaken in my soul which give me the power to aid the free development of the human being, to contribute to human progress in the place and situation where I am." GA 186, p.15 What better contribution to our "place and situation" than developing a love and understanding of our own community? With this new translation, we are offered the opportunity to take up this challenge enriched by a new treasure chest of social insight.



The Spirit in Evolution

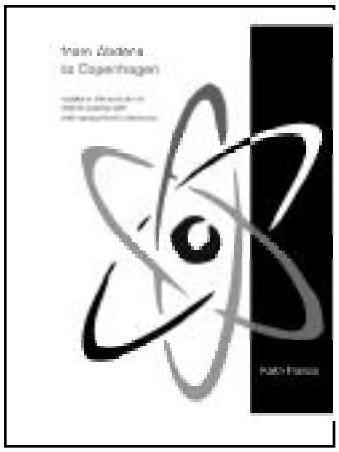
by
Martyn Rawson

AWSNA Publications

Martyn Rawson, seasoned Waldorf teacher and biologist, takes the reader on a journey into modern anthropological thinking from the perspective of a spiritual scientist.

Chapter headings include:
- Self-knowledge, Truth, and Goodness
- Contextual Thinking Versus Reductionist Thinking
- Anthroposophical Anthropology and the Developing Human Being
- First Steps
- Lucy, Flatface, and Friends
- Working Man
- The Ancients
- The Moderns

A full review will be offered in the next edition of the *Waldorf Science Newsletter*.



From Aldebara to Copenhagen

by
Keith Francis

AWSNA Publications

This book is for all of us who would like to know more about the origins, evolution, and the present state of those theories in physics upon which most interpretations of the physical world rest, and to see how these things are related to a spiritual scientific knowledge of human evolution.

Keith asks the questions, "Why do people believe in atoms in the first place?" "How is atomism connected with the evolution of human consciousness?"

Beginning in ancient Greece, then encountering Isacc Newton, perusing Egyptian art, and on to Hannibal the Chemist —the reader is taken on a fascinating journey.

This promises to be an interesting read for all those interested in the evolution of physics from an anthroposophical perspective.

Developmental Dynamics in Humans and other Primates: Discovering Evolutionary Principles through Comparative Morphology

by

Jos Verhulst

Adonis Press, Ghent, N.Y.

Cloth $39.95. xviii, 413 pages; well illustrated; Publication date: August 1, 2003.

In this book, Belgian scientist Jos Verhulst presents the most thorough research to date elaborating an evolutionary theory first set forth by Dutch anatomist Louis Bolk in the early 20th century. This theory is based on the proposition that dynamic principles inherent in the development of individual organisms are also at work in animal evolution as a whole. For example: A chimpanzee fetus is strikingly similar to its human counterpart: its cranium is rounded, its face flat, and its hair is restricted to its head. As it develops, however, the chimp diverges from its original, humanlike form, assuming specialized apelike features. In a detailed comparative study of numerous organs, Verhulst shows that, unlike the other primates, humans retain their original juvenile form. Standing Darwin on his head, he concludes that humans have not descended from apes but rather that apes evolved by diverging from a humanlike prototype. He also shows that our human tendency to retain our fetal form (fetalization, or retardation) is complemented by further development (hypermorphosis) of such organs as the legs, heels, forebrain, and larynx through which we attain our eminently human capacities of upright posture, thinking, and speech.

In the last chapter, Verhulst sketches a broad view of how retardation and hypermorphosis have worked together in animal evolution. He speculates, for example, that vertebrates evolved from invertebrates when ancient sea squirts (a form of tunicate, a marine invertebrate) retained their larval characteristics and developed them further as they evolved into fish. Sea squirt larvae are free-swimming and resemble tadpoles. Their brain includes a light-sensitive eyespot, and they have a rudimentary spinal cord. In their adult stage they are sessile filter-feeders with neither nerve cord nor eyes. Verhulst postulates that primitive tunicates like the sea squirt retained their larval characteristics (through retardation) and evolved (through hypermorphosis) into fish, the first vertebrates. Following in a tradition as old as Darwinism, he proposes that, from the very beginning of animal evolution, these dynamics have led progressively toward the emergence of the human form. In this view, the gradually emerging human prototype is seen as the driving force and central trunk of the evolutionary tree, as the wellspring from which the animal world has sprung.

Comments about the book

"*Developmental Dynamics* is a tour de force: a refreshingly original, profound and thought-provoking synthesis rooted in impressive scholarship. As Verhulst penetrates to the vital, dynamic essence of human biology, we begin to see ourselves in a rejuvenating new light. A welcome antidote to too many evolutionary doctrines grown stale, trivial and materialistic. Creative science at its best."

—Martin Lockley, author of *The Eternal Trail: A Tracker Looks at Evolution*; Professor of Paleontology, University of Colorado, Denver.

"Jos Verhulst approaches human evolution with refreshing open-mindedness. In *Developmental Dynamics* he presents an astounding wealth of little-noted facts that assume surprising new significance as he develops his thesis. From the outset, Verhulst incorporates a spiritual perspective into his scientific exploration of the evolutionary process. Though some readers may not agree with his conclusions, all will find the rich content of his book extremely thought-provoking."

—Wolfgang Schad, author of *Man and Mammals: Toward a Biology of Form*; Professor of Morphology and Evolutionary Biology, University of Witten, Germany

"Jos Verhulst's penetrating grasp of human development leads to a refreshing view of human origins. In a perceptive, lucid and lively account, he argues convincingly that there is more to evolution than just Darwinian natural selection. Following in the footsteps of Goethe and Bolk, Verhulst champions the view that evolution was guided by an intrinsic drive that has culminated in the human gestalt, and that the harmonious form of the human body is a reflection of what he calls our synergistic composition. No part of human anatomy is left untouched as Verhulst examines the impact of changes in the rates and timing of development as the source of our evolutionary heritage. He demonstrates most effectively that we are the product of both fetalization and hypermorphosis, which leave some traits less developed than in the ancestor, others more so, as growth is prolonged. And this he argues in a manner both compelling and eminently accessible. If you are in any way curious about our origins, then I invite you to read this book."

—Kenneth McNamara, author of *Shapes of Time: the Evolution of Growth and Development*; Senior Curator, Invertebrate Paleontology, W.A. Museum, Perth, Australia

(continued from page 3)

For example, some booklets by Roy Wilkinson from England have troubling comments which do not distinguish the anthroposophical ideas mentioned in them from appropriate science teaching and content that will prepare the students for life. Steiner invited people to consider anthroposophical ideas and explore their validity or usefulness, and not just take anything on faith. And, he also clearly emphasized that while he invited exploration, he did not want us teaching anthroposophy in Waldorf schools. To the extent that our personal study illuminates some facts of modern science and is verified through careful research, we might consider its pedagogical usefulness and how it could inspire us to present material in a more educative way. But, clearly it is not appropriate to just pass on Steiner's ideas to the students. Wilkinson's books seem to fail to make this distinction and we have not reccomended them to teachers seeking resource materials nor have they been included in the offerings of AWSNA Publications. Likely, other books have areas which would also benefit from review and correction.

So, we invite your comments and suggestions on how we could have a free exchange of ideas, and yet highlight "exemplary" materials and identify problematic resources and materials to correct or replace them.

— John Petering
— David Mitchell
editors

Waldorf Moms

Waldorf moms wear cotton socks
Woolen sweaters, Birkenstocks.
Waldorf moms have long full skirts,
Big silk scarves and layered shirts.
Waldorf moms have fluffy hair,
They're kind and firm and make you share.
Waldorf moms drive Volvo cars
And talk of fairies, gnomes, and stars.
Waldorf moms love Waldorf meetings
Where they greet with Waldorf greetings.
Waldorf moms make Waldorf dolls
From purest wool and cotton balls.
Waldorf moms drink lots of tea
Which has been grown organically.
Waldorf moms serve fruits and meats.
Veggies, grains, and not much sweets.
Their favorite word is "nourishing."
They love to hike and knit and sing.
They leave the gluten out of bread
And make you spend twelve hours in bed.
And if you fall and scrape your knee
They give you rescue remedy!

— Brianne McPhearson, 7th grader
Shining Mountain Waldorf School

A Call for Research

The WHSRP Waldorf high school research project) has received funding to support ten new research papers at $500 each. The following topics are particularly being sought:

- Sex awareness as taught in grades 6-12
- Changes in pre-adolescence (grades 5-8)
- Use of computers and the teaching of technology
- The development of a new Waldorf high school
- Art and experiential education

However, all proposals will be considered. Guideines are posted on the On-Line Waldorf library at:

http://www.waldorflibrary.org/

Science Links

An excellent resource is *The Physics Teacher Online*, published by The American Association of Physics Teachers and hosted on AIP's Online Journal Publishing Service, is a fully featured electronic version of the print journal of the same name.

Note: Access to TPT Online will be free to anyone through August 5, 2003. After that date, a subscription will be required to continue access to "premium features" such as full text in multiple formats and hyperlinked references.

LINK: TPT-Online, Home page:

http://ojps.aip.org/tpt/

SPIN Web - Searchable Physics Information Notices:

http://ojps.aip.org/spinweb/

Research
The Decrease of the Senses and the Evolution of the Fast Brain

by

Michael Kneissle

Translated by Leif Sonstenes

About twenty years ago, the first evidence came to light showing that something unusual was happening to our brains. Scientists discovered a surprising phenomenon while they were investigating the processing of stimuli and the emotions of Germans. 4000 test subjects had participated in a series of bio-psychological tests stretching over a period of many years. After the conclusion of the experiments, it was discovered that the tested people were no longer able to use their senses of smell and taste as well they could at the beginning of the project.

"The receptivity of the senses of smell and taste had degenerated significantly, "according to Henner Ertel, a psychologist from Munich. "The brain had set a new sensation threshold, so to speak, and had refused to recognize sensations that were below this new limit, sensations that would have been unconditionally accepted before."

The scientists noted this unusual state of affairs very carefully back then, but were not unduly concerned. The changes had been minimal. Only the two senses that were the oldest from an evolutionary standpoint had been affected. The important senses of sight and hearing were unchanged.

However, at the beginning of the eighties, there was a dramatic development. Henner Ertel expressed his amazement in this way, "Suddenly all of the senses were impaired. The brain refused to take any action on a significant proportion of the stimuli. It was getting more and more difficult to stimulate the corresponding centers in the cerebral cortex."

The researchers were now alarmed. The organization of the brain had apparently changed. In order to get a reaction now, they had to use barrages of action potential[1] which only a few years before would have caused a shock.

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[1] Changes of electrical potential with action currents when nerves, muscles or glands are stimulated.

* See additional resourses on adolescent development on the OWL website, >http://www.waldorflibrary.org<

"The Waldorf approach is to a remarkable degree in harmony with recent developments in the cognitive sciences related to how children learn and understand."

— Dr. Paul Dehart Hurd,
Professor Em.
of Science Education,
Stanford University

Towards A Sensible Kind of Chemistry

Part Two

by
Wolfgang Schad

edited from Autumn 2000
"*Tycho Brahe Yearbook of Goetheanism*"
translated
by
Nina Kuettel

Teaching about Electrochemistry and Chemical Bonding

The introduction of electrochemistry, apart from the discussion of its technological applications (electrical batteries, electrolysis, electroplating), is important to the empirical development of lessons about chemical bonding. It is advisable to avoid a formal, theoretical introduction and begin with experiments showing archetypal/primal phenomena. Only for this reason we illustrate two such experiments. First, it can be shown that without any extra source of electricity, we can directly extract it with specific materials. For this we construct a "Daniell cell" (See Fig. 1)

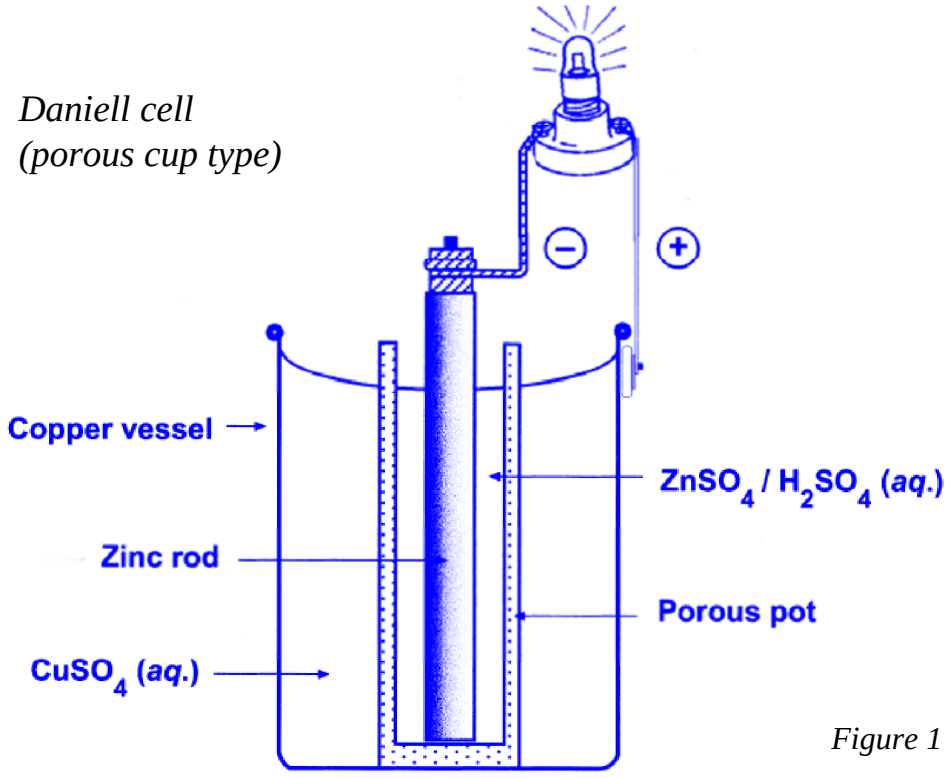

Figure 1

The light bulb glows when the inner container is a fired and unglazed clay cup that is closed at the bottom. A copper sulfate solution is added to the cup and a zinc sulfate solution to the surrounding container; then we insert the appropriate strips of zinc and

copper metal into the solutions. In the process, the copper electrode will become heavier while the zinc electrode becomes lighter, as can be shown by weighing. Also, with production of electric current, the zinc dissolves into solution, and the copper plates out. In their dissolved states, zinc, copper and sulfate all wander around the solutions as conductors; they are wanderers = ions. Sulfate ions must move through the semi permeable membrane of the cup because they accumulate to excess inside the cup, and are under-accumulated on the outside. Thereby the electric circuit can be seen overall as closed into a circle. In this way, through thought and observation, one can seamlessly develop understanding for the basic principles of ionic chemistry.

The inverse and also a phenomenologically unifying experiment is electrolysis of dilute sodium sulfate in a beaker with platinum electrodes (thin iron wire such as florist's wire will also work in a pinch) and universal indicator, only now it is necessary to supply electric current from an external source, (see Fig. 2).

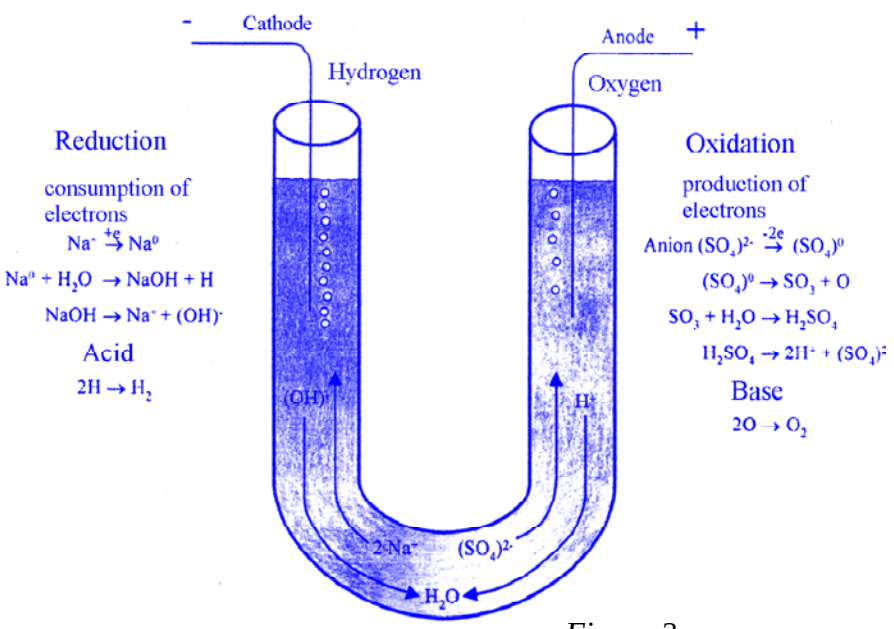

Figure 2

Numerous basic chemical concepts can be linked to the above experiments. The archetypical value of the process can be made aesthetically memorable through the colorful primary phenomena of blue to red indicator colors, with all the transitional colors of the spectrum.

Naturally, the universal indicator is a synthetic mixture of various organic pigments chosen in order to make all the possible pH-levels plainly visible [we could also use red-cabbage extract for the same effects]. There are indicators that don't so clearly exhibit the blue-to-red transition when going from alkali to acids (Congo red, Phenolphthalein, etc.). But still, a qualitative justification for Goethe's viewpoint is found in the chapter on Chemical Colors, in his Theory of Color: "Yellow and yellow-red devote themselves to the acids, blue and magenta-red to the alkalis." The Anthocyanin of many flowering plants shows a corresponding qualitative color transition from blue and red. For instance, many blossoms such as those from the Borage Family (Boraginaceae), like Forget-Me-Not, (Myosotis alpestris), lung-wort, or "stone seed" red-blue Gromwell (Lithospermum purpurocaeruleum, Fig 3), all demonstrate this in their form: In the active phase of the still-opening flower, the cellular fluid is acidic and hence the blossom crowns are red. When the flower has come to rest with complete blossoming, then the cellular fluid is alkaline and the color is bright blue.

Figure 3

These polarities and their "enhancements" (polar ion formation and neutral water in between) were made experimentally vivid in our experiments described above. At the same time, it becomes clear that just as electric current can be produced from chemicals, so can chemical transformations be evoked by electricity.

Goethe followed the beginning of electrochemistry with the greatest interest. The following is taken from his report about Doebereiner sent to Heinrich von Treba:

> "Through the progress of galvanism, the experience itself has become theory, and so, everything proceeds more surely and clearly."

And, to Doebereiner himself, Goethe wrote:

> "If one never leaves the superb and sound electrochemical guide, then all the rest will also not evade us." (Dec 26, 1812)

Analytical chemistry has always been concerned with the question of what kind of forces are the ones that bind the chemical elements into compounds. The most concise approach to this question is found in the Periodic System when, for instance, we examine the elements of the third period in the following sequences by means of their compounds (see Fig. 4).

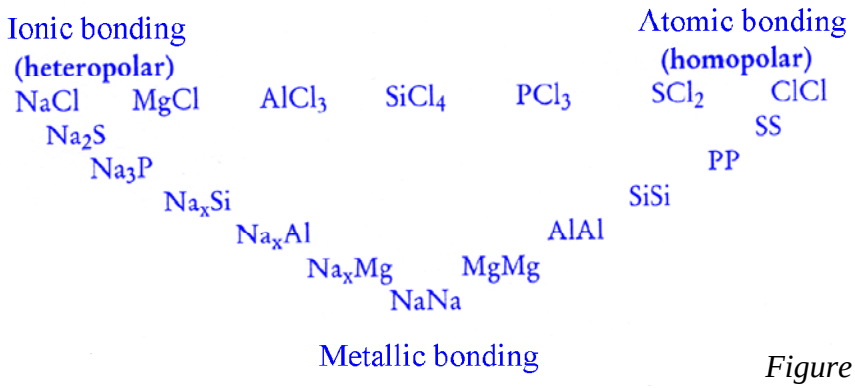

Figure 4

THREE TYPES OF BONDS

The three main bonds-types stand out, from which our attention is drawn to all the transitions. It becomes clear that pure ionic (heteropolar), pure covalent (homopolar) or pure metallic bonds exist only in rare, extreme cases. The in-between states are the norm. The transition from ionic bond to covalent bond is made evident in the following bonding sequence:

LiF BeO BN CC

If one looks at the chemistry of lithium fluoride, beryllium oxide, boron nitride and carbon, then it becomes clear that a decrease in the salt character means an increase in the ability to polymerize. On one pole, electric, active, dissociation processes quickly occur in water, and on the other pole is the tendency towards association until we have electrically neutral material. If one examines the theory of bond-types, then it stands out that such typical inorganic compounds as salts, acids and bases, i.e. all electrolytes, are most easily explainable using classical electro-physical attraction of differently charged ions. The bond is interpretable through the donation and acceptance of electron-particles from the surrounding "cloud," to complete the corresponding electron octets, and interpretable as simple electro-

static attraction of the ions that are produced through electron "transfer." However, the closer the bond type gets to an atomic (covalent) bond, reaching the point of allowing the formation of the polymers so basic to life, then the ability of selective localization of electrons conceived as particles ceases. How should an electron-pair bond hold itself together when both electrons are identically charged? That is only explainable through quantum theory, through a "softening" of the laws of classic physics so that indeterminacy applies to space-vector or force, or of time's-arrow, or energy. Position and time are no longer precisely assignable, but rather only probabilities, potentials. Exact conceivability is no longer. It is of great interest to note that such "experiences on the edge," so to speak, occur unavoidably just when thought-forms approach closer to organic substance–and thus to the biochemistry of living things. The same applies even more to hybridization which applies to nearly all organic compounds: namely that the bond type lies between two formulae assignable through electron-pair bonds. The hydrogen ion in every carboxyl group already belongs to both neighboring oxygens. In doing so, the simple bond of hydrogen is gladly dissolved into two half-bonds; so what remains of the shared electron-pair bond? Whether it is construction of electron pairs or hybridization, in both instances quantum-theoretic conditions exist that do not describe something that can be found, but rather only describe a probability of what is possible. The wave theory of electrons that is applied here, also does not deal with any actual waves, but only their probability. The world of substances from life, like life itself, cannot be rationalized in the sense of mere addition of modular or discrete units–in contrast to the inorganic characterization of electrolytes. Of course, there are also highly polymerized minerals, especially within the silicates. But they don't present a contradiction when they are understood as the "biochemistry" of the Earth, as the geochemistry of a "telluric life."

In his own way, in1921, Rudolf Steiner had this "softening" of rigid concepts of molecules in view when proceeding from crystal structures of the inorganic to the inner configurations of living matter:

> "But there substances are always formed, which the chemist can keep track of, which to some extent now do not always have an external crystallization, but an inner configuration. In modern times this inner configuration has even been indicated through well-known structural formulas of chemistry. (….) However, the secret lies in this: the more organic the context of the substances are, the less they bond chemically one to the other, thus the more chaotically is the matter jumbled and whirled around." (Steiner, GA 205: 88/89, 7/1/1921)

In life, matter that was previously inorganic sheds its powers of crystallization. Therewith, we have a qualitative transition from the ionic [inorganic] to [a domain of] covalent bonding, theoretically justifiable only in terms of chaos- and quantum-theory. Theoretical acceptance of this by the leaders in this field of science at the time, was in dramatic discussion into the 1930s. It revolved around the most objective determinism of Einstein or else the probablistic indeterminism of Bohr. The latter won out and Einstein admitted at least what William Bragg formulated: "Everything that has already happened is corpuscular; everything in the future is waves." And Bragg's son Lawrence, recently described it as follows: "The progressing sieve of time coagulates waves into particles in the present moment in time," (Clark 1973). It is clear that also the physical reality of matter is not comprehensible without the inclusion of time, since matter also continuously coagulates out of becoming, into reality.

At this point, the problem with high school chemistry is that the chemistry teachers themselves normally had no opportunity in their studies to delve into the content of fundamental quantum theory. But what of quantum theory should Waldorf high school teachers basically have learned? Here is an essential requirement from the year 2001 onward. In the long term it makes no sense that the teacher of 11th and 12th graders can only say to their penetrating questions that he or she also doesn't quite see through quantum theory of the octet-tendency, covalent-bonding, hybridization, and the pi-bonding in the benzene ring, but the students still have to be able to write on exams using the appropriate language. And it is no consolation to know that currently public school chemistry is just as nonimalistic [knowing just the right words and terms]. Here, something must happen at least as a starting-principle to promote understanding. It's worth it.

Therewith, at least something would initially to come to fulfillment that Goethe foresaw in his last years as a goal for future chemistry:

> "The chemist, who cancels out the content and structure (of an organism) and merely has paid attention to the chemical characteristics of the material and the ratios of its compounds, is indebted to those in profession (the study of organic nature) and will owe much more because the newer discoveries allow for the most delicate separations and combinations, and through this one can hope to get closer to the endlessly tender workings of a living, organic body. Just as we now have acquired an anatomical physiology through exact observation of structure, so we can, in time, expect to acquire a physical-chemical physiology. And, it is desirable, that both sciences always want to progress as if they each were to accomplish the entire undertaking alone."
>
> (Walden 1932:81/82)

Speed of Bond Formation

First of all, what interests us here is the process-character of the bond types, that is, the amount of time needed to form. That is exactly where the heteropolar and the homopolar bonds are real polarities. Ions bond together immeasurably fast. If one combines sodium hydroxide and hydrochloric acid then water comes immediately out of the hydrogen [H^+] and hydroxyl [OH^-] ions. On the other hand, the bonds between electrically uncharged partners (thus atoms or, as the case may be, molecule groups instead of ions) are markedly slow in the classical instance. Charcoal from the earliest use of fire by prehistoric humans (1 million years) can still be found in sediments. For instance, crude oil remains practically unchanged since Earth's antiquity until today (Zechstein, 250 million years). And in the oldest rocks on Earth, one certainly finds graphite that has already undergone photosynthesis (Pflug 1984). Carbon bonds are included in the process environment of the living principally through hetero-polarizing steps. The oxidation series first win their perpetuating assertion under the aspect of time; for instance, aliphatic hydrocarbon, so often used as an introduction to organic chemistry. We start out with the four oxidation levels of the simplest bond, methane, up to the energetic end-product: carbon dioxide.

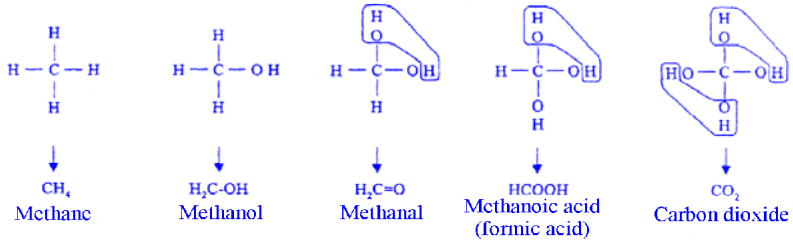

Figure 5

Methane is purely covalent-bonded (see figure) and so, without supplemental activation energy, it is slow to react. Methanol (methyl alcohol) already reacts sooner, and methanal to an enhanced degree. However, Methanoic acid (formic acid) already clearly dissociates into ions, and with that goes over to lightning-fast ionic reactions like the carbonic ions that emerge from carbon dioxide. If, in a general way, we put up the series of the alkanes, alkanols, alkanales and alkan-acids (carbonic acids) to discuss their capability for life, then it soon becomes clear that if an organism consists only of ionically-bonded matter, then, in the shortest interval of time and with final, terminating reactions, it would have already have arrived at its destination. If it consists only of covalent-bonded matter, then the necessary reaction sequences would not even get started. In the one case, the end of life would have immediately been reached already at the lowest energy level. In the second case, the organism remains metastable the same, at the initial, predetermined high energy level without ever getting started. It is clear that real life mostly uses the in-between stages of bonding.

If one takes a rather short carbon chain with a few hydrogens as the energy carrier, several alcohol groups as weakly-reacting potency, and at least one aldehyde group as a stronger reaction component, without a carboxylic acid having yet formed, then one of the most life-friendly substances appears: a simple sugar like glucose, just as arises in all photosynthesis. So it is understandable why a polyvalent alcohol and a univalent aldehyde (or ketone, as the case may be) is such an important metabolite; because it represents a proportionate middle-ground between opposing time patterns [of bond types]. Not only the spatial structure, but the time-gesture can and should be read out of this. And, they should be read from this in order to go from the chemistry of matter to the chemistry of process. (see Fig. 6 for glucose structures).

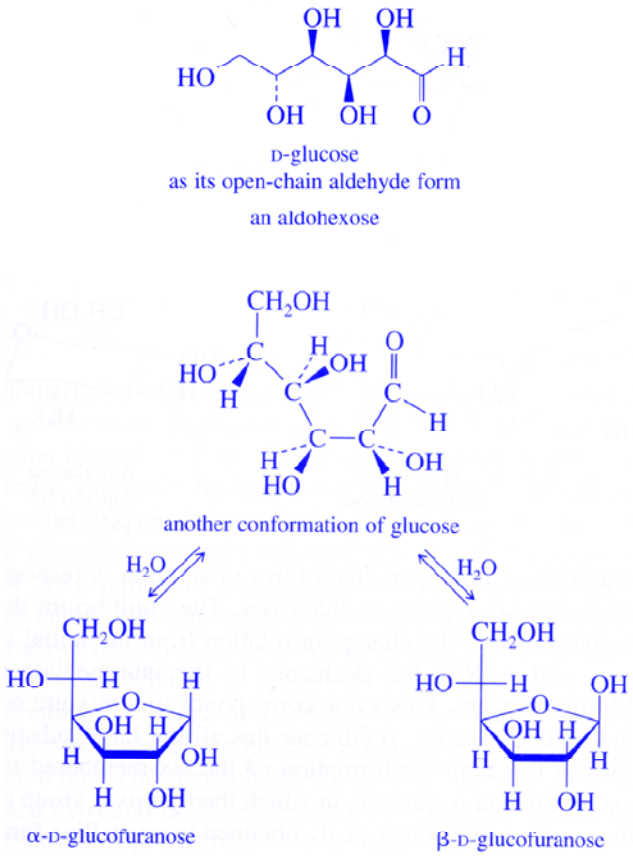

Figure 6

Amino acids, beyond being foundational substances for proteins, also have alkalinity and acidity integrated into their molecular structure, and thus are constituted for a faster reaction capability than just the amino- or carboxyl-group, because both groups are ionic– the one through accepting protons to become R-NH_3^+ anion, and the other through giving off protons to become R-COO^- cation. It is no wonder that plants are quantitatively made up mostly of carbohydrates, but the mobile animals are made up mostly of proteins. It is equally interesting to note that the very life-friendly element water consists of the elements hydrogen and oxygen covalently-bonded–mainly but not exclusively. The weak dissociation of its ions (ion product $[H^+] \times [OH^-] = 10^{-14}$) first makes possible its ability to react; forming hydrates for instance, and thereby a solvent for all water-soluble ions. Through its predominantly covalent-bonds, it has the possibility of slowing down by dilution, many conversions that would otherwise proceed too fast. The chemistry of water is by no means completely understood with only the range between the homopolar and the heteropolar bonding quali-

ties, because there is also a whole gamut of further, weaker bonds that come into play; only the hydrogen-bond, through the dipole effect of water's unbalanced (angled) structure, has been named and are understandable only through quantum theory. Thereby, the fact that water has been allotted a richly-graded claviature of bond types, means that it can take on many finely structured bond-types and bond-speeds, to the benefit of life. Every good chemist knows that water is more than $(H_2O)_x$.

The most physiologically active organic substances slow their reactivity by condensing into long-chained, large molecules through dehydration reactions (giving off water) or by polymerizing (without giving off water): Glucose to cellulose, phenylpropane to lignin, acetic acid to fatty acids, isoprene to terpenes or perhaps to rubber, simple alkane up to the waxes, n-acetylglucosamine to chitin, the amino acids up to proteins. Not only framework/support substances, but also energy storage substances come about in this way, such as starch, hemicelluloses, long-chain fats, etc. All of these condensates are for the most part covalently-bonded, energy-rich, and give organisms structure and mass. On the other side, the completely ionizable materials present the opposite picture. Not through bonding and condensation or polymerization, but rather are physiologically active through dissociation of their bonds. Not electrical neutrality as with the polymerizations, but rather electrical polarization occurs. Where they play a role in an organism, rapid reactions quickly run to completion, because they react rapidly, taking lower energy levels. Every protein in a living cell gets its interior design from its cyto-skeleton with mostly covalent bonds, and its propensity for reactions from its inventory of ions in the surrounding cytosol. Certainly, both are always there in close cooperation in living protein (whether as gel or sol): long-chained molecules contain energy potential acquired in their synthesis. The mildly ionic amino- and carboxyl-groups, at the first approach, cause decomposition reaction-cascades and in that way actualize the potential through release of energy. That they don't cause a simple salinization of cell-contents, is prevented through the a-position of the amino group to the carboxyl group in most amino acids. Every other placement quickly leads to "inner salinization" already within the molecule. Life consists, also in its chemical characterization, not in the suspension but rather in the retention of moderate tension, and that in continual, cyclical alternation between tension development and partial (!) tension equalization. So we get to a comparison of the foundational polarities of bond-types:

HOMOPOLAR =Covalent =Atomic-	BONDING	HETEROPOLAR =ionogenic =Ionic-
Polymerization Condensation Association	MOLECULE formation	Electrolytic- dissociation
Energy-Rich	ENERGY	Energy-Poor
Development of Substance mass Up to framework Substance	METABOLISM	Dismantling to lower molecular-weight i.e. inorganic compounds
Body-construction of life processes Incarnation	LIFE-PROCESS	Disintegration of life processes Ex-carnation

A Goethean understanding of nature quickly perceives from this comparison that we are dealing with the instruments of the two polar activities of life. In one instance, the vitality of a living organism is sacrificed to the building up of its physical body. It is precisely the domain of the plant kingdom and has increasingly appeared since the early Devonian, and most significantly in the development of trees. Redwood and eucalyptus trees are among the largest organisms on the Earth. Building up bodily substance is also the "plant" function in animals and in human beings. The disintegrating processes of high-molecular to low-molecular substances, proceeds in the reverse direction through release of energy. It is precisely this physiological decline of vitality that first allows for perceptual ability and mental awareness in animal and human organisms, (Fortlage 1869). (For the equivalent deterioration processes in the plant kingdom, Rudolf Steiner didn't point to the perceptual life of individual plants, but rather to the entire landscape, the Earth-Spirit.) Quick ionic processes are needed to support awareness. The fastest physiological frequencies in the rhythm spectrum of the human being (Rosslenbroich 1994) are the nerve rhythms through the polarization and depolarization with Na^+/K^+ ion migration in nerve cell membranes. In utilizing covalent bonds, the processes of life are oriented to the physical, and utilizing ionic processes, towards awareness. The double sidedness of life is chemically clearly expressed in the antagonism between the homopolar and heteropolar bond.

The transition to metallic-bonds and considering the metallic compounds in alloys, complexes, and salt compounds of metals is worth it, and can here only be named as a desideratum.

The relationships of life are never solely comprised of polarities, but rather also in augmented dynamism between them. We are psychically most closely associated with our body chemistry through taking in food for our nutrition. What is it that we so love to taste? Sugar is a transitory substance between starch on the one side and carbon dioxide and water on the other side. Both of the peripheral states have no taste, but not so the transitional area: monosaccharide and disaccharide! Proteins are similar. The outermost substances, carbon, hydrogen, oxygen, nitrogen and water have no taste or smell. The same with high-grade proteins like albumen or untreated, pure meat. Only in the in-between stages, the marginal edges of breaking down and building up, do they taste like anything. Plant proteins are usually tasteless, and get their flavor through their partial fermentative deterioration into peptides. Pure fat and oil also do not have much taste. We flavor it with ions; that is, cooking salt in lard, and vinegar in salad oil. when relatively short-chained fatty acids are esterified with short-chained alcohols, we get the delicious essential oils found in the fruity aromas of strawberry, raspberry, peach, pear and banana flavors. Also here we have the intensified chemical center between high-molecular weight synthesized materials and completely decomposed low-molecular-weight substances which appeal little to us as an extreme. What Goethe brought out in his Theory of Color as the colorful seam, the archetype of stepwise "enhancement" between light and darkness, is also presented in the chemical world as its "fragrant edge" between the polarities.

Search for Chemical Reagents for Formative Forces

What happened to the chemical reagents for formative forces: the sensitive flame, copper chloride crystallization, the *Steigbild* (vertical capillary dynamolysis)? None of the methods has held up under even one well-meant critical study, as measured by the earlier standard that that which is super-sensible must be capable of being imaged in the laboratory. The richest and most promising is still the medley of forms arising with copper chloride crystallizations, and with the *Steigbild*, especially through the addition of organic material. As far as the reproducibility through standardization of all the parameters goes, it is still

most possible with copper chloride crystallization. It goes so far that, in the meantime, one can also produce the characteristic composition of form with synthesized polymers, (Hummel 1992). But with the *Steigbild* method the standardization of paper is limited because the cellulose fibers in it are a mixture of differing lengths and every batch of paper, even the same type and manufacturer, is different again. That is why today's thin-film chromatography on silica gel has much better reproducibility.

For a long time the scientific dialogue of those working experimentally with the *Steigbild* method was an open problem. Namely, for the most part, it didn't exist. I campaigned for it for 10 years until in 1986 such a meeting with unlimited exchange took place in Dornach with the findings of that meeting published in issue number 46 of *der Elemente der Naturwissenschaft* (*Elements of Natural Science*) in 1987. Together, a unanimous judgement was reached that the use of image-producing methods could not demonstrate the direct effect of etheric formative forces, but rather demonstrates the characteristic of the constituent substances, that had previously been organized in a living organism by formative forces. In each case, one has a reduced phenomenon because the respective plant is killed, chopped up, its juice pressed out and purified, and thus removed from any holistic connection to life. So, in that way it is very tedious to reproduce the correlation in a particular plant between its organs, its gathering time, etc. Jochen Bockemühl said correctly that the morphology of the intact, living plant makes more things visible with its transformation dynamic than can be done by any analytically-oriented laboratory treatment.

However, this also has its declarative value when one looks at it in terms of plural methods. Especially two scientists from the WALA Research Laboratory, Ruth Mandera and Hans-Joachim Strüh worked with fresh impartiality with the *Steigbild* method and produced three conspicuous broad types which they named:

"Loose/ relaxed Type";
"Sugar Type";
"Colloid Type"

In ascending paper chromatography it can be observed how slowly it travels and, therefore, only in the lower part of the paper, and how medium-term and/or how fast and markedly high the sap level is. Therewith, from the above Goetheanistic consideration and understanding of bonding, it is soon clear that the "Colloid Type" includes all organic substances which have a high degree of polymerization but are still only slightly water-soluble. The ionic substances are the opposite; for instance, the anthocyanin in cherry-fruit pigment, which easily and quickly climbs and deposits into the upper color bands of the "Loose Type." In between are found the balanced substances which possess counterbalance and achieve a harmony of both poles—for instance, sugar! If the fractions of organic substance are not themselves colored, they can even be "developed" by metal-complex salts which make the bands visible afterwards.

Such an interpretation of the *Steigbild* of organic saps in connection with the bond spectrum of homopolar to heteropolar nature can agree with two diametrically opposed evaluations. The first is that of disappointment because we now have something explained in front of us, which we would have rather not see explained and so we comfort ourselves with the accusation that materialism and rationalism are the image of the foe. The other valuation is that one does not suppress the explicability, but rather accepts it in order to qualitatively expand it. The spiritual should never become the gap-filler for the unexplained but rather just the opposite: It should be celebrated in the real world even in its most expressive resplendence. How did Rudolf Steiner put it to the first Waldorf teachers?

> "Just as little should the impression be cultivated, which people love so much, that the unknown is proof of the spiritual. It's true, isn't it, that people say: Oh, one can't know that, there the spirit is revealed!—instead of people getting the idea: One can know about spirit, spirit reveals itself in the material,—people are so very inclined to the idea that where something cannot be explained, there is proof of the divine." (Steiner GA 300/I: 100, 9/26/1919)

Thomas of Aquinas was in favor of not misusing the spiritual world in the life of thought as a refuge of ignorance, as an *asylum ignorantiae*.

DYNAMIC EQUILIBRIUM

Transformation always comes to completion in the intermediate field of polarities. As we have already said: Ideal covalently-bonded matter is just as rare as purely ionic-bonded matter. The intermediate positions at all stages make up the majority of most molecular bonds. Within their transformation they can still appear stationary from the outside. But they are not stationary, but rather find themselves in dynamic balance; just think of all the buffer systems in intercellular and extra cellular biochemistry, even if it's only the pH-buffer in blood. The *intermediate bonding structures* of the substances involved always underlie acids and bases, especially weak ones. All carbonic acids and amino compounds have buffer capability: If over-acidity occurs, it will be dampened and if basicity becomes too strong, it will be toned down. In 1867, two Norwegians, Peter Waage (1833 – 1900) a chemist and Cato Maximilian Guldberg (1836 – 1900) a mathematician, discovered something they dryly called the "Law of Mass Effect." The name is more than unfortunate because it involves not the mass effect but rather the *concentration* effect, which everyone knows who has come to an understanding of it. The dose makes the effect.

The Law of 'Mass' Effect is itself only a specific case contained in a much more comprehensive principle, which includes situations of dynamic equilibrium also under the inclusion of energetic processes: *Le Chatelier's Principle*. Endothermic bonds develop when there is a heightened energy supply and thereby lessen the energy magnitude. Exothermic bonds are likely to develop when there is a low energy supply and thereby release energy. The same applies not only to chemical, but also to physical exchanges, if one doesn't also include the transitions in the various aggregate physical states with the chemical reactions (which they really are because the conversion of molecular structures also takes place with the utilization of bonding forces and thermal tints).

All climate-forming weather processes are governed by this. When warmth is introduced then energy-binding processes like melting and evaporation take place. When there is reduction of warmth, then it will be built up again through condensation and crystallization. Water is capable of any equalization and precisely through that makes possible the Earth's biosphere. The *Le Chatelier Principle* is operative in all balancing equilibrium processes. Life can only be realized within the balancing of polarities without ever allowing for complete equalization. Complete equalization is only possible in death and then only with inorganic substance and in this respect, the principle of "keeping outer compulsion to a minimum" in its mathematical form in chemistry and physics, belongs to the dead. However, it mirrors something here that is characteristic of life because it forms a region of increased intermediacy as here, for instance, between the bonding polarities because only in this way can it fully develop. Buffer solutions cannot be produced with strong acids, but only with weak acids. One could name the *Le Chatelier Principle* directly as a fundamental biological law that landed in the physical-chemical world. Does, perhaps, the inorganic,

even in its adherence to laws, come from the organic? An anthroposophical understanding of evolution would answer yes to that question.

The capacity to form a steady, compensatory equilibrium is at home in the etheric. Goethe himself discovered the compensation principle of organisms. For example, our entire sensory organization is controlled by this principle. If we view too much brightness, then our eye becomes less sensitive and we see only relative dimness. However, on a nighttime hike we can see the faintest traces of light. If we see green, the eye becomes sensitized to red, and if we see violet it becomes sensitized to yellow. If we stretch our limbs then the flexor muscles go into heightened readiness, etc. Colored shadows are neither objective nor subjective. They are a result of our sensory physiology and–like everything that is etheric-living–they are beyond objectivity and subjectivity. They reside where the cleft of dualism between body and soul is bridged; namely in both connectors: Life. Projected from there into the inorganic, the lawfulness of the *Le Chatelier Principle* enters and it is therefore indispensable for the physical existence of life.

The discovery of stereoisomerism, especially by Louis Pasteur (1822-1895), Jacobus Henricus van't Hoff (1852 – 1911) and Joseph Achille Le Bel (1847 – 1930), is one of the most significant in biochemistry: Not only the what, but much more the how of the substance is noteworthy. Not only the participating elements as such, but rather the respective spatial structure is crucial to the effectiveness of their bonds. Not primarily the mass, but rather the form is decisive. Through this, chemistry (until now merely a study of matter) will become molecular morphology. One does not say that structural chemistry is only "theoretically construed." We could trust earlier maps of the landscape for use with planning every trip even before we had satellite images to confirm them directly. And today there are correspondingly good pictures of molecular morphology that bring what was found theoretically to perception. Steiner advised the first Waldorf Teachers that if they were going to use formulas, then to immediately introduce the spatial/structural formulas (Steiner GA 300/III: 32). The substance C_2H_6O can either be ethyl alcohol as well as dimethyl-ether–two widely different substances which are both building materials. The material alone is actually not what is essential, but rather much more the "how," the epitome of every comprehension of form.

The most impressive phenomenon of stereochemistry in biochemistry is chirality. There are many organic substance that are chiral, and their physiological effect essentially depends upon their specific asymmetrical rotational direction. Pasteur discovered it with right-handed (d-) or else left-handed (l-) lactic acid. Le Bel und van't Hoff each found independently from the other that most of the time the asymmetry of the four carbon ligands was decisive. In some cases, our nose can directly smell the difference: caraway seed oil Carvone smells differently in its d-form than in its l-form, both with exactly the same formula, only with a different mirror-imaged stereo-isometry, either smelling like caraway or like curly mint. With two polarizing filters above and below an optical cylinder, one can easily make visible the different "optical rotation" of sugars (+)glucose, (+)sucrose, and (-)fructose. All chemical micro-structures relevant to life are clearly asymmetrical. Then it is more astounding that symmetries in the body structure of organisms can macroscopically appear at all. It makes no difference if radial or bilateral symmetry exists (i.e. sea urchin or fish), still most of the time the central, vital, metabolic organs are asymmetrically formed. At the tip of every snail-shell spiral are the digestion-steering midgut glands. The majority of all snail shell

spirals rotate to the right like our edible snails (*Helicides*). Still, counterclockwise spirals do occur, as in most of our species of small *Clausiliides*.

Inorganic chemistry shows little chirality. So, the exception of rock crystal and its related silicates is all the more astounding. They make up the vast majority of the Earth's crust and are familiar to us in crystalline plutonic rocks; and this main substance of the earth, close to the biosphere, is itself capable of chirality. There is right-quartz and left-quartz. Should they also be physiologically active and that even in varying ways?

This thought lies close to Spiritual Science in conceiving every organism as a wholeness, even as an open wholeness. Already as a student, Rudolf Steiner asked what the comparative whole in the inorganic is and didn't see it in details, but rather first in the "totality of the inorganic as a system" and that is the cosmos (Steiner 1886). So, because it is a whole, every individual living organism is, to a certain extent, a miniaturized reproduction of the entire cosmos. The geometrizing everyday consciousness looks at the outer cosmos as homogenous in all directions. In contrast, Steiner presented the view that the cosmos has inhomogeneous directions: If it's to be a geometric picture, then not that of the round sphere, but rather that of the bird egg (Steiner GA 136: 4.11.1912; GA 205: 90/ 7.1.1921). The embryologist knows that the body axis of a chicken in the first stage of formation inside the egg stands perpendicular to the egg axis, and further 70% of the time is oriented so that the head pole is away from the viewer and the tail pole toward the viewer when he holds the egg with the blunt pole to the left and the sharp pole to the right. The original position in the egg is always asymmetrical and its frequency of direction is likewise asymmetrically divided. Looked at in this way, that all higher-order organic substances formed by living metabolism are asymmetric even to their minutest level, then it is an expression of the complete, cosmic nature of life processes.

In 1956, physics first discovered an inherent dissymmetry of the physical universe with beta-decay. In 1997 the American astronomers Nodland and Ralston found experimentally the asymmetrical spiral structure of the physical universe from the radio emissions of 160 distant galaxies which didn't show equal changes their cross-sectional area. Previously, a strict isotropy in all directions of space was assumed.

The nucleus of $^{14}_{6}C$ decays with emission of a β^- particle, and a neutrino $\bar{\nu}$, as confirmed in 1956.

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + e^- + \bar{\nu}. \qquad [\beta^- \text{ decay}]$$

The idea becomes obvious that the bio-dynamic horn silica preparation (by the way, always prepared in an asymmetrically rotating cow horn) by reason of the chirality of the quartz, is the most effective preparation. Otto Wolf already made this conjecture years ago. In 1982, Rainer Dietrich and I made our first trials with separated spraying of right and left quartz in the research garden at the Institute for Waldorf Pedagogy in Witten-Annen in Germany. The pole beans, for the most part, reacted better to right-handed quartz than to the left-handed quartz, in terms of leaf-size and intensity of chlorophyll pigmentation. Under the aegis of Professor Wolfram Achtnich, Christina Senger could, within the framework of a dissertation, further corroborate this hypothesis in a field crop trial at Goettingen. But, despite many trial-starts, the biodynamic research circle has not been able to achieve any conclusive results. One can only wonder at the ingenious grasp of Rudolf Steiner, that with the horn silica preparation he latched onto just this mineral standing nearest to the physiology of life. And Goethe expressed it in his Maxims and Reflections in this way (Nr. 705):

> "If, in its lifeless beginnings, nature wasn't so thoroughly stereometric, how would it finally achieve incalculable and immeasurable life?"

How did the wise man from Weimar already know about this?

THREEFOLDNESS IN THE STRUCTURE OF MATTER

Looking to the future, Rudolf Steiner once spoke of the fact that some day the activity of the *highest spiritual forces* could be revealed in the physical world, even in the laws of chemistry (Steiner, GA 15:66). Spiritualism and materialism would then no longer stand irreconcilably opposed to one another. The future has always had its seed in the present. Is there already some content there in the inorganic sciences? Probably only the first, unnoticeable approaches. What does nuclear physics and nuclear chemistry describe about the subtle structure of matter? The over 100 elements are traced back to the notably fewer elementary particles, although their number has grown significantly in the meantime. But always there are at least three qualities that characterize every elemental particle. First, the *mass* is collected onto the smallest central space and therefore also surrounded by a minimal gravitational field. But, in addition, most elemental particles carry a particular *electrical charge* and for this reason have a very much stronger, corresponding electrical field around themselves. Charge fields always extend indefinitely into the space (even though they diminish quickly by the inverse square of distance). Mass is focused and confined in the center; the electric field extends to the periphery. Those are two principle antagonists in the formation of matter.

However, an elemental particle is not determined alone by the mass number and the size of the charge. It is determined by still a third value, the spin. It is an asymmetrical moment of rotation that the directions of the mass as well as the charge rotations take on. In this lies a unifying, rhythmic-oscillating characteristic that is just as much constitutive as is the mass and charge. Only all three values describe each individual elemental particle.

Similar dynamism lies in the configuration of every atom. The mass-increasing nucleons concentrate in the nucleus, where neutrons directly increase the nuclear mass but not the charge. They are often necessary so that the equally-charged positive protons don't repel each other, that is in order to shut off their reciprocal charge effects. On the other hand, the atomic shell consists of mass-poor, strongly-charged negative electrons which establish a field force in their surroundings. Between the nucleus and outer shell, that which incorporates itself is a rhythmic process full of "quantum jumps"—still only interpretable through quantum theory. The pedagogue from Basel, Johann Jakob Balmer (1825 – 1898), who was the first to discover the mathematical organization of this rhythmic sequence in the form of the Balmer Series of hydrogen atoms, saw in the relationship he had discovered a pronounced Pythagorean element (Hagenbach 1941, Hartmann 1949).

The description doesn't need to be more closely interpreted here. It seems clear that all material structures have a three-fold aspect, in the sense of [Goethe's terms of] "polarity" and "enhancement." This trinity, as it is made visible through anthroposophically-illuminated Goetheanism gives these small details—until now only of specialized technical interest—such a value that it is also an aid to orientating the human being's self-understanding and how they fit into the natural order.

Herder made fun of Goethe: "One of the most laughable periods of genius was the mining one in Weimar, as the mines in Ilmenau were to be made passable again;. There, man was nothing, rock everything. Goethe found the divine Trinity in the organization of granite, which could only be explained through a mysterium" (Conversation with Falk). Herder is here referring to Goethe's essay "About Granite."[1] However, Rudolf Steiner spoke about this essay by Goethe with great respect, and recommended it in the "Supplementary Course" for teacher preparation:

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[1] *Available from AWSNA Publications.*

> "It is above all, subjects of this kind–history, geography, geology– that should be put before the children with real feeling. Geology, for instance, becomes quite fascinating when the teacher has a deep and sympathetic understanding about the rocks and stones found within the Earth that they describe. In this connection, I would recommend to every teacher to read Goethe's treatise "On Granite" to read it through, entering into it with heart and soul. He will find there a proof of how, by entering into the world of nature not merely with thought but with his whole being, a person is brought into a human relationship with that primeval-father, the sacred granite of remote antiquity. Naturally, other things can be approached in the same way."(GA 302, Lect 2; p.25; 6/13/1921,)

Actually, with Rudolf Steiner the three-fold nature of granite finds its therapeutic application in the three-fold human organism. (Steiner, GA 349: 19, 2.17.1923).

Back then Goethe had at his disposal the geologic knowledge of his day, which Heinrich von Trebra introduced to him. Quartz, mica and feldspar, in their behavior to light, show polarities and a color intensification (sequence). Goethe's entire theory of color is likewise an attempt to grasp an area of physics in terms of qualities.

Today we have a disproportionately more voluminous, detailed, and differentiated knowledge about all sorts of natural phenomena. However, the educational meaning *for the human being* is missing; in fact, it tends to turn our *understanding towards nature* upside down. The spiritually-interesting educational stratum of this knowledge is abandoned—it is evident only as a bare reductionism and materialism, which purses the lips and looks down the nose. And yet, the natural sciences are full of the good spirit. We should strive to discover more of it. The methodology has long been available but a discovery must be desired and sought after. Otherwise, every passing form of spiritualism that does not relate to the physical world, (missing its calling), begets more than ever a form of materialism that is fallen and so becomes something negative, (Steiner, GA 295: 167). This has already had a tragic, centuries-long tradition from which we should free ourselves.

This is the second part of a two-part article. The first section appeared in the Autumn 2002 edition of the *Waldorf Science Newsletter*.

—eds.

Professors Vie With Web for Class's Attention

by

John Schwartz

New York Times

Universities are rushing toward a wireless future, installing networks that let students and the faculty surf the Internet from laptop computers in the classroom, in the library or by those ponds that always seem to show up on the cover of the campus brochure.

But professors say the technology poses a growing challenge for them: retaining their students' attention.

In a classroom at American University in Washington on a recent afternoon, the benefits and drawbacks of the new wireless world were on display. From the back row of an amphitheater classroom, more than a dozen laptop screens were visible. As Prof. Jay Mallek lectured graduate students on the finer points of creating and reading an office budget, many students went online to Blackboard.com, a Web site that totes course materials, and grabbed the day's handouts from the ether.

But just as many students were off surfing. A young man looked at sports photos while a woman checked out baby photos that just arrived in her e-mailbox.

The screens provide a silent commentary on the teacher's attention-grabbing skills. The moment he loses the thread, or fumbles with his own laptop to use its calculator, screens flip from classroom business to leisure. Students dash off e-mail notes and send instant messages. A young man who is chewing gum shows an amusing e-mail message to the woman next to him, and then switches over to read the online edition of *The Wall Street Journal*.

Distraction is nothing new. As long as there have been schools, students have whispered, passed notes and even gazed out the window and daydreamed. The arrival of laptop computers, however, introduced new opportunities for diversion, and wireless introduces an even broader range of distraction, said Dylan Brooks, a senior broadband and wireless analyst at Jupiter Communications.

> "They could have played solitaire or Minesweeper before," Mr. Brooks said. "Now they can do that or seven million other games, or watch a full-length feature film."

This is especially galling to law professors, many of whom still live in the world depicted in "The Paper Chase," the 1973 film in which an imperious Prof. Charles W. Kingsfield Jr. held his students in terrified thrall.

"This is an addictive thing that hurts the students themselves," said Ian Ayres, a professor at the Yale Law School who opposes much of the Internet's entry into the classroom, saying that computer use is rude and that other students are "demoralized" by seeing their peers' attention wander.

"When you see 25 percent of the screens playing solitaire, besides its being distracting, you feel like a sucker for paying attention," Professor Ayres said.

Unless law students are fully engaged in the class, he said, they miss out on the give and take of ideas in class discussion and do not develop the critical thinking skills that emerge from "deeply tearing apart a case."

Professor Ayres tried to prohibit all Internet use in his classroom. The students "went ballistic," he said, and insisted that their multitasking ways made them more productive and even more alert in class.

Lately, he said, he has loosened the restrictions, telling students they could surf from the back rows, so others would not be distracted.

One professor at a law school in Texas became so upset by the level of student distraction in 2001 that he took a ladder to school, climbed up to reach the wireless transmitter in his classroom—and disconnected it. The students protested. The administration told him to plug it back in. But the point was made, he said, and he regained the attention of the class.

In 2002, he told his students that they could not use laptops in his class at all, even for taking notes.

"It has made an enormously positive difference to shut those computers off," he said.

Today's college students are a truly wired generation. A study in 2002 by the Pew Internet and American Life Project in Washington found that 86 percent of students have gone online, compared with 59 percent of the general population. Although the study did not focus on wireless technology, the authors did delicately predict that "issues readily apparent with the spread of cellphones, such as etiquette and distraction, are likely to emerge as students are able to access the Internet anywhere, including in classrooms."

Dozens of colleges are going wireless, including Dartmouth, Carnegie Mellon in Pittsburgh, the University of California at San Diego and the University of Minnesota.

The wireless rollout at American University is especially ambitious, because it integrates cellphone coverage into a single data-delivery network that can deliver messages to laptops, handheld devices and telephones anywhere on the 84-acre campus. The university plans to stop offering traditional phone service in its dormitories eventually.

In any building, the wireless access ports are likely to be there, looking a little like the top half of a Lava Lamp, painted white and stuck upside-down to the ceiling.

The director of e-operations at the university, Carl Whitman, said being early to the wireless world created an advantage in attracting students who demand the latest technology and "becomes a plus for us."

Matthew Pittinsky, founder and chairman of Blackboard Inc., the large Internet education company that puts Professor

Mallek's class materials online, said wireless access had "made higher education much more of a 24/7 educational environment than ever before," with instant access to classroom materials and research resources and a growing potential for collaborative study.

Mr. Pittinsky said the greatest power of wireless showed up in the dorm, the library and the commons. "There's less of an obvious use for wiring the classroom," where the benefits have to be balanced against the distraction, he said.

At American University, Professor Mallek said the benefits of the technology in his classroom far outweighed the problems. He ran the pilot project at the business school that helped the American decide to put in a campuswide network and said he had grown used to students' flipping their screens.

"It's a new type of social commentary, to hear clicking," he said. "It's an audible vote."

He suggested that it might even be making him a better teacher. He takes the threat of losing his students to e-mail and online newspapers as a challenge to keep lectures interesting and lively.

"As a professor," he said, "if you are not productively engaging them, they have other opportunities."

Mr. Whitman, the director of e-operations, said he was testing new programs that might address some of the problems of online distraction. A system that takes the locations of students into account could be used to set rules that varied from place to place. Any use of the Internet might be acceptable in the library or the dean's office, he said, "but if you're downstairs in Jay's classroom, you could not surf the Internet or you could surf the Internet but only go to CNN.com for in-class reading."

Joseph Sun, a first year M.B.A. student in Professor Mallek's class, takes notes with pen and paper. He owns a laptop but does not take it to class. Although it "comes in handy to look up an article or quote during discussion," Mr. Sun said, he has to resist "the temptation to surf the Net during lectures."

Students say they are finding a balance in the classroom between the good uses of online technology and its temptations. Tetse Ukueberuwa, a major in environmental studies at Dartmouth, said, "Over all, it's a great thing," being able to check e-mail messages and conduct online research anywhere on her campus.

Ms. Ukueberuwa said she preferred to take notes by hand, however, saying: "I feel I'm more in touch with what the teacher is saying. You're looking at the teacher instead of looking at your computer."

As a junior, though, she realizes that she may be "old-fashioned." Every incoming class, she said, seems "more technologically advanced" than the last.

— January 2, 2003

* See additional resourses on adolescent development on the OWL website >http://www.waldorflibrary.org<

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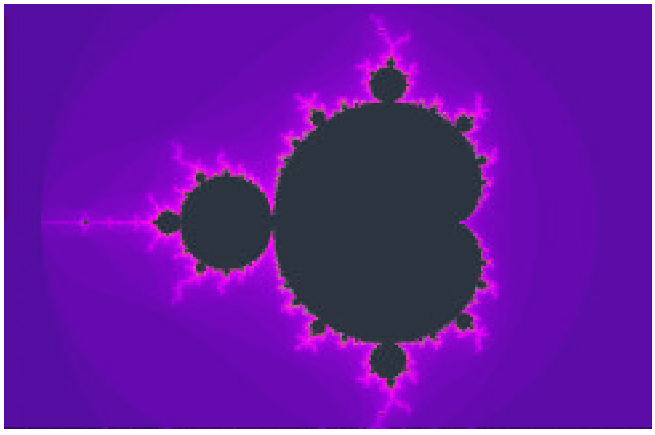

Mandelbrot Set

The Teenage Edge

by

Ted Warren

(This is an edited and condensed version of the third chapter of Ted Warren's forthcoming book *The Teenage Edge* from AWSNA Publications—eds.)

The "edge experience" is that critical moment in a teenager's life when the Self fully engages his or her actions. In these moments teens discover the unique aspects of their personality. These experiences are the key to the future because they help to identify what is worth living and working for. The most important aspect of her "edge experiences" is the fact that the teenager gets a glimpse of who she/he is becoming. It is amazing to speak with teens who receive this confirmation of their identity. They feel acknowledged. Their integrity is strengthened!

Every "edge experience" is an action through which the teen creates their future. Why is this so? The future is created because the teen is able to connect the power of the Self with his or her actions. Put another way, when the Self is present, the teenagers actions are filled with thoughts or feelings that are tempered by values. The power of their true ideals and productive ideas works into their personality as each "edge experience" takes place. For example, Hilde, a teenage activist, told me that her decision to save a wilderness area struck her "like lightening." That phrase indicated to me that she had an "edge experience." Such experiences may last for a brief moment or over a longer period of time. To define and appreciate the "edge experience," Hilde must leave it. In order to get back to it and determine if it has become truly important to her, that is, if it has been incorporated into her personality, she will have to test the reality of her activist plans on a daily basis. Every time, getting to the edge depends on her initiative. She has to want the changes or they will never happen.

Many kids have the courage to take chances and push through the myriad resistances that put them down and lead them away from their edge. Those resistances can be peers, parents and experiences that undermine development or institutions that ignore teen's search for vital resources in their personality. Yet I watch teens teach themselves how to connect with their Self and bring it into play in their daily lives. These kids have remarkable presence!

I know teens who are blessed with such powerful "edge experiences" that important steps in their personal growth take place. This growth takes the form of a realization that they want to change important parts of their lives, like working habits and how they treat other people. They may decide to take risks in their social life that lead to accountability and new confidence. One of my pupils had been a computer geek for five years when he slowly began to realize that his life was becoming more and more narrow. He left home and worked on a farm for a year, the last thing anyone ever expected him to do! But experiencing the edge gave him new insight into how he wants to live his life.

Another pupil with "edge experiences" learned from his mistakes. Up until the age of seventeen he had been arrogant and at times cruel to his sister. When he saw himself in a moment of "edge experience" he realized he had terrible habits. It didn't take long for him to turn himself around.

Though a teen becomes conscious of his "edge experiences," life does not necessarily get easier. Many become insecure. All of them see more clearly the discrepancy between what is true and false. The fact that they have discovered a part of the potential of their Self leaves them with new gaps. The best way to bridge that gap is to continuously work towards more continuity in decision-making, setting right priorities and unfolding their personal maturity. This is not easy for teens to do alone. They need strong adults to give them guidance along the way. This book will guide you—the parent, teacher, or the friend—in helping you challenge your teen.

For long periods of time teens can become temporarily lost or confused. They may indulge in excessive behavior as a reaction to the superficial world they experience. They have not yet learned how to fill their lives with meaningful content! In some cases their schools and employers stifle their creative vitality. The kids realize that they don't really belong within these institutions. Temporarily, their substantial talents become wasted in a sense of powerlessness. When you see a teen experiencing this kind of confusion, you can bet that his or her Self is not engaged sufficiently.

Some teenagers continues to have unsettling experiences on the edge. The positive side of the "edge experiences" is that old parts of the personality break away, resurface, and stare the teenager in the face. This process leaves them with decisions to make.

CONVENTIONAL EXPERIENCES ON THE EDGE

Teens hit their conventional edge every day. There they explore the boundaries of their existence. Why do I call it conventional? The conventional edge experiences differ from the "edge experiences" in that we cannot be sure that the Self is engaging in the experiences on the edge. It may and it may not. For example, some teenagers push thmselves intellectually, often to the point of exhaustion but it is very difficult for us to know how much of the Self is engaged in the intellectual activity. In nature they test the limit of their physical prowess.

As a teacher I have seen kids quickly tap into their intellectual edge during my lessons and ignite the conversation for everyone. They know how to inspire a room of peers by putting their ideas into powerful words or asking the right question! Some of my pupils have an artistic edge. They reach their boundaries as musicians, dancers or painters and push on to new experiences. What do they bring to their boundaries? They bring their will to be creative, their passion for dramatic experiences. They provoke the edge, incorporate the experience into their Self, and then reap the rewards.

The emotional edge is explosive for all kids! Their Self is not necessarily engaged in the explosions. Here we see our kids exploring a wide spectrum of experiences. Sometimes they open up to their friends. At other times they hide away emotionally. Quite often they get involved with reckless abandon. The conventional, emotional edge comes from the power of the personality and it often overwhelms the Self.

For the most part, kids can learn from their experiences through constructive dialogues with other teens or adults. That is preventative medicine because it takes place over time and they learn how other people deal with their emotional edge. In the classroom teachers constantly receive distinct impressions of a pupil's emotional edge. A major challenge for teachers—but also extremely rewarding one—is to figure out how to reinforce those edges in a way that leaves most of the work to the student himself while ensuring that work will be productive. Those of us who are fascinated by human behavior, can learn something new every day from the amazing kids we meet and work with.

HOW DO YOU KNOW WHEN KIDS ARE ON THE EDGE?

As I mentioned previously, the most important factor in "edge experiences" is whether or not the Self is engaged in the process. From the sidelines, concerned adults can learn to observe the quality of Self working into their teen`s experiences. My goal with this book is to help parents and professionals learn to focus on this essential side of teenage personality development. A picture of healthy edge experiences looks like this:

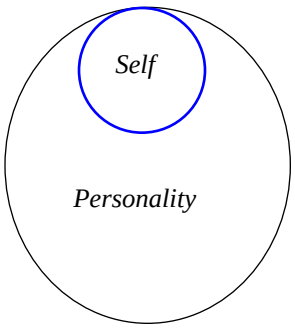

Figure 1

The Self is the core of the teen's personality. It is present in the personality and it engages in their actions. In order to observe the core of the personality in our teens, we need to focus our attention on it over a period of time.

The first clear sign you may notice of a teen experiencing the edge is usually a major change in attitudes, thoughts, or activities. If you notice new ideas they are thinking or a new sense of maturity in the way they address daily issues, these may be signs that the teen's Self is integrating into her personality in a new way. You may also notice that she is dealing with people better or that she is learning from mistakes she made earlier. You may notice new self-esteem in the way she presents herself. You may hear your teen express sound insight in an area that you did not expect. These are great moments that tell you that your teen is taking new steps toward newfound maturity, toward discovering the essence of who she is becoming. She's discovering new ideas through "edge experiences." She may not tell anyone but the ideas are working into her daily life giving her direction and self-confidence. Only some of these signs of "edge experiences" surface well enough for us to see. And talking about them is not always the best thing to do, unless the teen directly asks for recognition or for adult insight.

The insecurity that often arises when teens have "edge experiences" shows that they are struggling for more clarity. They search for a new balance between the old and the new. When old experiences are judged and integrated by the teen's Self, the teen can then appreciate the new experiences. We can see this process very clearly in the changes that take place when teens fall in love. A fifteen year-old falls in love in a whole different way than a seventeen year-old or a nineteen year-old does! The motives for falling in love change between seventeen and nineteen. The depth and the quality of the relationship is also much more advanced. What makes the difference? It is the quality of Self working into their lives through the edge experiences they are going through. In each phase of their lives, new confidence is created.

Nobody is perfect. Teens can always make new moves. And if teens have already made plenty of bad moves, nothing is final. The edge is out there. What is most important is that they repeatedly find their way to healthy "edge experiences". Then they take new steps. A good experience one day may be followed by a bad experience the next day. And a bad experience one - day can lead to a good experience the next day. Teenage life is that dramatic. Once again, the key is how much of the Self integrates into the good and difficult experiences. This is essential because the Self—that powerful feeling of being unique—is the teenager's true source of health.

REACH THEIR ATTITUDES!

Most adolescents are at the mercy of their attitudes. Attitudes lie even more deeply in the personality than the teenager's temperament or feelings. Each attitude has its inherent strengths and weaknesses. How attitudes are dealt with is the real key to self-esteem. If they are used productively, then new sides of life can be unfolded. The power of the Self, available through the "edge experience," gives teens the ability to work productively with their attitudes. Productive attitudes lead to openness and understanding. Unproductive attitudes such as self-pity or "I deserve more" create fear. Fear often leads to extreme self-consciousness or dullness. Eventually these unproductive attitudes lock the teenager into grudges or hate.

We all recognize these attitudes that teens frequently express:

They do not understand me.
Things usually never work out for me.
I never know what to do.
I always get what I want.

The challenge for adults who care about teens is to help them create a productive relationship with their attitudes. In all my years of teaching and parenting, the toughest job has always been to confront a kid with her unproductive attitude, whether that attitude was egotistical, or based on lack of respect or insecurity! I always had to be sure that my judgment was fair and that my intentions were good. Even then it is never easy to take a stand and enter an unpleasant area with a teen who is in a lot of pain! Once you tell her how you experience her way of behaving, you strike a deep chord in her personality. You have to be direct

and aim correctly or you may miss your target—the bad attitude that is slowly destroying a lot of the creativity in her personality. How might this teen respond? Some kids have been so shocked at my approach to them that they simply look at me and acknowledge my insight. These kids are easy to work with because they want to change and they trust me to guide them. One fourteen year-old boy was not that responsive. He did not like being confronted! Instead of acknowledging that I might have been on to something true, if unpleasant, about him, he just lashed out at me physically!

Another boy needed a whole year of direct confrontation with clear feedback and a lot of love in order to turn around his destructive attitude about himself. I had to go so far as to recommend that he leave school and get a start somewhere else. In the end he recognized my recommendation as a wake-up call and decided to stay. The turnaround he created inspired the whole class. He gave us all a lot of love.

We are now considering a very critical area of personality development. Many kids are left on their own to make necessary changes. They have unlimited freedom. Along with freedom always comes responsibility that they are sometimes too inexperienced to handle. Without responsibility, though, kids will not lead productive lives. Those who have not learned to be responsible for themselves and others often receive brutal messages from their peers or adults who exploit their weakness. Such responses would not be necessary if adults who truly care about them had been able, in a loving way, to help them turn around their bad attitudes.

Identify their Multiple Attitudes

If you look deeply into your kid's attitudes you will be surprised how complicated and potentially explosive their situation really is. Some teenagers combine superficial attitudes with arrogance and often have a hard time learning from their own mistakes. These teens then often have an experience of fate striking them hard blows that seem to come out of nowhere! With "out of nowhere" I mean blows that are unexpected. They are dealt by strangers who respond to the teen's attitudes mercilessly. I often tell parents that if they don't take it upon themselves to teach their kids what is fair and respectful, other people will deal their kids unpleasant and maybe even tragic blows from outside the family. Such hard blows seem to come out of nowhere but really come form the teen's inability to excise their bad attitudes from their moral Selves.

One of my pupils had a superficial attitude that reinforced her fatalistic attitudes! She had struggled for years to keep her balance between vulnerability and durability. She chose to be superficial about her experiences, always covering up her lack of confidence with arrogant comments about other teens. Christine did not believe in herself and her self-esteem dwindled year after year. She became a master at pulling herself together to hide her pain and perform well. Unfortunately she built up so much denial that she also became a master at avoiding personal issues.

Kids often need help from trustworthy adults to identify their own attitudes. It is hard to put your finger on deeply anchored problems and when you do, you must expect extreme resistance! If you dare to tell a seventeen-year-old that he has an extremely positive attitude of carrying on despite resistance, he will be very happy. If you dare to tell an eighteen-year-old such as Jason that he is wasting a lot of his time and energy with his fatalistic attitude; and point out examples of what you mean, he may not appreciate it at the moment, but there is a good chance he will years later. As I noted above, it is up to the teenager to take responsibility for any changes he may find necessary.

Bad Attitudes Below the Edge

When teens have multiple bad attitudes there is great potential for conflict. They dwell in experiences far below the edge that put them in a self-destructive zone where they easily make life miserable for themselves and others.

For example, the wise guys who seek immediate gratification may be frustrated by not getting what they think they deserve. They express negative attitudes such as:

I want it and I want it now.
I have it all but I deserve more.
They sold me short.

Quite often these teens combine their bad attitudes with another devastating one; placing the blame on others! The problem is them-not me! These teens take this attitude to another level by stating, “Either you are for us or you are against us!

A fourth bad attitude that may complicate the picture is;

I won’t make an effort to change.

I DON’T HAVE TO EXPLAIN ANYTHING TO ANYBODY!

If teens carry around more than one negative attitude they find it extremely hard to make significant changes. Such teens risk becoming lean young wolves with bad attitudes continually scorning others in their spiral of hate. Grudges and total lack of understanding for other ways of life build up. The personality development of such extreme teens with multiple bad attitudes is limited unless an adult is there to prevent a loss of Self.

A LOSS OF SELF

What is happening psychologically when teens turn to violence? What makes a teen say to another person, “ I hate you!” What type of personality are we dealing with when a teen calls in a bomb threat to a high school just for fun? What is missing when teens commit well-thought-out crimes or become pre-meditated murderers? Such teens, suffering from twisted minds and bizarre behavior, carry an aura of invincibility. They believe they can live way beyond the law.

The Columbine High School Massacre on April 20, 1999, in Littleton, Colorado, is an example of the tragedy of denying the Self. The kids who stormed into the school with semiautomatic weapons and explosives were filled with hate, not the power of the Self. What made them laugh as they shot their fellow students hiding under the tables? How could they shoot at propanetank bombs they planted around the school and then amuse themselves by picking off teachers running through the hallway? How could they kill 12 students and a teacher while injuring 23 other kids before turning their weapons on themselves?

They were filled with hate because they had no sense of belonging—and no one they could look up to. They lacked the power of their Self and instead responded to the power of hate. The following picture of hate took possession of their personality.

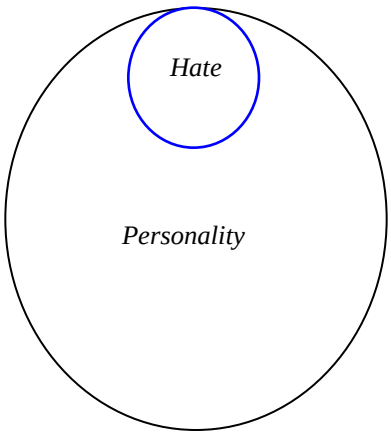

Figure 2

A tragically destructive circle of hate can eventually take the place of the Self in the teenage personality. In these cases, the Self did not work into their daily life or take part in their actions. Nor did it inspire their thoughts with good ideas and healthy ideals. Whenever the teen does not connect with the Self, destruction fills the gap. This extreme situation is now a national problem. Too many kids are living without productive “edge experiences.”

Teens at severe risk do not connect with anyone. They start forcing their attitudes on others. In this way they unconsciously affect the willpower of other kids. I have seen kids in this phase take pleasure in tormenting animals on field trips. Often they continue the amusement in the classroom by tormenting other kids and abusing any teacher who lets them. Parents who observe these symptoms at home and teachers who see it at school need to react appropriately each time they appear. Chapters 6, 7, 10 and 11 of this book will give you the keys to actions you can take to prevent your kids from developing the power of hate.

There are three phases in the process by which teens either lose contact with the Self or never develop a healthy relationship with it.

The first phase starts when teens consciously use their power to affect the will of others—that is, they no longer have any genuine interest in other people. They merely enjoy using people! These teens are mean and egotistical. Some of them are in contact with adults who teach them the power of hate. We define this power as purely egotistical love—that is, always at the expense of others! Such adults lead kids down a dark path of destruction.

The second phase starts when the teen develops his hate on a daily basis and learns how to systematically manipulate others. He gets other kids to work for him. He uses violent videos, computer games, drugs and alcohol to build up his rage. These crutches help him lose the control that would otherwise put the brakes on such activities. Daily dosages of second-hand violence make him feel good. His fantasy life dwells on abuse. He learns how to bring hate into his personality thereby displacing the good, moral impulses of the Self.

These attitudes continue into the third phase, where he decides to kill. I have never worked with kids in this phase. The symptoms in the first and second phases are clear enough for any caring adult to identify. The third phase is more difficult because the teen has placed his intelligence in the service of pure hate and uses that intelligence to prevent others from identifying him. He may collect weapons and learn how to use them in his plans to ruin the lives of as many people as possible.

The temptations of hate are always present if teens do not get in touch with their Self. “Edge experiences” are important because they reinforce a teen’s growing perceptions of truth and love, especially when the Self is engaged in the activity. Conventional experiences on the edge are more common and of no less importance. Just how well we can support our kids on the teenage edge depends on our focus and efforts.

With significance of “edge experiences” in mind we move forward to the next chapter where we will look at eight key factors of personality development. We will focus on each one of these factors and explore how the Self gradually emerges during the teenage years.

Application Note:

Oscillator Coil Demonstration Using an Ultra-Low Frequency LC-"Tank" Circuit

For 11th Grade Physics/Electronics Block.
by
Fred Bassett

This application note is the result of discussions with John Petering and subsequent test bench experiments, to work out a practical demonstration of oscillations between a large Capacitor and a large Inductor (the classic LC-oscillator or "Tank" circuit). The circuit design began with experiment notes suggested in von Mackensen's "Fields, Rays, Atoms" [1] and also from ideas in Peter Wenger's website with an outline of "Experiments leading to Electromagnetic waves." [2]

In the key indications for the grade 11 physics block, Steiner suggested we study "the newest discoveries in physics, [such as] wireless, and …Roentgen [rays]…"[3] First, we note that this will mean covering a lot of topics, and we must be very economical to manage all this in the usual 3-4 week block. Also, in order to work our way into understanding the radio, clearly a key will be understanding the resonant oscillator circuit.

This is often done with a classic experimental apparatus such as the resonant coil kit, originally developed for the PSSC physics curriculum.

Another version is described in detail by Se-yuen Mak, in *Physics Teacher*.[4] His demonstration note points out that although many teachers "use a large air-core coil [such as the PSSC coils described above], we prefer to use a ferrite-cored AM radio antenna instead . . . so for the [larger] value of inductance, the number of turns in the solenoid can be greatly reduced." Both PSSC and Mak's setups are interesting, but have a resonant frequency in the radio-frequency range which can only be shown with an oscilloscope.

However, Mackensen's experiment note suggest a way to show this effect in a more directly perceptible way, by having the resonance low enough to see it with a d'Arsenoval lecture Galvanometer. So, our goal was to create a demonstration that would show easily perceptible oscillation and could be easily set up using inexpensive components.

Figure 1: The PSSC Coils

A galvanometer is a current meter that has an indication scale range laid out as "negative–zero–positive." Zero current being the center scale quiescent point, with meter deflection in one direction for current flowing from connection pole #1 to #2 and meter deflection in the opposite direction when current flows from connection pole #2 to #1. In order for the meter to register current flow changing directions, it is recommended that the resonant frequency be less than or equal to 2 Hz and the current meter have fast enough response so that the changes can be tracked. Frequencies higher than 2 Hz may be too fast to be indicated as complete positive and negative swings on the meter due to the mechanical damping characteristics of the meter.

Figure 2 Galvanometer

After charging the capacitor from a power supply, we then switch the charged capacitor to be in parallel with an inductor (the classic LC "tank" oscillator circuit), that has a sensitive galvanometer connected in series between one pole of the capacitor (C1) and one pole of the inductor coil (L1). The galvanometer (G) would show energy moving back and forth between a charge in the capacitor (C1) and a magnetic field in the inductor (L1), at the resonant frequency of the circuit with component values indicated that are different than those used below).

The resonant frequency of this type circuit is defined as the frequency (F) at which the inductive reactance (X_L=2 pi F L) equals the capacitive reactance (X_C=1/(2 pi F C). This frequency is often denoted as "center frequency" (F_0). Solving for F_0 the equation becomes: F_0=1/(2 π SQRT(LC)). What is somewhat unique about this dem-

onstration is that we want to use a large lecture galvanometer (which is generally a DC current device), to demonstrate an AC circuit, by slowing the resonant frequency down to such a point that the galvanometer can visibly follow the oscillating current.

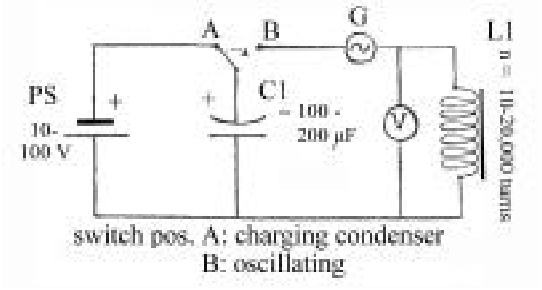

Figure 3: The Resonant LC circuit

The circuit is set up such that a ~10 Volt DC power supply (PS) is connected to the capacitor (C) through a double pole single throw (DPST) switch (see basic circuit diagram, above). The positive pole of the C is connected to the common pole of the switch and the positive terminal of the PS is connected to one of the 2 stator connections of the DPST switch. The other pole of the DPST switch is connected to one leg of the inductor (L) via the galvanometer style current meter. The second leg of the L, the negative pole of the C and the negative terminal of the PS are all connected together. The switch acts to first charge the C and then, when thrown, to connect the C to the L (and galvanometer) and form an oscillating LC (tank) circuit. In order to see several positive and negative swings on the meter, the Q (ratio of inductive reactance to the inductor's DC resistance at the resonant Frequency) of the circuit must be as high as possible. This is accomplished by selecting an inductor (L) with as large an inductance value as possible (minimum 2 Henry) with as low a DC resistance as possible (<2.5 ohms). I was able to find an iron core transformer with a 120VAC primary and 20VAC secondary rated at 100VAC which had an effective inductance value of ~2 Henrys on the Primary side (leaving the Secondary leads unconnected and taped off). This transformer cost less then $5.00 at an electronics surplus supplier. The resistance of this transformer's primary winding was 2.5 ohms. I calculated the Q of this transformer to be ~10. By contrast, Peter Wenger's "long time constant transformer" is 1200 Henrys and has a DC resistance of only 12 ohms, with an effective Q of ~1200, for a center Frequency of ~2 Hz, (see reference #6).

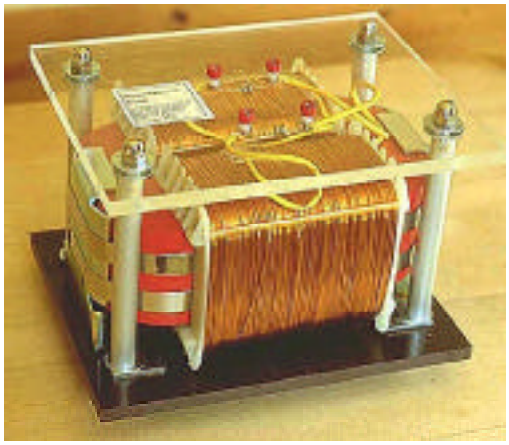

Figure 4 Wenger's Coil

As mentioned above, in order for the "quality" (Q) of the circuit to be as high as possible, try to find an inductor or transformer with *lots* of windings using a *large gauge* wire for low DC resistance, and an Iron core. I sampled several transformers and inductors (both conventional and toroidal) at the local surplus electronics store before selecting the best one that I could find. For your tests, you will need an electronic voltmeter that has an inductance measurement function. I borrowed one owned by the store (that the staff uses) for me to use while I shopped. None of my own 3 meters has this function–and it is not very common to most handheld meters. You could also order an inductor domestically manufactured by Stancor, or purchase the very nice custom unit from Wenger (and pay overseas shipping). Unfortunately, I didn't have one of Peter Wenger's nice coils to test for this demo.

I used a 4500uF Electrolytic capacitor rated at 50 Volts for my testing. This value along with the ~ 2 Henry transformer being used as an inductor (choke) mentioned above produced a measured F_0 ~ 1.25Hz. If you plug all the values into the equations given above you won't get this exact value, but it will be close. This discrepancy may be because the actual capacitor value was not exactly equal to what was printed on it. For our purposes this is not of significant importance.

SAFETY note: Electrolytic capacitors which are available in large values are not normally used in this fashion. Reverse polarizing an electrolytic capacitor for extended periods of time will dry out the electrolyte, causing the plates to deform and eventually develop enough conductance internally between the plates (breakdown of resistance across the electrolyte between the plates) that they will heat up, warp, leak and possibly explode. Take extra precaution to be sure to wire these type capacitors so that the + pole on the capacitor is connected through the switch to the + terminal on the Power Supply. The negative transition charging of the capacitor when the inductor is switched in is of such low amplitude that it will not significantly harm the capacitor. However, a constant reverse polarity charge on the capacitor if you wire it backwards will cause the breakdown problem. If the capacitor starts to get warm to the touch, or you see measurable current being conducted as measured on the power supply panel meters after the capacitor has been connected and charged, then check to see if it is wired backwards. If it is not wired backwards, and is warm or conducting current, you might have a bad capacitor, and should replace it.

I used an oscilloscope to first verify that I had a usable F_0 and high enough Q to see at least 2 wave cycles. Once I had a known usable circuit with the F_0 < 2 Hz and at least 2 measurable cycles (high enough circuit Q to maintain oscillations) I moved onto introducing the galvanometer.

The galvanometer that I used was a ±50uA full scale that I bought at the same electronics surplus store for $8. I estimated that I needed to read ~5A full scale by using my digital current meter to establish a first approximation.

The digital meter is not well suited to measuring DC current in this demo as it cannot continuously sample DC but only at periodic intervals of set duration. Switching the circuit in and out a number of times with the digital meter in series gave me a maximum current value of >2 amps.

I needed to use a "shunt" to put the measurement in the best range for demonstration, since the analog galvanometer can only handle 50 uA full scale in either direction. A shunt is a piece of wire with a known low resistance value placed in parallel (connected between) with the galvanometer posts. When wired in parallel with the meter, it "shunts" most of the current through it, with only a small proportion of the total current flowing through the meter itself. The 50 uA meter had an internal resistance of ~2 K-ohm. If I wanted a full scale reading of 5 amps, then I would need to put a piece of wire with approximately 100,000 times less resistance than the meter in parallel to the poles of the meter, so most of the current would flow through the wire and not the meter (and break it by "pegging" the needle or burning out the delicate meter coil). As a first approximation, I put 30 cm of 14 gauge solid wire between the poles of the meter (14 Ga wire has 2.58Ohms/1000 feet DC resistance). The meter was fairly numb when I tried this. I took the 14 Ga wire out and substituted a 20 Ga clip lead and this provided a good range that allowed me to see a 2/3 scale negative deflection on the 1st _ cycle. Tuning my "shunt" with various combinations of 20 and 24 gauge clip leads totaling about 60 cm long, I was able to finally get a full scale negative deflection on the 1st _ cycle, 1/13 positive deflection on the second _ cycle, 1/20 negative deflection on the 3rd _ cycle, and then return to center 0 and rest.

The exact current measurements were not material to this demonstration as the primary objective was to show the positive and negative movement of current. That said, you will want to disclaim the accuracy of the meter scale as soon as you start putting in custom shunts to save confusion on misinterpreting current value. I think that I would have gotten better results (wider swings and more cycles of swinging) if I could have found an inductor with a higher Q. Peter Wenger's coil has a very high inductance, and should work better, but its weight will incur significant shipping costs, so we have not tried it out. If any readers have suggestions for an inexpensive source of a larger coil that might work, we enthusiastically invite comments!

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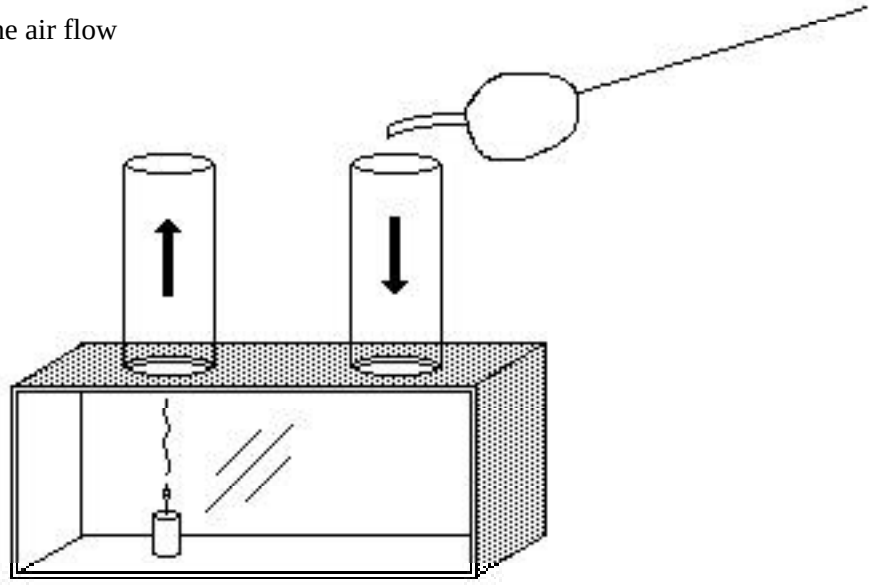
Thermodynamics

Heat and the First Law: Convection

Two Chimney Convection Box

— Light the candle under one chimney

— Use smoke paper to show the air flow



Thermodynamics

Heat and the First Law: Convection

Convection Tube

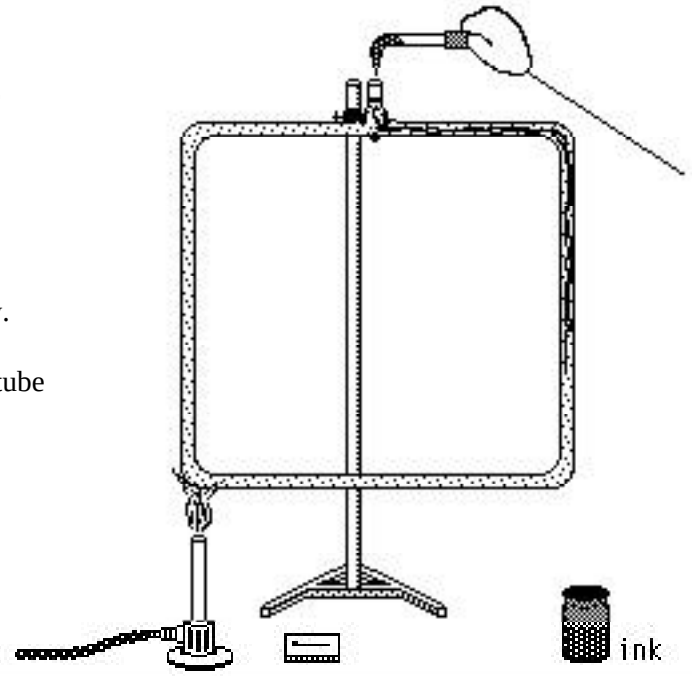
— A square tube is filled with water.

— Light the Bunsen burner and place under one side.

— Using the dropper, drop several drops of ink into the top hole.

— The ink shows the direction of fluid flow.

— Move the burner to the other side of the tube to reverse the flow.



Thermodynamics

Thermal Property of Matter: Solid Expansion

Break the Cast Iron Rod

— Use safety goggles.

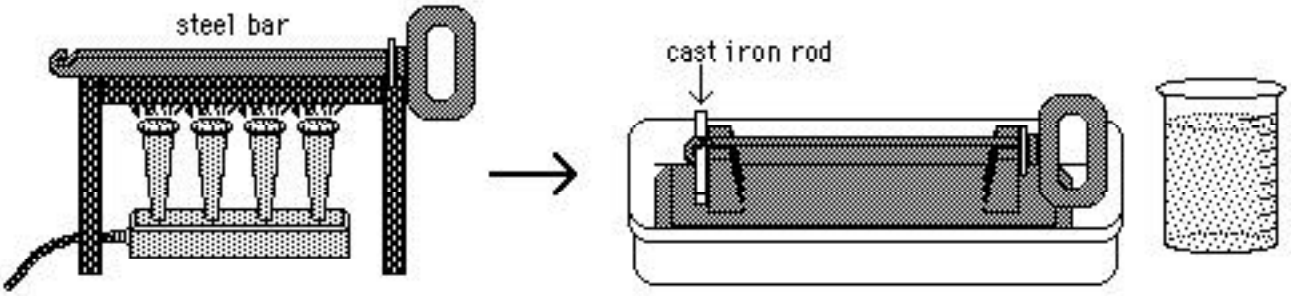
— Heat the steel bar over the Bunsen burner for at least 5 minutes.

— Using gloves, place the heated bar in the iron vise and slip the cast iron rod onto the hook.

— Screw the handle into the bar to tighten the rod against the frame. THIS IS A CRITICAL STEP.

— Gently pour water over the assembly to cool the bar.

— Observe the rod snap.



Thermodynamics

Thermal Properties of Matter: Solid Expansion

Ball and Ring

Equipment:

- ball and ring
- propane torch and lighter
- (optional) liquid nitrogen

Observation: Objects expand when heated, and holes in objects expand as if they were made from the same material as the object.

Description: At room temperature, the ring will not fit over the ball. Heat the ball for a minute and see if it will pass through the ring. It won't. Allow the ball to cool to room temperature. Heat the ring for a minute and now see if the ball will pass through the ring. It will. Ask the students to describe what they have observed. From the observations, see if the class can formulate a law. (The metal expanded when heated.)

Setup time: 5 minutes

- See AWSNA Science Kit #4, AWSNA Publications for equipment and detailed instructions

Thermodynamics

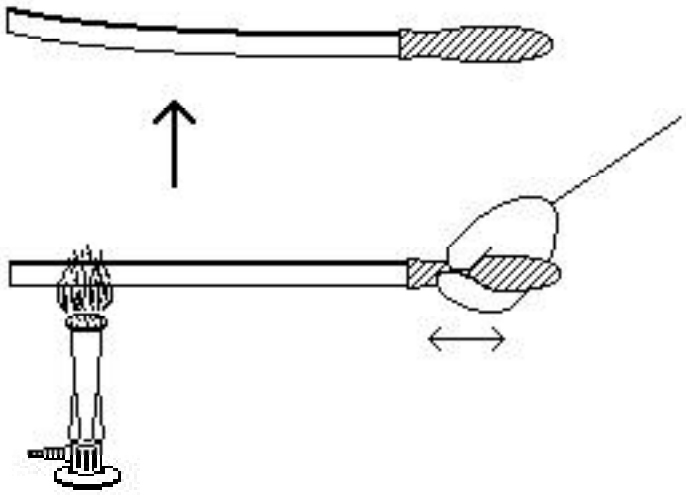
Thermal Properties of Matter: Solid Expansion

Bimetal Strip

—A bimetal strip is brass on one side and steel on the other fused together.

—When heated over a Bunsen burner the strip curves toward the steel side, when inserted side-ways.

— Try holding it flat over the flame, alternatively face each side upward, heat it, and observe what happens.



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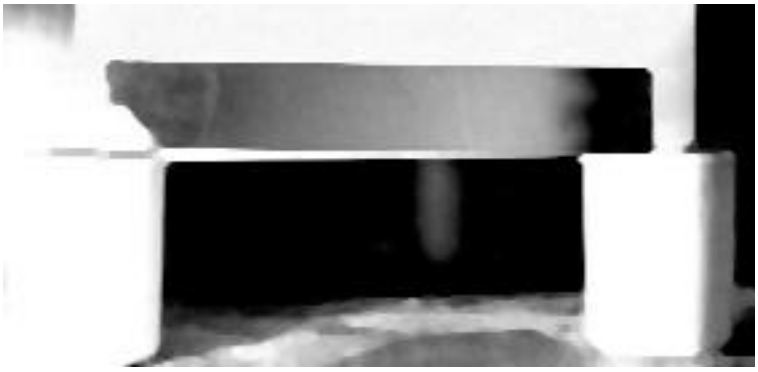
- See AWSNA Science Kit #4, AWSNA Publications for equipment and detailed instructions

Thermodynamics

Heat and the First Law

Heat Conduction

Liquid-Crystal Indicator



Equipment:

- Liquid-crystal indicator
- two styrofoam containers, with lids
- kettle
- light, socket, and cord

Observation: Temperature-sensitive liquid crystals can be used to show how heat conducts along a metal bar, as their color depends on their temperature.

Description: These liquid crystals are red at 25 °C, violet at 30°C, and the other colors of the spectrum in between. Boiling water should be placed in one of the styrofoam containers, and room-temperature water in the other. When the bar is placed with one end in the hot container and one end in the cold, heat will be conducted along the bar. A thin red band slowly works it's way along the bar as the temperature goes up, and the other colors follow behind.

The liquid crystal must be brightly illuminated, because you need a lot of reflected light to see the colors. Placing a light bulb in front of it is a good idea.

Setup time: 10 minutes

Thermodynamics

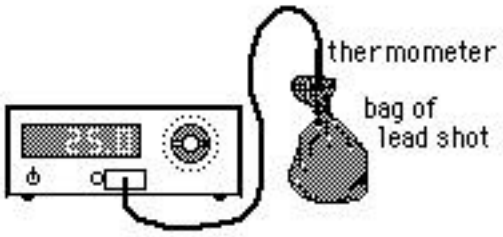
The Mechanical. Equivalent of Heat

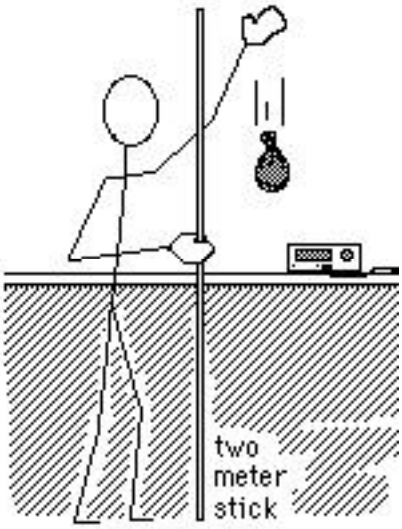
Dropping Lead Shot

— Stick the temperature probe into the bag of lead shot to find its initial temperature.

— Drop the bag from the height of about two meters between 10-20 times.

— Once again, take the temperature of the lead. The temperature should have risen 2-3 degress Celsius.

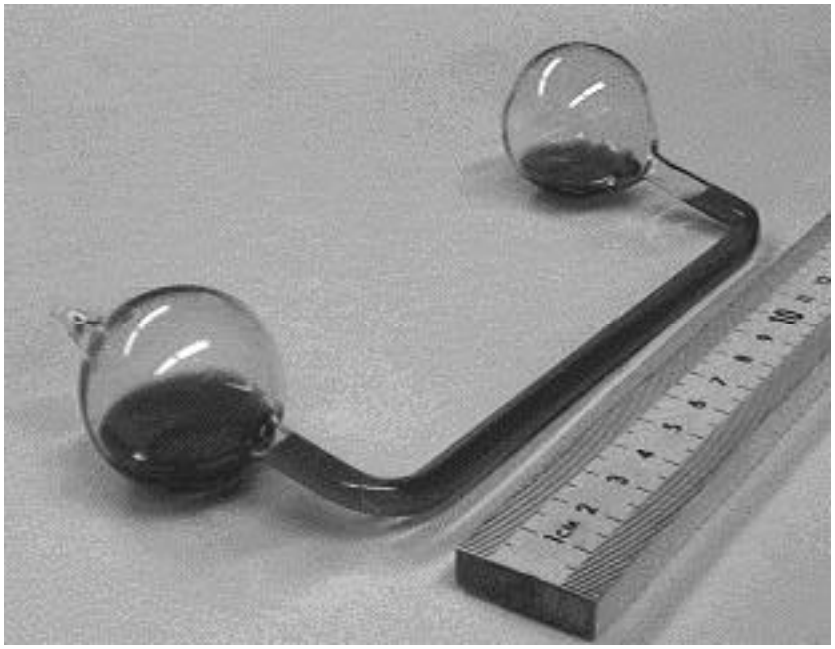




Thermodynamics

Change of state

Vapor pressure



Pulse glass

Instructions / Notes:

WARNING: The liquid in the pulse glass has a low boiling point. Body heat from your hand is all that is necessary to make it boil. No hotter heat source should be used.

Equipment:

- pulse glass—(purchase from Frey Scientific or other science warehouse).

Theory: The volatile liquid is sealed in the pulse glass under reduced pressure, so the pressure comes from vapor pressure of the liquid. Heating one bulb with your hand increases the vapor pressure in that bulb, forcing the liquid through the connecting tube into the other bulb in a series of pulses.

Description: Enclose one bulb of the pulse glass with one hand. It generally works best if you hold the bulb witl the pointed top, and angle the pulse glass slightly so all the liquid starts off in the bulb you're holding. After several seconds the liquid should move to the other bulb, and then will bubble quite violently for a few seconds.

Setup time: 1 minute

Index of Past Issues

Waldorf Science Newsletter: edited by David Mitchell & John Petering

This newsletter is published twice each year and is dedicated to developing science teaching in the Waldorf schools. Teachers are invited to pose questions, seek resource material, discuss experiments, write about their classes (successful and not very successful), and investigate phenomena. The editors also translate relevant science articles from Waldorf periodicals from around the world. The following past editions are available from:

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Volume 3, #5

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Partial contents – Space and Counter Space; New Eyes for Plants; Experiments of Academia dell Cement; Physics and Chemistry in the Grades; Goethean Science Credits; Chemistry Workshop; Table of Important Salts; Goethe's Scientific Imagination; To Infinity and Back in Class 11; ∏ and Trigonometry; Science in the Waldorf Kindergarten; A Note on Pascal's Triangle; Experiments

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Partial contents – The Message of the Sphinx; Honey; Cell Cosmology; Einstein's Question; What is Goethean Science?; Prototype Computer Program; River Watch as a Classroom Activity; Thoughts on Curriculum Standards; Comments on Building a Waldorf School; Experiments

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Partial contents – Towards Holistic Biology; How DNA Computers Work; Solar System Facts; What is Goethean Science?; Human Movement and the Nervous System; What Is Science?; What Is Meant by "Teaching the Children to Breathe?"; Experiments

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Partial contents – The Globe Inside our Planet; Music, Blood and Hemoglobin; Standards in Science; Cognitive Channels—the Learning Cycles and Middle School Students; 8th Grade Physics, From Dividing to Extracting Roots; What is Lambda?; Waldorf Science Kits

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Partial contents – A Chemistry of Process; Sponges and Sinks and Rags; How to Read Science; Experiences and Suggestions for Chemistry Teaching; Experimentation as an Art; Biographies—Dmitri Mendeleev, Joseph Priestley, Marie Curie; Destructive Distillation; Experiments

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Volume 8, #16

Partial contents – Waldorf High School Research Papers; Inside the Gulf of Maine; How Do Atomistic Models Act on the Understanding of Nature in the Young Person?; The House of Arithmetic; Origami Mathematics; Sixth Grade Acoustics; Sixth Grade Kaleidoscopes; Tricks with Mirrors; The Flour Mill and the Industrial Revolution; Web Gems; Understanding Parabolic Reflectors; The Capacitor; Oscillation and Waves; Crystal Radio; Qualifications for High School Mathematics Teaching

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Partial contents – Book Reviews; Acknowlegement from a Waldorf Parent; Raising Money for Science; the Twelve Year-old Child and Orpheus; Towards a Sensible Kind of Chemistry, Part One ; The Lightning Bug; The Ladybug; Exploratory Experimentation: Goethe, Land, and Faraday; Faraday's Synthetic Investigation of Solenoids; Faradays Analytic Investigation of Induction; Geometric Addition Table: A Curious Configuration;

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