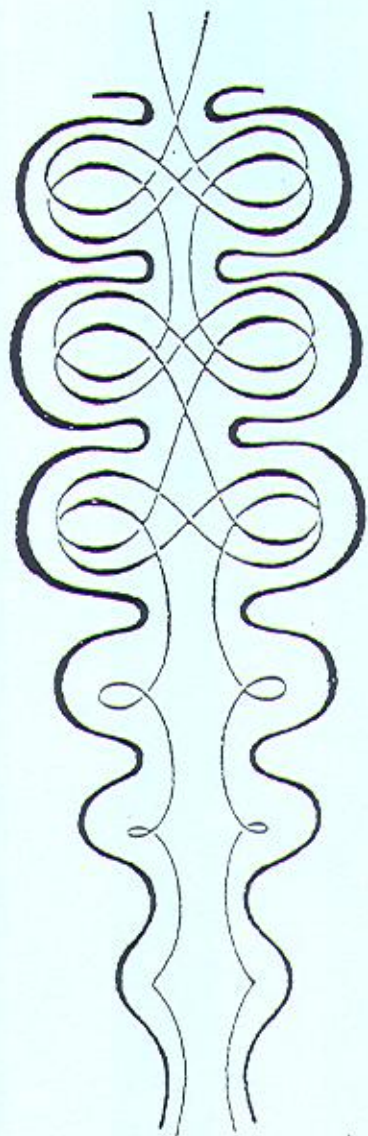




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WALDORF SCIENCE NEWSLETTER

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Australian Conferences

from Jim Steil 8/24/95

Report of Australian Science Conferences

On the strength of my impressions of Dr. Mackensen's work in the grade 6-8 physics materials (recently available from AWSNA Publications), I made arrangements to attend a conference with him in Australia. In the first week, he presented an overview of the grades 6 through 12 physics curriculum in optics and electricity, to a mixed group of class and High School teachers. Seminars and morning lectures were also presented by other participants. The physics workshop was very good, but I found it rushed; Dr. Mackensen was obviously tired from the long plane journey here.

After a one week break, the conference continued, but with only 14 participants instead of the mixed group of 60. This time, we were a mixture of High School teachers and biodynamic farmers! We spent a whole week of full days (9 am to 3 PM) studying the Agriculture course. It was truly excellent! This was much better than the chemistry workshop he led in Spring Valley. Here was the author of the ideas I knew from the physics booklets. We had a balance of study, lecture-demonstrations, and hands-on experiments, as well as field trips. We enjoyed it, and experienced how sincere disciplined research and thinking can bring life into the barren world of modern chemistry. It was truly inspiring!

Upcoming Australian conferences

In July-August 1997 Manfred von Mackensen will be returning to Mt. Barker Waldorf School in Australia for another two-week conference on natural science. The '97 conference themes are still open, but many people voiced the wish to bridge the split between modern science and spiritual science (and even new-age movements) something I'm sure most of us are still actively trying to do, inwardly as well as in the classroom. This theme will likely be addressed and could prove quite stimulating.

A final note to potential conferees: Australian schools are in session during the northern Summer season, except for the period of the conference. Presently, there is a lot of work for scientists in Waldorf schools, so guest blocks may not be that difficult to come by, which might help defray the substantial travel costs, if you have the time.

New Publications

The Australian Waldorf schools are pleased to announce that *Themes from Physics Lessons in Grade 12; illustrated through Theory, Science, Pedagogy and Experiments* has been translated and will be available in autumn 1995. The booklet may be obtained from Peter Glasby, Mt. Barker Waldorf School, Sims Road, Mount Barker, South Australia. Phone 011-618-391-3910.

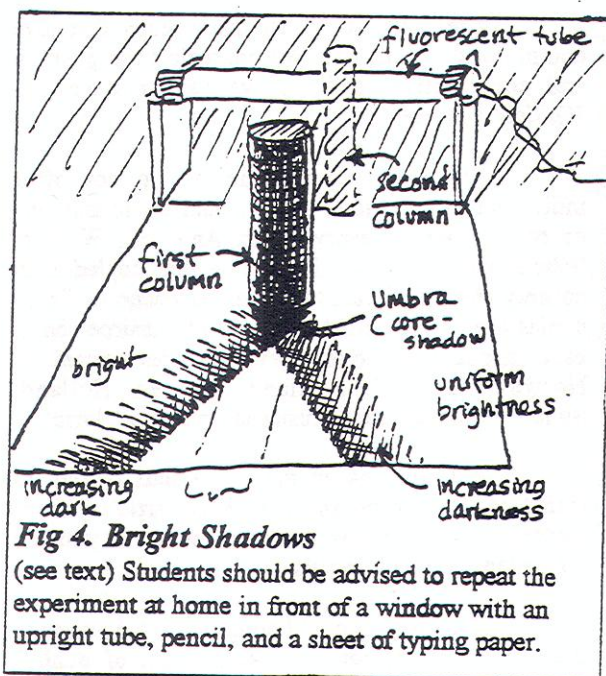
This little booklet of 70 pages begins with a discussion of philosophic and pedagogical starting points, and then develops more material than I think could be included in most main lesson blocks. It encompasses the following topics: photometry (illumination), shadows, mirror-phenomena, transparent media (including the prism, lenses out of a supplementary booklet). Notably missing is a section on color, which he only mentions as being available elsewhere. But, as we might expect, this little work is highly instructive, practical, illuminating. Hooray! A short excerpt from the draft manuscript translation is enclosed which can give a taste (for now).

* * * * *

The following extract of the above mentioned book is meant to be a tickler!

Grade 12 Physics Lessons Manfred von Mackensen

The randomly arranged bodies in nature present a rather complicated relationships of light and reflection. We can penetrate [such] relationships by practice with a special lighting-setup. On a large table in front of a north-lit window, or a horizontally suspended fluorescent lamp tube, behind a cylindrical column creating shadows, we can see revealed various fields of illumination and shadow. [Try it using an empty cardboard hand-towel tube, and a pencil!]



Section III. Shadows

If you now insert a second, perhaps somewhat thinner column (as shown in Fig. 4) you

get additional fields of shadows; but, more importantly, the first column shows a "bright shadow," located exactly aligned with the second column, and clearly visible in between the strips of penumbras behind the first column. The whole thing is explored and described in more detail by Georg Maier (1985).

After our initial astonishment, we can reason that the second column somewhat obstructs the view of the light source (window or fluorescent tube) for most of the paper area (region j) – but [creates no new obstruction] for those locations where the first column blocks the view to the second (region k); from these, only that part of the light is blocked which was already obstructed by the first column. For other areas, that which is covered by the second column is now also missing. Therefore, [with a darkening of region j] we see a relative brightening of the new area (region k).

This step-by-step explanation gives us the needed security. Another explanation moves the phenomenon into a larger context. In the picture of such shadows, we find a kind of "inversion." In the penumbra fields of the first column, a kind of "negative image" of the lamp scenery manifests. In this negative image, the second column – which is dark – shows up bright. If we inserted a narrow vertical gap (such as a sliding door) instead of the first column, the "positive image" would be created for the second column. What we do here with column or gap (door) we can also do with a little hole or ball: we get the well-known complete positive image as in a camera, or the [surprising] negative image behind the black disk.

The contrast of light and darkness, which lies in the effect of the brightness, is able to represent a picture content consisting of lines and areas in two ways, as seen as a positive or as a negative image. By means of an external arrangement we achieve what is produced out of our inner life-forces of the eye in the after-image.

V. The Objective Reality

In these lessons, we are seeking a radical re-orientation – away from the ideal of science, which confronts us, the observer, with a ready-made "objective" external world, from which we receive some limited signals through our senses, and which we have to "reproduce" within ourselves by means of ever more refined imaginative images. A re-orientation towards a method of recognition, which builds up ideas of a solution from a sequence of thought-provoking, puzzling observations, and which searches for the origin of a real internalization of the world-content. Because of the deep-rooted conventional way of looking, this radical re-orientation cannot be made clear to its full extent within the context of a lesson. But, it is possible, for example, to challenge the primitive idea of reality and objectivity ("objective" as what can be measured by

or shown by a photo), and to free the view towards a more complete idea of cognition [and participatory perception].¹

A column stands on the lab table. Formed by a lamp in the middle of the room, we see its shadow on the black-board, with the room dimmed 75%. At first, the lamp is dimmed to a very low level, the wall is dusky, the shadow medium gray (i.e., brightened a little bit by light gaps along the window shades). Now, we increase the brightness of the lamp, and the blackboard becomes bright, the shadows deeper and finally pitch black.

After we show this a few times, we ask the students how the shadow has changed in their opinion. Usually you will get three ideas. One group of students can consciously grasp and express what we saw, that the shadow become darker. Another group reasons that the changing lamp lightens everything but the shadow, so the shadow has to remain equally bright or dark; that's what we surely saw! A few students will reason further and say that the whole room was getting lighter, therefore the shadow will receive reflections from all these brighter areas, and so the shadow must be brighter.

One or the other student will now be able to (allegedly) "see" what they thought by means of strong concentration. Some of the third group will start to explain why we have all been "deceived."

Step by step, we can now explain that by reason the third opinion is correct, but by percepts the first is correct! If I don't want to sit there as being deceived, torn between perception and thinking, I'll ask in a startled way if I can't perceive somewhere what I had reasoned. How should I look at the shadows in order to really observe the brightening [the third group] reasoned necessary? On the other hand, couldn't I think though the real perceptions in a way that there is no danger of being sent to the realm of "optical or sensory illusions."?

It is easy to answer the first question as follows:

a) Go close to the shadow on the wall, possibly block off unshadowed areas with your hands and try to read a scrap of newsprint or the like, which is held in the shadow. When the lamp is turned up, it becomes possible, and at the same time the other students further back in the room will see the shadows becoming dark.

b) You could look into the room from the shadows, the light obscured by the column; the entire room brightens up when the lamp is turned up.

¹ See E. H. Land's *Retinex Theory of Color*, where Dr. Land proposes a cooperation of four retinal receptor systems, and a complex cortical (consciousness) interpretive system.

c) You could use a photo-electric cell² which will measure the brightening of the shadow area.

For the second question [how to avoid the 'illusion'], we first have to clarify how brightness arises. An area takes on a brightness depending on the total scene surrounding it (the illumination cupola or environment). The brighter the surroundings, the darker another shadowed area will appear within this brightening. If I exclude the surroundings, (by going very close) I see something completely different. All my surroundings now are the shadow or the dark bands, the shadow is isolated from the whole in which it first appeared, so we get closer to the 'objective reality' as measured by the photocell.

But, what is the true reality? What our vision sees or what the photocell is showing?

Let's first try to clarify the problem with the intellectual capacities available to the adult, to the teacher. We say, light is an idea created from the illuminated world, it is the central idea of the world connected by the visible. Light is connection – it only shows up in the thinking. Light is no object of perception. But, every perception of brightness – when viewed through thoughts – is able to reveal light as a being of thought in a certain way. This is our special embedding in the perceptible world, with respect to our vision. Light reveals itself to our physical, sensual organization. External activity of nature, and our own activity of will devour each other in the calm perception. Our physical activity of sensing awakens at the resistance of the physical exterior. The idea of light doesn't appear freely in our inner self, but is acquired at the boundary of world and our own body. The results of the optical explorations in the preceding chapter are little steps in that direction. The impression that are gained in that way we can move into the spiritual, in order to come to terms, to come to the idea.

If we don't perceive ourselves, we never arrive at the universal, because we don't position ourselves in the particular. Longing for the universal, there is nothing we can process. And without this spiritual activity – not in our self-contained thought life, but in the external, un-spiritual – without this struggle, without this complete view, there is no idea. The spiritual is only possible when we live through and comprehend its connection with the particulars, with the physical. What can there be apart from it? Only a spirit, with is common beforehand; which is presupposed and formed in the isolated intellect. Such a spirit is of course of particular clarity, because it is constructed within ourselves. An out of what? Out of position, extension, movement, out of the mechanical categories [of perception]. Finally, it

originates out of the abstraction of our lower senses, and therefore out of our own body.³ Just like the other (the external). Both are going the same way: only the mechanistic way – and with our clear models of light definitely not the ever open way of the phenomena of brightness. The explanation that is built out of the mechanical, is originating in principle out of a dark world. In that respect, the mechanistic explanation of light is the subjective one, only based on the physical body. Naturally, we take the explanation from being physically engaged in the physical world, but indeed only with the past, monotone mechanical engagement with only the lower senses, not with the many-sided engagement in the world of brightness via our experience of seeing.

Through such thoughts we can feel our way towards saying: the photocell registers something totally different, because only the local brightness in the area of the shadows affects it. It is "looking" like someone who excludes all connection in seeing. But the understanding of seeing is based on one's own experience of the relationships. The phenomenon is not the single area, in its isolated value on the photocell, but the whole field of my view in a differentiated whole. The phenomenon is the single field in the surroundings with its brightness. When we want to process the perceived brightness in optics, it always has to be related to the surroundings, because thus is our seeing. Added to that is of course the whole difference in quality between perception of the eye and measurement of a photocell. Only the eye experiences brightness as its own quality. The photocell never experiences brightness, all it does is showing parts of a scale without any quality.

Only when we experience with our own body the qualities, and understand the make-up of conditions, only then can we undertake once in a while particularly fine measurements, or measurements in inaccessible areas by means of instruments. Such measurements can fill gaps, giving hints for the possibilities of perception. But we will always re-translate those measurements into the perceptible scenery.

It may be added, that the experiment with the darkening shadow happens on every walk. A tree in the garden, between shrubs or perhaps close to a wall of a house, shows certain colors and shades of its bark. If you follow the trunk further up to the little twigs near the sky, the bark will change into a deep black – even though it is brighter 'photometrically'!

In summary:

- only when I perceive with the eye, I have

². A photo resistor in the circuit of one milli-amp and a voltage of 10 to 20 volts is sufficient.

³. See Edelglass, et. al., p29, discussion of how the concepts of space, matter, time, force, energy, are derived from our experiences with these 'bodily' senses of touch, balance, kinesthetic-position, and bodily well-being (inner-life).

the surroundings

- only through the surroundings do I get the qualities of an illumined scene
- only through those qualities and the surroundings can I, as complete human being with all other senses, engage myself physically into the world
- only when I let myself go into the physical, do I receive the strength for the whole path, to concentrate myself again in the spiritual, in the idea
- only through this path, the whole idea gains physical weight, reality comes into being
- the reality are the ideas contracted out of the complete human participation in sense perceptions, contracted within those perceptions
- this reality is the 'objective reality' because it is the only reality
- all mechanically abstractly defined so-called 'exact' concepts are subjective short-cuts; out of subjective preference for what seems precise. Ultimately they only create alienation

How much of such thoughts you achieve in a class 12, and how much you just touch, remains with the pedagogical skills of the teacher. The following steps are thinkable.

The three answers: a) shadow becomes darker; b) shadow remains the same; c) becomes brighter; are each allocated to different levels of reflection – the share of original perception and intellectual processing is made conscious.

1. Naive impression: a) is correct [shadow seems darker];

2. First reasoning: the area of shadow cannot receive less light when the lamp is turned up, because you can't see the lamp and its variation from there. The darkening is only relative, only seeming, because the shadow's surroundings are getting brighter;

3. Refined reasoning: from the shadow you can see the room becoming brighter, therefore, c) is correct [shadow must be lighter]. The photocell indicates it – the perception of our eyes is 'wrong' and must be "corrected;"

4. Further refined reasoning: a) and c) are not contradictory, but answers to different questions.

Conclusion a) to relative brightness, within our surroundings; answer c) to absolute brightness independent of surroundings;

5. Evaluating reflection: answer c) makes still less sense if we want to recognize "shadow," because shadow without surroundings is no shadow. Therefore, we return to a), but on a higher level of reflection, where the "relative brightness" gains an 'absolute' value of cognition.

This final resolution is usually difficult for students in class 12. You shouldn't aim for the students to "confess" such a statement. It is sufficient, when the pros and cons of the various opinions with all their reasoning are clearly acquired in lively discussions, and thus are reflected by the students – in written form (the main lesson book) as a dialogue. The fact that such a far-reaching starting point as "the world is not complete without my thoughts" can emerge out of one's own philosophizing and becomes essential for one's own view of the world, would usually be reserved for a later age. But it can be of importance then, when you have first met and reflected on such starting points.

Of course, there are a large number of examples to show that we should observe a phenomenon in its relationship with the surroundings rather than in isolation. The most beautiful example of these particular optical phenomena are the colored shadows.

In our experiment with "bright shadows" it already became clear, that it is advisable to understand shadows not simply as the "absence of light" but to understand the whole shadow image as reversing the relations of brightness of the surroundings. The last experiment shows in a different way, that there is no reason to consider the "bright shadow" as something less valuable, deceiving, only because "in reality" it only happens through the darkening of its surroundings. Let's change experiment Optics 5 a bit by replacing the second column with a colored foil (not too dark); the "bright shadow" was complementary to the second column only in relation to brightness, but now a shadow shows, which is even of the complementary color to the foil's color. The phenomena are delicate, but clearly visible, particularly when the foil is moved right and left in front of the lamp, so the colored shadows are traveling the opposite direction. An explanation of this surpassing phenomena is now totally based on taking seriously the observer within the surroundings (simultaneous contrast). The main condition is the light tube. An additional bright thing of another color tone is added to the original lighting, like our foil. In such a not day-to-day situation, the shadow images consequently have to be complementary. If the foil is green, everywhere the lighting is toned in green and slightly darkened, but not in the area of the shadow behind the first column. It has to show light purple within its surroundings.

Because, for areas that are colored by illumination but not colored themselves (by pigment), we now have the theorem enriched by the laws of the color circle: there is no color without surroundings⁴.

RESOURCE NEEDS

In this space the editors hope that individuals and schools will write to us so that we can list the resources that you are looking for your teaching or research.

CURRENT RESEARCH

For those who are "Net aware" there are several addresses which may be of interest.

For those with SLIP/PPP access, send e-mail to subscribe to :

s.c.brown@reading.ac.uk

for information on general Waldorf Science.

For those with World Wide Web (WWW) access, log into:

<http://www.io.com/~cradock/rsc-hp.html>

This is WWW page for Rudolf Steiner College, with links to all known relevant news groups.

LETTERS TO THE EDITORS

We have received thanks from many people including Betty Staley, Mark Riegner, Arthur Zajonc, and Klaus Schickert, to name a few, along with many promises for future articles.

Please send them in!!!

⁴. See also the following texts: E. H. Land, "Retinex Theory of Color," *Scientific American*, Vol. 237, No. 6, Dec. 1977; and S. Edelhglass, G. Maier, H. Gebert, J. Davey, *Matter and Mind*, especially Chapter 2, Sec. 3, *The Relation of Materialism to Sense Experience*, Lindisfarne Press, Hudson, NY 1992.

HELP ME! I NEED THIS!

I'm keenly interested in any experiments on the "moral and spiritual" aspects of color for grade 12 Physics. There is only 2 to 4 days maximum for this and the experiments need to be really excellent.

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SOME THOUGHTS ABOUT TEACHING BIOLOGY IN THE 11TH GRADE

Craig Holdrege, October, 1995

WORKING WITH THE CURRICULUM

Rudolf Steiner discussed the Curriculum of the 11th grade with the faculty of the first Waldorf School in a two and one half hour meeting on June 21, 1922. He speaks of two main areas of content: cytology and botany. Regarding methodology he stresses that cytology needs to be taught cosmologically. In addition, whether in cytology or botany, one should not teach in terms of linear causality. In contrast, he speaks of finding mutual causal relations ("Wechselursachen-Verhaeltnisse").

I have worked with these indications for many years, with every new 11th grade biology block asking, "What does Rudolf Steiner mean?" Clearly, we cannot take such indications as recipes for what we "should do" – no recipes are so full of riddles. Rather, they can stimulate questioning and research, they can motivate us again and again to look more thoughtfully at what we are teaching.

Working with the curriculum in this sense can help to keep us from falling into ruts and passing on unreflected Waldorf traditions. If the curriculum solidifies to "what one does," then Waldorf education will gradually lose its inner force. But, if we go to the other extreme and ignore Steiner's indications in the name of being up-to-date, then evermore superficiality will creep into our schools. I don't think we should underestimate the significance of working energetically with Steiner's thoughts. Through this work we can develop inner muscles that help us to be independent in deciding how and what each of us, in her or his own way, teaches. At the same time, our work becomes more firmly rooted in the spirit – in the inner activity that gives our work depth.

CYTOLOGY AND COSMOLOGY?

I have struggled for a long time with the question of how to teach cytology. We learn this discipline at universities as an essentially analytical

science that delves into ever smaller realms in great detail. We become Waldorf teachers and Steiner prods us to teach cytology cosmologically, "considering what happens in the cell to be a small cosmos" (lecture in Stuttgart, June 21, 1922; Bibl. Nr. 302a). How is this possible?

I can in no way claim to have understood or researched adequately what Steiner means with cosmology. But I do believe that steps of understanding can be made, especially if one does not narrowly define the term cosmology from the outset. In a public lecture on education Steiner makes an interesting distinction:

When we make claims about the sense perceptible aspect of plants, animals, minerals or the physical human being, then the claims must be proved by experiments and sense perceptions. This means that the object must be supported. When we enter the realm of free spirit, then truths must carry each other. The only proof that one can find for things in this realm is that the truths mutually support each other. Therefore, when presenting matters of the spirit, we must place the insight into the whole context, just like the earth or other heavenly bodies are freely placed in cosmic space. . . . The heavenly bodies mutually carry each other, the laws that are valid for the immediate proximity of the earth no longer reign (Lecture in Stuttgart, April 9, 1924, Bibl. Nr. 308).

In terms of this lecture, my thinking is earthly when it looks for outer proofs, when it seeks monocausal connections. When I begin to see things in light of context, when they begin to mutually illuminate and each other, then I am moving into the Cosmic realm.

DEVELOPMENTS – A THEME FOR THE 11TH GRADE

I teach cytology in the context of developmental biology. In the course of time I have increasingly come to find the concept of development to be at the heart of 11th grade biology, and more broadly, at the heart of the 11th grade curriculum. When teaching embryology it is immediately evident that cells are embedded in the context of, first, the organism out of which they develop (egg and sperm), and second, the developing organism within which the cells are formed. It is relatively easy in embryology to keep the whole in mind, easier than when one teaches about the cell as an abstraction with particular organelles and functions. (How many biology students have memorized the citric acid cycle without knowing where it goes on and what it is for?)

Nonetheless, it is very easy to suffocate in the tremendous richness of facts (for example when learning about all the details of cell division – mitosis and meiosis). Can we delve into details and then reign in, discovering larger patterns or connections between

apparently unrelated facts? If so, then we overcome one-sided materialism, exercising our thinking to see more in the phenomena than merely meets the eye. We are taking a first step into cosmology.

11th graders are interested and able too participate in the discovery of patterns and connections. For this (and other) reasons I teach embryology in the 11th and not the 10th grade. The specific quality of thinking I want to reach in the 11th grade would not be appropriate for 10th graders. One can explore more subtleties in the 11th grade, the students usually have a greater inwardness of thought. or to put it differently, 11th graders are more existentially connected to what they think, whereas 9th and 10th graders are facile using thought as an instrument (or weapon!).

I spend two weeks studying human development. We begin with the menstrual cycle, a wonderful example of intertwined development – the monthly development of the uterus lining (endometrium) that is correlated with the development of the egg and follicle in the ovary. We go on to discuss fertilization and, in detail, the first few weeks of embryological development. More in the form of an overview we consider organ formation (organogenesis), fetal development, birth and postnatal development.

At the end of this time the students have learned a good deal. Now I ask them to think about the developmental process as a whole – from the egg through embryonic developmental postnatal life and finally death. Can we see any overloading patterns? Are there common themes or motifs that are repeated at different times in modified form? Can we see how processes reflect each other?

With such questions I want to initiate a discovery process. There is little point in my lecturing on what I have already discovered. I want the students to try to discover patterns and connections themselves. They should experience the joy and satisfaction of seeing with the mind's eye.

This year (fall 1995) the 11th grade was particularly active and discovered various connections. I then asked for any students would be willing to summarize what we had discussed. Four students took on this difficult task describing what only the mind can see – connections – without being abstract and schematic. The following mildly edited and shortened essay is by one of these students. When reading please keep in mind that this essay is the fruit of two weeks of main lessons and that it has its place in this context. Nonetheless, I hope that it allows the reader to get a sense of the level of understanding I try to reach with 11th graders.

PATTERNS IN HUMAN DEVELOPMENT

(An essay by Samantha Karle,
11th grade, Hawthorne Valley School)

When we consider the entire process of life from the earliest stages of embryonic development to the

final stage of death, many connections can be made and many patterns in development can be seen.

Two of the most dramatic processes in embryonic development are ovulation and birth. In a way, these two can be seen to be similar. As the egg breaks out of the follicle it leaves the equanimity or its environment. In a similar manner the child leaves the nurturing environment of the womb and enters the world. Both the egg and the newborn are thrown into a stage of uncertainty by these occurrences. The egg must be received by the fallopian tubes. Even then if not fertilized, it will be washed out of the uterus during menstruation. The fetus, likewise, leaves its placid, watery environment to be cast into the outer world filled with the uncertainty of childhood. Will it be neglected or nurtured?

Parallels can be found between these embryonic stages themselves. Three stages exist in which an environment is built up to keep the developing organism safe. The first of these essential stages is the growth of the endometrium. Without this growth, the blastocyst would perish for lack of nutrients. The healthy growth of the follicle in the ovary is a similar process. The follicle builds up an environment where the egg can survive. A third essential building stage is the development of the embryonic membranes such as the amnion and the placenta. They provide a protective and nourishing environment for the embryo and fetus. Failure of this stage to occur would normally result in miscarriage.

Yet another parallel can be drawn between changes in the sperm and the embryo as they adapt to their new environments. There is a dramatic change that occurs in the sperm when it enters the egg. The sperm's nucleus swells to the size of the egg's nucleus. Likewise a dramatic change occurs in the embryo when it attaches to the endometrium and grows into its new environment. Both change and adapt to the new environment that receives them.

More comparisons can be drawn if one looks at differentiation and growth at two different stages. The zygote divides during cleavage into many cells, but the whole embryo does not grow in size until implantation. This is comparable to the inner differentiation during organogenesis, when the embryo has not yet begun to grow outwardly in size, but the organs have begun to form.

Now if one looks at the life of a human being from birth to death and beyond, several parallels emerge. A dramatic change in life is puberty. In a similar fashion to birth and ovulation, at the onset of puberty, human beings have reached a stage in which everything about them changes. They are thrust like the egg and the fetus into a different environment. They are, as they were at the two previous stages, vulnerable, though in a different manner. Their challenges are different from those of the egg and fetus, but are nevertheless life threatening or life shaping. For the fetus the challenges involve nutrition and survival. The

questions for the adolescent are questions of moral survival.

Changes that a human being makes from the egg stage to old age vary in importance. Perhaps the most drastic change in some ways is death. Once again, as in ovulation and birth, the human being is moving on to something new. Setting religious beliefs aside, however, the human being is, at the moment of death, leaving behind a kind of outer shell in which, if it has succeeded in adapting to the world, it has been cared for and protected. This is to me the most vulnerable stage. In ovulation, birth, and puberty, we know the possibilities and the dangers. In death, what comes is not known. In my opinion this makes death the most uncertain and therefore fearful stage of all.

A Large Organism

(taken from the Washington Post - DSM)

Lurking in the soil under the hardwood forests of eastern North America, biologists have discovered what appears to be one of the largest and oldest living creatures known to science.

Or, more accurately, it is a fungus whose main "body" is a vast network of underground filaments and tentacles that sprout mushrooms at the surface - a species, as it happens, that is good to eat.

The largest known specimen underlies at least 37 acres of forest floor and is probably larger still. (Its full extent has not been determined.) The many thousands of mushrooms that pop up in late summer throughout the 37 acres are all outgrowths of the same underground organism the many tips, as it were, of one terrestrial iceberg.

The researchers estimate that the one individual fungus they have studied weighs at least 220,000 pounds (blue whales top out at about 250,000 pounds) and is a minimum of 1,500 years old (sequoias may live 3,000 years). Since the search has only begun, the scientists suspect larger, older fungi may be found.

"People have tended not to appreciate mushrooms for what they represent - a significant component of the forest ecosystem and, in this case, a very large and very old organism," said James B. Anderson of the University of Toronto in Mississauga, Ontario. Anderson and his colleagues, Myron L. Smith at Toronto and Johann N. Bruhn of Michigan Technological University in Houghton, published their discovery in *Nature* magazine.

Fungi, contrary to what was once taught, are not plants but members of their own kingdom. All mushrooms are like the giant species in being outgrowths of a network of filaments, called hyphae, that are mostly hidden, either in the ground or in some plant or animal, dead or alive, upon which it is feeding. Most are known to be relatively small. A few were thought to be big but until now, none was known to be so huge.

The Michigan fungus lives in the Upper Peninsula just over the Wisconsin border. But its species, *Armillaria bulbosa*, inhabits hardwood forests throughout eastern North America and Europe.

Its reproductive organs are often called honey mushrooms for their color. Foresters and gardeners may know its underground portion as "shoestring root rot" for it looks like a dense network of pale, shoestring sized tentacles that invade and eat dead tree roots.

(Subsequent to this article the world's largest organism was discovered in Utah. It is a growth of Aspen trees which all share a connected root system. - DSM)

* * * * *

EUCLID'S ALGORITHM

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In the early 1950s Herman Von Baravalle lectured on the principles of Waldorf education at Adelphi College on Long Island. Shortly after this Von Baravalle and some of the people who attended his lectures moved to Los Angeles and began Highland Hall School. Gisela Thomas, later Gisela O'Neil, was among them. After her death it was discovered that she had carefully kept her lecture notes along with other material pertaining to the work of Von Baravalle. These materials, particularly when combined with the tape recordings that had been made by Cynthia Schwabenland of Seekonk, Massachusetts, allow us to reconstruct Von Baravalle's lectures. Not only did he make a memorable impression on many listeners, but the content of his lectures is still fresh, even after forty years. Gisela O'Neil's notes were abbreviated. She recorded evaluations, key words, many phrases, and carefully made drawings – but she did not put down sentences or explanations. Her notes had to be filled in before they could be read. Our approach has been to add the minimum amount of text which allow the reader to grasp the concepts without pulling over the meaning. We have not attempted to reproduce Von Baravalle's style of speaking or writing. The fragment painted here concerns Euclid's algorithm for finding the greatest common divisor, or greatest common factor, of two natural numbers. Some remarks on the significance and classroom use of this topic follow the lecture notes.

The Greatest Common Divisor

Euclid studied pure numbers; these studies are older than any algebraic methods. Euclid's algorithm is a calculation that repeats an arithmetic procedure. It can be described in purely arithmetical terms without algebraic notation.

First, consider a typical fraction:

$$\frac{76,084}{63,020}$$

Factor these two numbers into primes obtaining:

$$76,048 = 2^2 \cdot 23 \cdot 827, \text{ and } 63,020 = 2^2 \cdot 5 \cdot 23 \cdot 137.$$

The factors that appear in common can be canceled from the fractions leaving:

$$\frac{827}{137 \cdot 5}$$

The largest number that could be canceled was $2^2 \cdot 23 = 92$; this number is said to be the *greatest common divisor* of 76,048 and 63,020.

There is a computational algorithm that leads to this greatest common divisor, 92. First, observe that 63,020 goes into 76,048 but once. We may write this in three staggered columns.

$$\begin{array}{r} 76,048 \\ 13,064 \end{array} \quad \begin{array}{r} 63,020 \\ 1 \end{array} \quad \begin{array}{r} 1 \\ 0 \end{array}$$

The difference, 13,064, is recorded beneath the original entry. We divided the middle column into the left one and recorded the remainder. Now, we do the reverse and divide the leftmost column into the middle, obtaining:

$$\begin{array}{r} 76,048 \\ 13,064 \end{array} \quad \begin{array}{r} 63,020 \\ 10,764 \end{array} \quad \begin{array}{r} 1 \\ 4 \\ 1 \end{array}$$

since the quotient of 63,020 by 13,064 is 4 and the remainder is 10,764.

Continuing the algorithmic process, we take 10,764 into 13,064 and record the quotient and remainder.

$$\begin{array}{r} 76,048 \\ 13,064 \\ 2,300 \end{array} \quad \begin{array}{r} 63,020 \\ 10,764 \end{array} \quad \begin{array}{r} 1 \\ 4 \\ 1 \\ 4 \end{array}$$

Yet another repetition gives:

$$\begin{array}{r} 76,048 \\ 13,064 \\ 2,300 \end{array} \quad \begin{array}{r} 63,020 \\ 10,764 \\ 1,564 \end{array} \quad \begin{array}{r} 1 \\ 4 \\ 1 \\ 4 \\ 1 \end{array}$$

The numbers are decreasing as we make up these columns, so the process must end sometime. Continuing, we soon arrive at

$$\begin{array}{r} 76,048 \\ 13,064 \\ 2,300 \\ 736 \end{array} \quad \begin{array}{r} 63,020 \\ 10,764 \\ 1,564 \\ 92 \end{array} \quad \begin{array}{r} 1 \\ 4 \\ 1 \\ 4 \\ 1 \\ 2 \\ 8 \end{array}$$

Upon dividing 92 into 736 we find that the quotient is 8 and the remainder is 0. So the process halts here. There is no way to continue by dividing 0 into 92.

This algorithmic process has led us to the greatest common divisor of 76,084 and 63,020, namely 92.

The Algorithm at Work

As a second example let us simplify the fraction $\frac{2754}{1632}$

This fraction can be simplified by finding the prime factors of the numerator and denominator and canceling them.

In the left hand column, we have found successive prime factors of 2754. In the right hand column we find the factors of 1632. Of course, these factors could have been found in a different order. Once they have been found, we search the two lists, locate the factors that appear in both, and cancel those out.

2754	2	1632	2
13377	3	816	2
459	3	408	2
153	3	204	2
51	3	102	2
17	17	51	3
1		17	17

$$\frac{2754}{1632} = \frac{3^3}{2^4} = \frac{27}{16}$$

Plainly, the greatest common divisor of these two numbers, 2754 and 1632, is found in the common factors that have been canceled: $2 \cdot 3 \cdot 17 = 102$. Again the algorithmic process of successive divisions also leads to this same result:

2754	1632	1
1122		1
	510	2
102		5

The process stops at 102 because 102 divides 510 at the previous step. As soon as there is no remainder, the algorithm halts.

To choose another example, form the fraction

$$\frac{3552}{7400} = \frac{2^3 \cdot 3 \cdot 37}{2^3 \cdot 5^2 \cdot 37} = \frac{2^2 \cdot 3}{5^2} = \frac{12}{25}$$

In simplifying this fraction $2^3 \cdot 37 = 296$ was canceled. So also 296 is the *gcd*, the greatest common divisor, of 3552 and 7400. In this instance the algorithm in which we carry out successive divisions is quite brief. It halts when one of the divisions can be done without a remainder.

7400	3552	2
296		12

Again the algorithm gives the *gcd* of the two numbers. It halts because 296 divides evenly into 3552.

Proving the Algorithm

The term algorithm refers to the successive repetition of the same procedure. Now, return to the first example of this algorithm, the calculation of the *gcd* of 76,084 and 63,020 that appears in section 42. Adding some detail to the calculation we obtain the sequence

$$76,084 = 63,020 \cdot 1 + 13,064$$

$$63,020 = 13,064 \cdot 4 + 10,764$$

$$13,064 = 10,764 \cdot 1 + 2,300$$

$$10,764 = 2,300 \cdot 4 + 1,564$$

$$2,300 = 1,564 \cdot 1 + 736$$

$$1,564 = 736 \cdot 2 + 92$$

$$736 = 92 \cdot 8$$

Looking at these equations we see that the factors that are in common to the original entries, 76,048 and 63,020, must run through the computation and appear as factors of the three terms in each of the lines. So 92 must be a factor common to both.

In this passage Von Baravalle began with the idea that the most general way to simplify ratios is to factor into primes and cancel the prime factors that are in common. This way of thinking, whose fertility was emphasized by Gauss, can be supplemented by the Euclidean algorithm which allows us to find the common factor without actually calculating the prime factors. Euclid's algorithm is more, however, than a mere labor saving device that is particularly helpful in dealing with large numbers. It is closely bed up with the theory of continued fractions and in Fowler's book *The Mathematics of Plato's Academy* with the central philosophical method of Plato and his followers.

We have used the algorithm in eighth grade lessons at Green Meadow Waldorf School exactly as described in Von Baravalle's lectures. First of all, the students become skilled in factoring. Next, they use their ability in factoring for various purposes: Simplifying ratios is one of them. Finally, they can use Euclid's algorithm as a very direct process for finding the common factor of large numbers. In this context the algorithm is playful and relieves us from the difficulties of numerical factoring.

Readers of the Waldorf Science Newsletter who are interested in this topic, the notes of Herman Von Baravalle, or in the application of the phenomenological method in science, mathematics, and education, may contact the Science and Mathematics Association at Green Meadow Waldorf School for further information.

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THE LOGOS AND GOETHEAN OBSERVATION

By Friedeman Schwarzkopf

Meaning and Love

In recent years the question for the essential element of Waldorf pedagogy is discussed more and more frequently in countries with a multi-cultural diversity like the United States it is no longer easy to simply refer to the Christ impulse. Especially a Waldorf teacher often wrestles with words in the initial interview with the parents of the child who wants to enter the course of Waldorf pedagogy. If the parents belong to another cultural-religious background than Christian, for instance Jewish, Islamic, Native-American, Buddhist, or Hindu, the teacher is challenged to explain what he or she means by "Christ" or "Logos" – at least one has to be inwardly *aware* of this meaning.

In this day and age we have to overcome our nominalistic habits of thought which tend to lead us into a kind of "idolatry of the word." Nominalism means that a word no longer points to an understanding but to a *thing* or *convention*. The true and real function of language would be, for example that a word like "chair" asks us to use a certain object as chair and not as conventions, as "labels," without *essential* understanding, for instance words like "freedom."

Likewise the "names" of the spiritual initiators of mankind could lead our attention to an inner place of understanding and experience where the reality of these beings is to a certain extent fathomable. In principle it should be possible that their names lead us to the sources from where these initiators of mankind conceived their intuitions. In meditative awareness we can assimilate our receptive attention (*adaeqatio*, conformation) to these sources. We can have an inner experience which allows the other to say, "if that is what you call 'Logos,' in my language I call it 'so-and-so.'" In this way we can overcome the separation through our mother tongue – and/or religious-cultural paradigms – by referring to the sphere of *wordless understanding* (Michaelic language) *above* words. However, it will be important that we keep these kind of names as "sign-posts" (or reminders) for the reality which they represent.

If we are now asking ourselves what we mean the essential aim of Waldorf pedagogy, we can – among many other examples – refer to an untranslated lecture by Rudolf Steiner entitled, *How to Give Reality of Being to the World of the Idea?*¹ There Rudolf Steiner says that the only elements which the human being can add to the

1. Rudolf Steiner, *Wie bekommt man das Sein in die Ideenwelt hinein?*, 10 lectures, Dornach, Dec 12-27, 1914., untranslated, lecture 7 in *Okkultes Lesen und Okkultes Hören*, Dornach, 1967, GA 156, p. 116-133.

given word are “new meaning” and “love.”

“Why is it,” Rudolf Steiner asks, “that we are exposed to living in a world of ‘reality’ (sense-perceptible world), as Beings of the real world,” but placed into “a world of unreal images?”

... let us assume that we were placed into the physical plane in such a manner that we would not have images, but realities For the perception of the physical world that would mean, for example, that when we perceive a sequence of tones in a certain context, the effect of such a tone-complex would enter our ear, our hearing-nerves, and produce a certain effect in our brain. If we would merely enjoy the processes in our hearing-nerves we would not have the representational mental picture; then we would have reality, not merely images. But this is not what happened; we are really thrown out of the world of reality and placed into a world of images, a world of unreality. If we were in a world of reality . . . we could never have the possibility to give reality to a world by ourselves. Because we cannot provide reality to something we already experience as real Regarding our own creating of reality, it is indeed correct to say that we live in a world of images; but although the images have no reality we are able to endow them with reality.²

In this sense, “giving reality” means to give meaning, analogous to the way in which we integrate a sequence of sense-perceptible tones into a melody that emerges before our inner ear.

And Steiner asks, “How does this reality of added meaning appear in the sense-perceptual world?”

... We do this when we act morally. At the moment when moral impulses are flashing through us, through our inner soul-life, we are creating something for the world, which would not exist without us. In the representational image of the world we have merely pictures, by acting morally we place realities into the world. Our morality would never suffice in a world which would face us as real. Because then we would always interfere whenever we want to act morally.³

The Art of Reading – Logos-nature of the I

“New meaning” is that which every I has to give to a constellation of sense perceptual elements, such as words, letters, sounds, or natural phenomena.

If everything were really only given, we could do no more than merely stare into the external world and stare indifferently into the inner world of our individuality. We would at most be able to describe them as something external to us; we would never be able to understand them. Our concepts would have a purely external relation to that to which they referred they would not be inwardly related to it. For real cognition depends on finding a sphere somewhere in the given where our cognizing activity does not merely presuppose something given, but finds itself active in the very essence of the given. In other words, precisely through strict adherence to the given as merely given, it must become apparent that not everything is given.⁴

Only when our attention (not-given, because you or I have to give it) has consciously identified (posted, *geseizt*) a phenomenon, is the significance of such a phenomenon within a specific context established for our reading, the meaning-giving Logos nature of our I-being.

We can characterize the “Logos-nature” of human attention by its predisposition for the word-nature of a given phenomenon. For instance, for the human I the color “green” is not a certain wavelength but a specific “feeling perception” within a context of colors. The same wave-length of green might be called, within another environment of colors, blue, turquoise, or even yellow. The Logos-nature of an I-being is not really interested in a number of oscillations, or wave-lengths.

The activity of complementing a given sense-perceptual phenomenon with a not-given meaning – “meaning”

² Rudolf Steiner, *ibid.*, p. 127-128.

³ Rudolf Steiner, *ibid.*, p. 128.

⁴ Rudolf Steiner, *Truth and Knowledge*, Ch 4, Steinerbooks, 1981, p. 57-58.

in the widest sense⁵ – can be called reading. This requires a super conscious access to our inspirational level of understanding which relates an optical or acoustical image to a certain feeling-knowing. But this inspirational light alone does not constitute the “Logos-nature” of understanding;⁶ it only establishes that which would be called “logicity.” The “Logos-spark” originates from the intuitive level of the I-being who links and connects an outer sense-perceptual sign with an inner meaning.⁷

This predisposition which allows us to develop the faculty of reading, we can call the “Logos-nature” with which every human I-being is already imbued through the first “word” that it receives after birth: the loving look of the mother.⁸

This directs our attention to the nature of the human I as a wellspring of eternal newness, of new meaning and ever new beginning: loving deeds that can thus enter the world:

... What the human being allows to stream into the world in the form of moral impulses, this flows into the world as a reality which originates in the human being. The divine world has put us onto the physical plane, and made the experience of our soul-life unreal, that we should come into the position to introduce moral impulses as a reality into the unreality. Then you have creation out of nothing, crating into the nothing – in so far as representations are merely images, a nothing.⁹

This potential resides in the ever-present now. The openness of the present for a living future in the ever-present now has to be protected against restrictive determinations established by scientific expectations on the basis of statistics drawn from the past (“past” future), as well as misunderstood prophecies (which turn the intentions of their prophet into their opposite, i.e., fear and self-fulfilling prophecy).

With this understanding, we can articulate the aims of Waldorf pedagogy (on behalf of humanity) in such a way that we do not have to seek recourse in nominal confessions, but can agree (Matthew 18:19)¹⁰ on nurturing the “wording” faculty of a human being, the ability to become – and remain – an “open word.”

Cultivating the Logos-faculty of the human I process – above all – the possibility to remain a human being. It is the faculty to remain always “in the beginning,” to be never “finished,” to retain the capacity to make always new beginnings. If this faculty is lost, the human being becomes a product and crystallizes.¹¹

Goethe's "Seeing"

The means in which Waldorf pedagogy is cultivating this faculty is the artistic permeation of all disciplines and subjects with an improvising creative approach. Much has been written about this.

But also the Natural Sciences, which can be complemented by the Goethean approach, can give us an avenue that includes a focus on the essence of Waldorf pedagogy – the Logos. Goethe's look was always directed to the archetypal phenomenon, where the sense-perceptual world reveals primary creative impulses or archetypal forms for the understanding look of the beholder. These “beginnings” (“archai,” from the arché, the Greek word for “beginning”) can be found on every level of creation, in every kingdom of nature.¹²

For this way of seeing, every phenomenon reveals its origin, its “logos.” In Nature we can call this origin a creative substance.¹³ Since in Nature it is veiled by material sheaths and forms of appearance, it can be investigated by the Logos-nature attention of the human I, which is more receptive to quality and meaning, than to measure,

5. The feeling of green is also a meaning; it is a specific “suchness,” or quality.

6. See also F. Schwarzkopf, *The Metamorphosis of the Given*, New York, 1995.

7. There has been for several decades a tragic misunderstanding of the term Logos that it was solely related to the abstracting faculty of human intelligence (the merely inspirational level, with its exposure of being operable by means of artificial intelligence) without the concrete intuitive act of an I-being (“*substantia*,” substance, hierarchy – from the Latin verb *substare*, literally “under – standing”, which establishes the reality of the event between the sense-perceptual given and human consciousness (with its not-given integrating activity). Only this intuitive level relates the word Logos to the “Word that was in the beginning.”

8. See also Georg K h lewind, *Der sprechende Mensch*, Frankfurt, 1991.

9. Rudolf Steiner, *Wie bekommt man das Sein in die Ideenwelt hinein?*, p. 128-129.

10. Only such consensus and “consonance” establishes a shared paradigm.

11. In the language of the New Testament – the letter of Jude 4 – the angels who have “lost their beginnings” (arch ) are called the “fallen angels.”

12. F. Schwarzkopf, *The Archetypal Phenomenon – Guide for a Goethean Approach to Natural Science*, Fair Oaks, 1991.

13. See footnote 7.

number and weight – criteria which are analytical rather than integrating. In Waldorf pedagogy this is known as the “Goethean approach to Natural Science,” which allows us to cultivate a perception for the “speaking” of the natural and elemental world.¹⁴ This approach also cultivates artistic and musical faculties for creative activity in the realm of Nature, for instance in the way of Bio-dynamic agriculture.

The Goethean approach to Nature can also be an avenue to communicate the intent of Waldorf pedagogy among indigenous communities, which have an understandable reluctance to be receptive to any Christian impulse, if they had to suffer from inappropriate missionary ways.

In human works we can distinguish the logos¹⁵, by the way in which our creative activity is integrated into the context of life: whether it is for our own comfort and utility, or for a culture of the Word (a “cosmos of conversation”¹⁶.) and for the purpose of making love visible in our deeds,: “He who does my works is my true disciple.” This could be an orientation that can encompass all, “names.”

* * * * *



14. Its “speaking has become silent now” only for a being that has lost the faculty of hearing.

15. Here, “logos” is written with a lower-case “l,” because it refers to our logos, i.e., the way and manner in which we use our predisposition for creative activity, which originates from the Logos.

16. “Cosmos of conversation” is a term that is used by Gerog Kühlewind, see also F. Schwarzkopf, *The Metamorphosis of the Given*.

Nature Education

Understanding Nature and Religious Feeling

Ernst-Michael Kranich

INTRODUCTION

1. A SYNTHESIS OF THE IDEA OF NATURE AND RELIGION IN EDUCATION

The question of religion in education is one of the most difficult pedagogical questions of our time; it deals with the way the teacher works with young people right down into those depths where religious feeling is rooted. It is difficult because religion is quite foreign to contemporary consciousness, derived as it is from mostly outer perceptions; for us Nature's significance includes neither the spiritual nor the divine – it is perhaps just a place to relax. The religious domain goes to the depths of our being, where we perceive a connection with the divine which enlivens us.

2. THE POLARITY BETWEEN THE CONTEMPORARY IDEA OF NATURE AND RELIGIOUS LONGING

In education, we encounter a realm of deep polarities which run through modern life. On the one hand, a deep religious longing lives in us, connected with the feeling we will only find satisfying answers to basic life questions when such answers are drawn from the depths of this religious realm. On the other hand, people [take up the knowledge] that only contains the sensible.

On the other hand, however, our knowledge is based only on the senses. The media's view of Nature leads us to think of Nature and people as having sprung forth out of totally non-spiritual properties. These very ideas lead to a skepticism toward religion and a laming of all religious sensitivity. Therefore in education where religion is concerned, it is essential that the teacher works to acquaint themselves with the idea of nature that *does* see a connection with the divine and spiritual, so that the young people can find the spiritual in nature. Recently, natural scientists have begun to see the facts and laws of nature as connected to a 'basic ground' of being and view it as something also found in the great religions (Hindu, Bhuddist, Taoist, Christian).¹

¹ Ken Wilber, Ed., "The Holographic Paridigm and Other Paradoxes" Shamablla Press, 1982

Professor Wilber thinks that science *can* find a bridge to religion, as is widely thought. However, this 'basic ground' cannot actually be observed in the world of facts and matter, so a strange connection between mysticism and a non-spiritual material world is being created. This is a common way modern science tries to form a bridge between nature and religion; but, this is not the best way to accomplish it in education.

3. LOOKING TOWARD THE CREATIVE FORCES OF NATURE

May I recall a saying of Goethe's which points to another path. Jacobi had written a booklet in 1785 in which he wanted to refute Spinoza's ideas of Nature, and he sent a copy to his friend Goethe. And, in his reply, Goethe describes how one *can* form a synthesis of Nature and religion:

"He (Spinoza) doesn't prove the existence of God; existence *is* God. And if others scold him as an atheist, then may I call him a theist (the most godly), yes even a Christian (the most Christian) and praise him...

Forgive me, that I am so happily silent when people talk about divine being; I can understand that only out of the 'rebus singularibus' and Spinoza is the very person that will lead us to understand this as none other."

And even more clearly Goethe says:

"Here I am in the mountains, and seek God in the flowers, herbs and the stones."²

In the flowers and stones, Goethe found that initially modern man cannot find the divine in himself, he must seek it *in* the being of nature, not somehow hidden behind it.

This comes clearly to expression also in Rudolf Steiner's comment:

"People should open their eyes, and behold the revelation of the godhead in the things of the physical world, in stones, in the plants, not dream that these are only 'appearances' and that the true form of God is 'hidden' behind them. No, God reveals himself *in* his creations, and whoever wishes to know God, must come to know the essence of this creation."³

What Steiner here describes as "beholding," is not a "usual seeing," but a higher, an *imaginative beholding*. And, he considers the path leading to the divine in Nature as an extension of the path of scientific knowing. But, in order to tread this path we must leave the kingdom of the manifest (things), which surrounds our ordinary consciousness, and penetrate into the *realm of becoming* (processes). Where becoming holds sway, the creative, spiritual forces of nature are active; here we come into contact with the divine. This becoming is multi-layered: in spring we encounter it ever anew in the flowering and sprouting plants. But this must stem from some source – the hidden realm of becoming, the actual *workplace of Nature*. People must grasp this if we hope to lead students to an understanding of nature which has the depths of religious experience.

4. GRASPING THE WORLD OF PLANTS VIA "LIVING IDEAS"

Here I would like to describe the pathway to the "realm of becoming" and to the creative activity of Nature, insofar as it applies to the teacher. We need only touch on the initial steps wherein we study Goethe's methodology; this stage would consist of the

² Goethe, *Letters*, Vol. III, pp50, 52.

³ R. Steiner, *Stages of Higher Knowledge*. GA 12, p. 40.

observation of plants, in which you reflect on all of the forms of the plant in your mind's eye. In these reflections, you would grasp in the plant's previous forms something of the formation-processes which were active in the development of its current form. In the stem, we have narrow, linear growth which orients the plant toward the light, a form centered in itself and is related to the light only on its surface; in the leaves, comes a broadening-out and thus a unifying with the forces of the surroundings (air, light); and then, in the constant renewal of stem and leaf, i.e., all processes where the inner being of life expresses itself most purely in ever-new forms: recapitulation.

Through repetition, the green sprout originates. And following this, comes a powerful process of change through which the vegetative growth is raised to the blossom. At this stage, you would observe firstly how the blossom's growth strives out and away from the stem, and brings the plant to a higher level of development, oriented to the surroundings. The blossom forms its crown and petals as refined leaf-form, develop to higher forms. You would grasp how the sprouting growth expends itself, and how, in this extinguishing into an inner form turns toward the intense sun. And finally comes the process of transformation which leads to the final stages of the plant's life: pollination, ripening, and seed-formation.

During this inner visualizing, the viewing experience is transformed. You no longer see only the several forms of the plant next to or layered upon each other. They become the expression of a vital process of formation. In all the various forms, one perceives something of this shaping, creating activity. Above all, one understands how one form emerges through the inner transformation of every creative force that was active in the formation of the plant's previous forms. You fathom the inner coherence of the growing life, and so move from a sense-perception to a living, sensible-supersensible perception. If you wish to reach the ideal or imaginative realm, you must work for this change in perception.

Such soul-activities which lead to an imaginative consciousness are precisely those which are engaged in mathematical thinking. In mathematics we produce results in full consciousness, results which are accessible only through spiritual activity. Outer observations can no longer be used as a support for knowing. Here, only inner activity will bring results. If one transfers such a mathematical knowing to other areas, even to the realm of living things, then one enters the realm of imaginative perception.⁴

So, in the realm of the living, how *does* one come to a [clear and precise] perception similar to that in mathematics? You can take the living image of the plant that you have worked on in a Goethean way, and transfer it into the time of *late* Spring, that is, into that season in which via the soil moisture and other phenomena, the sprouting growth of the *stem* is most dominant. If this process of repeated stem and leaf formation in the plant's development gets especially powerful, it will also work into the subsequent phases of development. In the flowering realm, it won't lead to a culmination, where the sprouting or flowering burns out; rather, more and more new flowers will be formed, as previously the leaf shoots were formed. Thus, the characteristic forming-principle of the stem is now carried into the flower region; the plant's transformation into blooming is incomplete. The inflorescence becomes narrow, the flowers will stay small, and will not achieve a complete unfolding. And, they have characteristics which express the incompletely achieved sprouting principle.

The plant changes into a cruciferous plant, a form we can see in many regions in late Spring and early Summer, in plants like colza or rape, hedge-mustard, and [taschel-kraut].

One can in the same way also ask, how do the plants develop in the season of *early* spring or high up in cold mountain climates, where the snow melts only in summer? It will not go much beyond the stage of its winter bud. The unfolding stays at the stage of a rosette, i.e., before the stem grows. This initial unfolding will also be clearly indicated by the simple form of the

⁴ See R. Steiner, *Nature-Perception, Mathematics, Scientific Experiments*, GA 324, Lect. 1.3;

leaves. It will also be impressed in the rest of the plant development, so that the flower head will stay very narrow, or only one flower will develop. The flowers themselves will only open a bit, and a less developed unfolding will manifest itself in small cylinders that will open up only at the periphery. Such plants develop in forms like those seen in gentians and primroses.

Through this [kind] of observation you do not only learn to understand the plant from the outside; but penetrate *into* the principles of its evolution (becoming). In the living being of the plant, as one formation is inwardly connected with another formation, one of those processes of formation will be especially predominant, and thereby will influence the whole plant development and will give its imprint to it. One can only grasp this in such a way that, in the conceptual picture, one intensifies this process into the rest of the plant development. One works like an artist who creates out of certain inner principles. This is the kind of "design" Steiner points at.

So, for example, one can creatively follow how the plant-nature forms itself in the moist and warm twilight on the floor of a tropical rain-forest, how the growth of the stem forms overwhelming upwards climbing shoots, how the blooming is stifled by the powerful shoots, and only insignificant, small flowers are formed. One can also grasp how the plant being unfolds where light and warmth develop a special power in the Mediterranean or Middle Eastern summer, and out of its inner being especially a labiate and umbelliferae flower develops. In the Umbelliferae (carrot family) the raying-out into the periphery in the blossom is intensified far beyond the norm and reaches a total expansion into the surroundings. The inflorescence raises itself to a flower-like form. And the "striving beyond itself" into the vicinity intervenes (throughout) the whole plant development right into the forms of leaves, shoot, flowers, and fruits.

Through such a recognition that is becoming creative, the relationship to nature changes. This is not only true for the adult, but also for the children when they learn to understand how in one plant the sprouting process predominates, while in another the raying out into the surroundings dominates, and in yet another only the first beginnings of the unfolding prevails. One gets to know what was hidden up to now. One sees how the whole plant world is one being. One notices how it is one and the same being, which manifests here in this, or there in that other plant-form. In one situation, one type of formative process dominates, in a different situation yet another. And, one grasps how, in these various formations, it is one plant essence which expresses the various geographical and climatic conditions of the earth. So the individual plant manifests as only one part of a great whole. It becomes a concrete experience, what Rudolf Steiner expressed in the following words:

"One gets the idea that the whole plant kingdom actually forms a great unity with the earth."⁵

In this way the young people come to a living idea by way of their lessons; i.e., to an idea that carries so great a spiritual enlivening in itself that it can go into many separate forms. The individual plant forms now reveal themselves as particular embodiments of their living idea. The living idea is at the same time also a far-reaching, creatively acting entity that lets the whole plant kingdom emerge out of itself. The concept of plant, as one usually knows it today, contains nothing of this creative enlivening. It is a conception without inner life; i.e., it is a dead concept. With these dead conceptions, the human being lives apart from the world (separate in himself); through these dead concepts he is encapsulated in his egoity. In lifting himself up to the living ideas through the inner-artistic work, a person gains something that unites them with the world; for, the living idea in nature is a creative essence in nature. Through the living idea, the human soul reaches a spiritual connection with nature and the breadth of its existence; and, the feelings expand into the domain of this living idea. As long as one has only dead concepts, one sees in

⁵ Steiner, Rudolf; *Nature Observations*; GA 324, p. 61.

every plant only a singular isolated structure. But when one has attained the living idea, then one comprehends how the living being reveals itself in a specific way in the individual plant.⁶ One understands that the individual plant species are only one part of a living growth-process that spans the whole earth. Such an understanding enables one to feel connected with this living process. The human being is led beyond the narrow restrictions of his egoity. A power of selfless feeling revives in him. This is the basic mood in which religious feeling can begin to develop or unfold.

Such a "living idea" is not yet "imaginative consciousness." Living ideas, according to Dr. Steiner, are the "beginning of imaginative perception," the seed of imaginative consciousness.

5. THE CORRELATION BETWEEN PLANT DEVELOPMENT AND THE COSMOS

How does one bring this seed to germination? One has to go on to more all-encompassing perceptions through which one meets the spirit in nature more directly. A phenomena that leads deeper into nature is *rhythm*, which weaves through the development of the plants: the alternation of expansion and contraction.

Narrowing, or contraction, is active where the stem forms itself between one leaf and the next. In expansion and widening, the plant unites itself with the forces of the surrounding atmosphere and of the light; through these forces, the plant unfolds. Through contraction, life concentrates itself within the plant; this leads to separation from the environment to individuation, and also to becoming denser or more solid.

Life has its existence *in the rhythm* between these two polar processes. Without the flow of the one process into the other, life would have to dissolve into its surrounds or suffocate in its becoming ever denser. Life is the pulsating rhythm between expansion and contraction.

This rhythm leads our consciousness into all-encompassing global connections. If one follows carefully the growth of the stem in field cress, in *Campanula* and similar plants, a rhythmical sequence is noticeable. The intensity of the growth process oscillates in the course of the 29 day synodic lunar rhythm, increasing and decreasing. It is generally strongest during new moon and weakest at full moon.⁷ So, the growth of the stem pulsates in a (synodic) moon rhythm – the stem is closely interwoven with the moon in its development. In the same way, the expansion of leaf-development correlates with the sun. Only when the plant unfolds in the sunlight will leaves develop. In the darkness, only tiny, pale scales grow on the elongated stem (etiolation). So, the rhythm of expansion and contraction indicates how the forming forces of plant life correlate with the of the cosmos. One has to direct ones searching out into the cosmos and away from the plant, to understand the plant.

What are sun and moon and the forces that stream from them towards the earth? A first insight is gained into the inner qualities of these forces by contemplating the impressions that one gets from the sun and moon. The sun is raying-out power of light force. The light that shines out from the sun appears as a revelation of streaming power that penetrates the cosmos.⁸ The moon's

⁶ Here I would like to add the following: Principles that were hidden by the use of conventional concepts become accessible through the help of the living ideas; for example, the relationship between the individual formations within a plant form. In this way the perception through living ideas is not on the same level as that through conventional (dead) concepts; rather, it is a advanced stage of science. Almost all the sub-disciplines of biology are based on conventional concepts which determine the level of knowledge. But, this advance in our way of looking at organisms leads to a new interpretation of the facts, also in these sub-disciplines, e.g., in genetics.

⁷ G. Abrami; "Correlations between lunar phases and rhythmicities in plant growth under field conditions." *Canad. Journ. Bot.* 50, 1972.

⁸ Out of these definitions one should understand that what is meant by light is what one experiences at the sight (appearance) of the sun, not the interpretation of light as electromagnetic waves in a certain frequency. Electromagnetic frequency is different phenomena than light, just as a particular air vibration is something different than a tone. It is a parallel phenomena to light which has a different quality than light and which does not explain that which appears as light. The blinding intensity

light is a repressed (subdued) light, a glimmer. In comparison to that of the sun, this light has a strongly altered activity, which the moon, as cosmic mirror, sends to the earth. In its movement about earth, the moon forms a narrow sphere of shimmering light, cut off from the rest of the cosmos through its mirroring. Something of the isolation from the surrounding cosmos is expressed in the coolness of this shining.

We can express these relations via an image: the moon stands in a relationship to the sun such that it separates and reduces the radiating forces of the sun into a narrow sphere of his own. But the moon is also oriented towards the earth (with its condensing forces of gravity). Earth unfolds the moon's influence in mediating between sun and earth. This mediation happens continuously as a time process. The connection to the sun, and the interrelationship of the muted;

isolated effect of the sun with the radius towards the centerpoint of the earthly gravity, manifests itself in the plant development as the growing stem. So for an observation that includes the cosmos, the stem becomes a revelation of the moon in the life-processes of the plant. And, as the moon pulsates in the phases between new moon and full moon, so the growth of the stem is increasing and decreasing. (See illustration).

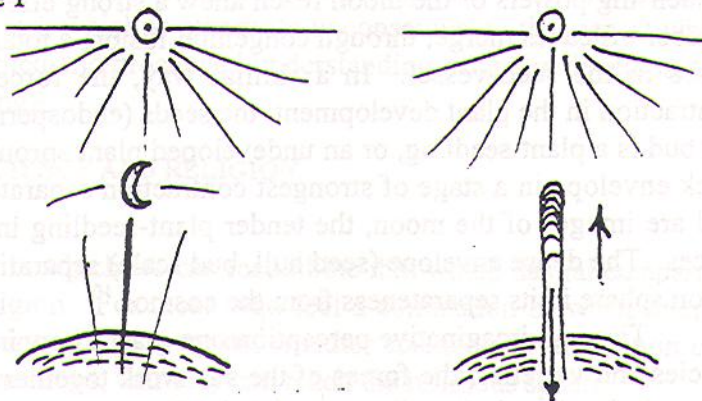
Now one can follow how the leaves unfold and expand themselves into the vicinity of the atmosphere, the manifestation of the moon, and how the light of the sun streams through them. With various phenomena, one can see how the forming of the leaves happens in connection with the sun – in darkness, they only grow into little scales – and how in the expansion of the plant into the leaf, the out-streaming into the surroundings and the dissolving powers of the sun are manifest. If one learns this through intensifying the inner power of observation, the understanding of the plant kingdom transforms into imaginative observation.

The principle of the imaginative lies in the following words of Goethe:

"All that will pass away is but a metaphor."⁹

In the sense of his words, the stem and leaf formations, i.e. contraction and expansion, become a manifestation of vast cosmic processes and principles. One has to differentiate this 'imaginative' perception, from pure "imagination," the first stage of true supersensible perception. Imaginative perception is still based on sense perception; it is, as it were, the preschool of free imagination where supersensible realities and processes are pictorially revealed without the support of the organs of the physical body.

Figure 1



Left: The moon, mediating sun and earth, with radius oriented with earth's gravity. Right: The higher plant stem as image of the moon stands in connection to the sun, but isolates itself from the sun, and is centered towards the earth. The geotropic orientation shows that it is permeated with the radial force of gravity. The growth of the stem is an expression of the continual action of the moon.

- besides many others - demands to call light a power sui generis. To be exact the shining brilliance (radiance) of the sun is the most intense revelation of the light which we normally know. Light itself is, as we know, an activity that is not accessible to the eye. What one sees, is the reflection of light on illuminated objects. So, one must understand the sun as the most impressive indication of what light itself is.

⁹ Steiner, Rudolf: *The Path of Knowledge and Its Stages in Original Impulses of Spiritual Science*; GA 96, Dornach, 1974, p.144.

One can learn to see the whole plant kingdom and all of nature in a new way through "imaginative perception." One can observe how the plant development transforms to form a flower, while the dampened growth of the stem, and the leaves metamorphosed into flower-crown become the flower envelope on the same level; the forces of the moon recede, and the sun forces are in a heightened activity. As the seed-vessel forms in the center of the flower, the condensing powers of the moon reach anew a strong effect at this next stage of development. A number of leaves merge; through congenital fusion, a totally separate, little self-contained sphere arises in the seed-vessel. In a similar way, the forces of the moon lead to the strongest contraction in the plant development: the seeds (endosperms) with its embryo. In the seed and in the bud is a plant-seedling, or an undeveloped plant sprout separated from the environment via a thick envelope in a stage of strongest contraction separate from the environment. So, seed and bud are images of the moon, the tender plant-seedling inside are an image of the dimmed sun-forces. The dense envelope (seed hull, bud scale) separating from the vicinity, is an image of the moon sphere in its separateness from the cosmos.¹⁰

Through imaginative perception one grasps how in the individual plant families and their species and varieties, the forces of the sun work together with the moon forces. In the bulbs of spring (tulip, hyacinth, gelbstern, etc.) the forces of the moon have a strong predominance over the sun forces. The plant development is partially held back into a bud-like narrowness. The bulbs are mightily swollen buds that root directly in the earth. The leaves are narrow, they do not expand. The contracting forces are visible even in the flowers, which don't unfold to the point of devotion to the sun; they stay narrow, as does the inflorescence. Also in the primula (primrose), the plant development is held back to a barely unfolded condition. It is not as narrow and self-contained as the buds and the small leaves of the lily-like spring flowers. It stays in its unfolding at a preliminary stage. There are no sprays yet developing, only rosettes whose leaves widen towards the outside but are still very simple and undifferentiated (without organization in stem and spray). Also the inflorescence is – like the sprout in the rosette – totally condensed, and the flowers form narrow tubes, that only spread out at the upper edge.

In these spring plants, the connection of earthly life and the cosmos is manifest in a beautiful way. In winter the moon is the dominant celestial body. During the long winter nights, the full moon passes as high as the sun did in summer. In the spring it recedes gradually in comparison to the sun, which slowly unfolds its force in nature again. But, the moon is still a strong force in comparison to the newly rising sun. So spring is just that time of year where the sun is not yet the dominant power. The plant kingdom of spring is the mirror of these cosmic constellations in the life of the earth.

In the plants of high summer (like the umbelliferae, Queen Ann's Lace), the strongly contracting forces of the moon recede into the background in comparison to the expanding forces of the sun. Thus a umbellate-like inflorescence develops in which the central shaft recedes, in comparison to the out-spreading into the periphery. In the leaves of the typical umbelliferae, the leaf structure dissolves into many pinnate leaflets. And even the stem expands and even becomes hollow. In contrast, if the contracting forces of the moon dominate the plant-development, then forms like grasses develop. Their leaves enclose part of the stem surface; only a part of the narrow leaf surface reaches out into the vicinity. The inflorescence unfold only a little. Especially in the grass heads, individual shoots are totally held back in the budding condition.

These examples can point out how one can learn to understand the higher plants in connection with the cosmos. This doesn't lead to mere theory. By rediscovering the cosmic principles in the formations of the flowering plants, we can live into these connections through imaginative perception. Then, we also experience the vastness and sublimity of these

¹⁰ F.H. Julius, E.M. Kranich; *Trees and Plants*; Stuttgart, 1985, p 122 a.f.

connections, i.e. the grandeur that lies in the fact that the earth, including the plant kingdom, is a member of the cosmos. A feeling though which one stands not only merely in the realm of earthly occurrences, but rather in the realm of earthly-cosmic events, takes hold of the will with enlivening warmth. Such inner warming and empowerment of the will is otherwise only known in religious experiences. Thus, the cosmic understanding of nature leads to greater depth and fullness of religious sentiment when it comes out of imaginative perception. This understanding speaks to the essence of the human being, which is otherwise unconscious, to that aspect which is connected with the divine. A deepened and broadened understanding of nature develops, that can ignite the powers of religious feeling.

6. DISSOLVING THE POLARITY OF SCIENCE AND RELIGION

Thereby, we have found the place in which we can recombine that which has fallen apart in our civilization: science and religion. For those who feel a connection between science and ideals of knowledge, a moving question exists, whether science and perception *can* penetrate so deeply into the world-connections, that they can reach the religious sphere.

In the Middle Ages, the view that Nature was divine still persisted. Thus, Hugo St. Victor wrote in the 12th century:

"This whole . . . perceptible world is like a book, written by the hand of God . . . and the individual creations are comparable to the figures (letters). They are nevertheless not set down according to a human measure, but rather introduced according to God's will, so to indicate the invisible will of God."¹¹

According to this expression, people initially find the divine when they survey the manifold expressions and occurrences of Nature. For, they are like handwriting, which only expresses its sense in its totality, not by its individual letters alone. The image of the 'book of nature' is not just a poetic metaphor, but should be taken as an indication of a methodology.

In the following centuries, this image lost more and more of its content. Its methodological significance has been reversed into the opposite. Since William of Ockham (early 14th century) people increasingly spoke of human words as mere indicators (symbols), which pointed at something else – to concepts; they contained nothing spiritual or essential. They are fictitious images, which people form according to certain rules of their understanding or comprehension of the world. Science "deals . . . less with things than with concepts and statements, concerning which it must first be investigated whether they really stand for things."¹² It is no longer a matter of the rose and its essence, but "the name of the rose" is that which remains as objectively withered scientific expression.¹³ Thereby, the connection of knowledge with religious content was lost. In the end, a fatal opposition arises: between science, without the deeper dimension of the religious, and a religion which, in its essential contents, is removed from knowledge.

The path of knowing which we have sketched in its methodological steps to imaginative perception, signifies the conquest of this dualism, or at least the beginnings of its conquest. And this is of practical significance for educators. This was indicated by Rudolf Steiner in the following:

¹¹ Citation in R. Assunto: *The Theory of Beauty in Middle Ages*, Cologne 1982. That this is a christian view, is clear if we read St. Paul, "For since the creation of the world God's invisible qualities – His eternal power and divine nature – have been clearly seen, being understood from His works . . ." Romans, 1:20.

¹² K. Flasch, discussing Wm. Ockham "*History of Philosophy in Text and Illustrations, Vol. 2 – Middle Ages*." Stuttgart 1985

¹³ A. Trembl: "The Name of the Rose. Self-understanding and the disaster of modern science in Umberto Eco's Novel." in *Universitas*, Vol. 12, 1986. He briefly works out how the much-read novel of Umberto Eco is also a presentation of the newly-achieved nominalistic science at the end of the Middle ages

"The world view can grow up in an experience of the cosmic. And people can see the [imprint of] sun and moon in all that grows on the earth. We should educate against such a background, for we will thereby engender in the right way the experience of the immortal, the divine, the eternally-religious in the growing child."¹⁴

The connection of plant growth with the cosmos, especially with sun and moon, should be studied by the children in their botany lessons starting in 5th grade. Naturally assuming the teacher has developed an imaginative way of seeing, since only through it can he lead the children to understanding. If the children grasp something of this, that the plant-covered earth is a vestige (clothing) of the cosmos, this view can provoke a religious sensibility in them.

Also in the upper grades 11 and 12, contemplation of nature can expand to a cosmological understanding. This requires that the young person comes to know the lawfulness within the planetary world, just as precisely as in plant formation. Then, the connection between these two seemingly separate worlds, will open up to a careful consideration. Many facts of living forms which otherwise remain a riddle, or otherwise require explanations in highly unpleasant terms (e.g., through genetics or by theories of evolution in their modern form), become understandable in this way. Through a cosmological extension of botany, an imaginative power enters into their judgment. In the depths of personal experience, this can ignite a feeling for the widths of world-connections as well as a religious mood. Then, the young person connects to Nature with their deepest feelings. Thus a presentiment resonates for the divine origins of the laws and forces of nature. So young people thus feel connected with these forces and laws.

7. MANIFESTATIONS OF THE SOULFUL IN NATURE

The imaginative perception of nature can also be formed in another direction. The small child experiences the world that surrounds him/her to a high degree physiognomically. Not only with people does s/he perceive with the outer an inner (reality), but also with the animals. The plants and even the dead objects. For the child the world is not only concrete (objective, perspicuous), it is for him gesture and expression. The spirit filled sentiment slowly fades away; and with that the meeting (encounter) becomes more and more (concrete) perspicuous. But in the adult the experience (or empirical knowledge) is still interspersed with physiognomical qualities. One finds beautiful examples for instance in the essay by J. Zutt, *On Life Systems*¹⁵. In our context it is of significance, what one has as an *experience of intuition* with the plants. One says, the rose speaks differently to the human "Gemüt" than the lily, a violet differently than purple vetch, and a snowdrop differently than a crocus. This part of nature observation/experience is [usually] excluded from the domain of science. It is the so-called aesthetic component, that lies outside the objective reflection.

Surely, what one feels/perceives there is fairly vague; it cannot easily be described – at least not at first. Even still, one can ask the question what lies underneath those experiences of intuition? Not to ask this question means a dogmatic self restriction of science. One can develop a method that can overcome the vagueness of these experiences, that is the empirical knowledge derived from them. That leads to imaginative perception¹⁶, which enables one to understand the connection of the earth with the cosmos in a new and deep way. This understanding is of

¹⁴ R. Steiner, *The Essentials of Education*, GA308, Stuttgart April 1924; slightly altered from the lecture notes.

¹⁵ In W. Bräutjam: *Medical-Psychological Anthropology*, Darmstadt 1980, especially p. 420 and following.

¹⁶ Steiner has presented this at different times, how this attaining of imaginative perception is an important arena of practice on the path to the development and expansion of consciousness. For example, in *Impulses Related to the Origin of Spiritual Science*, GA 96, Dornach 1974, p 144, and in *The Perception of the Supersensible in Our Time*, GA 55, Dornach 1959, p 188, and the following.

pedagogical significance for the children between 9 and 12 years of age.¹⁷

How does one acquire imaginative perception as an adult? The observations have to be strengthened in two directions: toward the outer, through an intensification of the attentiveness towards colors, the forms of the plants and their complete form; and, towards the inner, through a conscious entry into our soul process that are otherwise fairly unconscious, for example, into the feelings. Thus, you can be absorbed in the tender form of the snowdrop, for example. You follow how two small leaves grow upward from the earth, without turning to the side. You observe how the stem too grows directly upward from the earth and how the flower with its tender stem protrudes at the top out of the bud-like envelope. Its downward-turned form shows, how the whole formation is turned more inward than outward. The three outer flower petals widen only slightly, they form a loose envelope of inner space with their convex shape, in the way three inner flower petals surround a mysterious narrow core. This shape with its forms and its pure white color of the flower induces an intimate, tender mood when one observes quietly and exactly.

Now, the task is to bring to consciousness that which in these states of mind and heart becomes noticeable as special nuances of feeling. One can, for instance, concentrate on that which happens in the soul when we intuit. In this situation the soul is oriented inward. It does not go outward as in joy or enthusiasm. When a presentiment arises, the inner world widens. But, what lives in presentiment does not rise to full clarity of thought; it still remains in the veiled condition of the mysterious. One feels the way truth arises. It does not come to full clarity yet. And that is why one can not share it easily with everyone.

When one penetrates the soul process of presentiment with consciousness it turns into a directly describable inner gesture. This gesture is the same as that of the process of unfolding in the snowdrop. One finds in this a strange connection: what the human being in the feeling of presentiment experiences, shows itself in nature in an outwardly perceivable picture: the snowdrop.

Such a discovery can at first cause surprise and skepticism. It might stand in contrast to the concepts that one has formed about nature. One has to examine first, if that which one noticed with one plant is true in general.

So one deeply contemplates other plants, for example the daffodil (or Easter Lily), a plant related in form to the snowdrop, that grows out of a bulb but a little bit later. It strives higher, with its narrow leaves and stem. The flower turns towards the surroundings. The ring of the six yellow flower petals is expression of an open giving of itself. The yellow bell turns towards its surroundings in which the flower is turned out of its center. At the same time the surroundings penetrate deeply into the inner space.

The observation of the daffodil induces a particular feeling of soul in the observer. It has a nuance of pure openness, inner devotion, admiration. We learn admiration during inner observation, as a feeling of open devotion towards that the aspects we value as important as they come to meet us from the world. We don't only let this make an impression upon ourselves. We don't only turn towards it, we want to take it deeply into our inner being. In admiration, our inner soul forces stream towards what is beautiful and important to imbue oneself with it. in this way. The daffodil becomes an outer picture of admiration in this way.

Thus we get to know one plant after another, each in a new way. The old saying proves

¹⁷ At the turning from 9 to 10 years the child enters into a more distant and more critical relationship to his/her surrounding. This change was described by different psychologists, (for example Busemann, Piaget, Mickel). Rudolf Steiner outlined this turning point in the child's development from different aspects - mainly in its significance in education. The distance towards the world out of a stronger self-consciousness demands a conscious understanding of the world, now objectively experienced- about the characteristic of this turning point; see especially H. Müller-Wiedemann's *The Middle of Childhood*, Stuttgart, 1980. In the twelfth year causal thinking awakens in young people and this needs a different content for its development than that which leads to imaginative thinking.

to be true: Like is recognized by like. One observes the creations in nature with a fully conscious, enlightened feeling life. And in the light of this new way of observation, what was before only on the level of a dull unclear experience becomes clear. What we experience in our soul as longing, we now see in the crocus; what we experience as gaiety, we see in the image of the vetch; and the ranunculus becomes thus the image of joy, the monkshood the image of seriousness, the violet the image of humility, and so on.

Through a soul life lifted to clear consciousness, nature itself gets the character of an imaginative revelation. Through the colors and forms of the plant world soulfulness reveals itself. As the soul of the human being manifests itself as an image in his/her countenance, so the sequence of the plants appears like a wide-spread pantomime in the course of the seasons of the year. That a soul being expresses itself through the image-like manifestations of many different soul-stirrings, becomes a certainty when we learn to observe nature in the way we have just outlined. Those who think this is a projection of subjective experiences have not yet attained a clarity in imaginative perception. In imaginative perception one unites oneself with the plant kingdom through the feelings that have become conscious, and thereby, in their development, grasps an objective, i.e. imaginative manifestation of a soulfulness (soul world), that is related to the soulfulness of the human being. What in plants grows out of the earth towards the sun is not only a manifold life process. The life of the plant is interwoven by the forces of various soul movements. Not only the human being carries an individual soul, but the earth also. And the plant kingdom is the imaginative revelation of this soul force of the earth's being.

In earlier times people were convinced that the natural phenomenon were a meaningful manifestation of a deeper soul filled reality. This point of view can be found in the nature symbolism of the middle ages, and in its traces right into the modern age. Today we only know the scientific aspects of this perception which was once full of life. What is hidden to the intellect can be newly discovered through imaginative perception. However, not through artistic-historical interpretations, but rather through imaginative expansion of observation of nature.

The teacher can guide the children to an imaginative understanding of the plant through imaginative nature perception which he/she who has consciously penetrated the soul experiences. He/she can make it understandable to the children in the fifth grade that what they know as merriment or longing is in the processes of nature made manifest as vetch or crocus. Then the children combine their heartfelt experiences with the images of nature. The earth with its plants can become for them a majestic, sublime being. Out of this being with the sprouting life of the plant kingdom, soul forces arise and unite themselves with the life and formative forces of sun and moon. Through this the children learn to experience something of the sublimity and depth of nature. Thus they feel part of this majestic flowing together of the soul of the earth and the cosmos as it is manifest many-fold in the plant kingdom. The experience of nature expands and goes deeper into a religious feeling state of mind through which echoes something of that which is the spiritual essence or being of nature.

8 IMAGINATIVE UNDERSTANDING OF NATURE AND ANTI-RELIGIOUS POWERS

The imaginative understanding has a special task in the present time. It can protect the growing human being against anti-religious powers. For a number of years now, the consumption of horror movies by children and youths has increased drastically. From their comments, we know that they get a strange kind of pleasure and satisfaction from the gruesome scenes of torture and mangling. It is a pleasure in evil. Through these films, it is quietly brought out of the young people.

One faces a fact which E. Fromm, for example, tried to fathom. In his *Anatomy of Human Destruction*, he says that the destructive instincts that lead to evil are specific for

humans. They exist in all people. And it is only through meeting these that the human being is a being that can decide in freedom for the good and the noble. Morality can only be a truly free impulse, if it is attained by the refuting of evil.

The evil powers must rule in the underground subconscious of the human soul. They may not come up and rule over the human being; otherwise, the human being would be endangered. When they rise up, they act as an enemy of the religious. When a human being is overpowered by a pleasure in and impulse for evil, then s/he turns into an adversary of religion, especially an opponent of Christianity. S/he has only mockery, cynicism, and hate for the religious; it is deeply offensive to them. The rising force of evil is a power that can destroy the connection with the divine.

Today, where the unscrupulous production and marketing of action and horror movies draws out the evil in people, the following question arises, especially from the perspective of religious instruction: How can the forces of evil in the *subconscious* level of the human soul be held back? Through nourishing the selfless forces of devotion in education. When the children and young people devote themselves to the phenomena of the world in such a way that the essence of things begins to be revealed, then forces are developed that are *a counterbalance to the evil and destructive forces*. This happens when children connect with the formative forces in the plant kingdom through their *soulfelt experience*, and they learn to understand the plants as an *imaginative* revelation of joy, longing, *presentiment*, etc. Then the soulful experience becomes selfless as the inner being of the plant is speaking. The understanding of nature becomes a moral way of relating to nature.

Such nature observation is important today for the growing human being. It strengthens just those forces through which the connection with the divine stays alive. Where nature observation is cultivated *without* devotion in the cool atmosphere of the intellect, and knowledge about the world is gathered without an inner relationship to the world, an environment of the impersonal develops, in which destructive forces can easily take hold of the situation.

9 FORMATIVE FORCES IN THE ANIMAL KINGDOM AND IN THE HUMAN BODY

A deeper, more complete understanding of nature is not limited to the plant kingdom. Also, in observing animals a person can come to a living conception and imaginative perception. We will outline this with some methodical remarks and examples.

In the animal kingdom one has to also develop the supposition of a *synoptic perception*. The current state of affairs is rather dissatisfying. Animals are usually understood as a construct of functioning organs; with few exceptions, their form is not a focus of interest.¹⁸ The ideas about the animal kingdom are based primarily on the Darwinian interpretation of evolution. The concepts of chance and adaptation still dispense with the efforts to answer unsolved problems.

The key to an understanding of the animal kingdom that leads to the laws underlying formative forces lies again with Goethe. In one of his morphological works¹⁹ he develops how we ought to proceed. At first we should form a general picture of the animal organization. The manifold, individual animal forms develop out of the general 'type' in such a way that a certain organ predominates over the others. Thereby the organism takes on characteristic of that specific organ. We could say: the inner being of an organism exists in the way its organs interpenetrate with their processes; it has its foundation in the harmonic interaction of the parts within the whole. So, the dominance of one organ leads to a change in the whole organism. To understand

¹⁸ See also the works of F. Julius, Poppelbaum, W. Schad and A. Portmann.

¹⁹ First Draft of a *General Introduction into the Comparing Morphology beginning with Osteology*, in Goethe's scientific writings (pamphlets) published by Rudolf Steiner, Volume 1

an animal requires more than description; one has to follow how it gets its character in form and behavior through the dominating effect of a specific organ in the unique development of its life processes. This calls for a *creative* perception that corresponds to the *constructive procedure*.

So also in an animal organism, the formation of the spine and spinal cord can become especially strong and give the whole organism its imprint. Then the organization is concentrated in the inner part of the organism. Together with an extreme lengthening of the body, those formations through which the animal is strongly connected with the environment recede: the limbs shrink, as well as the eardrum, the eyelids grow over, becoming transparent or translucent. The movement of the animal *originates* out of the inner part of its body. The constant connection of the elongated body with the ground leads to a heightened self-awareness. The characteristic flexibility of the spine and ribs in the head region leads to a "clasping" formation of the "skull." So the animal cannot tear up its prey, but devours it whole as if the intestine already began in the head. So, we grasp how the animal 'type,' takes the form of a **snake**.

In a similar way, forming processes which are otherwise only at work in the skull enclosure can dominate the animal; that which forms a self-contained sphere in head, now works through a process of sclerosis within the whole skin. When this process takes hold of the body as well, then it hardens to a bony shell in which the ribs grow together in a sclerotic process, which otherwise only takes place in the skull bones. The limbs, organs that in nature are polar to the skull-formation, develop only weakly. They protrude only a little bit out of the skull-like rigid body. Also in the head, the jaws take a reduced limb-like formation. So the animal becomes a **turtle**, through the dominating formation of the skull throughout the organism.

When, in contrast, the leg-organization becomes so dominant in relation to the whole organization, that even the foot becomes leg, that the trunk with its muscles becomes a part of the movement processes, but also part of the breathing and respiration, and when the strong development of limb in the head leads to a strong jaw formation, the animal develops into a horse. In the same way does the dominance of the digestive system over the organism lead to a hippopotamus, the dominance of the neck in the whole of the animal organism leads to a **giraffe**, and the extreme tooth-formation of the incisors to the special organization of the **rodent**.

Here recognition and understanding becomes a process that is closely related to artistic creativity. When children are encouraged to understand animals in this way, in a sense they enter into the process of the animal creation. They recreate in their imagination as much as their age will permit them to do. Through this, they will learn to understand what animals are: significant revelations of the spine-formation, the head-formation, the leg-formation, etc. With a more exact formulation: animals are 'actualized' imaginations of this process of formation.

For the young person it becomes clear that the animal kingdom is not an arbitrary sum of animal groupings, species, and races. Herder has clearly spoken of that in his "Ideas of a Philosophy of the History of Humankind:"

"It sheds light on the fact . . . that because the main form (prototype)²⁰ . . . always has to be varied, one type²¹ explains another. What nature left as side effort in one creature, it develops in another as the central theme; Nature brings it to light, enlarges it and (lets) the other parts serve it while it still works in a well-thought-out harmony. Elsewhere those serving parts are dominant, and all creatures of the organic creation therefore appear as *disiecti membra poetae*. Whoever wants to study them has to do it inclusively, where one part seems to be neglected, it points towards some other creature, where nature has developed it and made visible."²²

When we learn to understand the animal kingdom in the way just indicated, it appears as one big organism, whose parts are the individual races, species or animal families. In each one of these animal forms, the growing human being learns something, which relates to themselves.

²⁰ The "type" in the language of Goethe.

²¹ Meaning species or race.

²² Herder, *Works*, in five volumes, Berlin & Weimar, 1982, Volume IV, p. 26.

The formative forces that work in the forms of the animal kingdom are of the same kind as those that work in the human body. Only, in the animal kingdom they have a more mighty power, and in the human being they are more withheld.²³ So, in each animal, the children get to know formative forces in their one-sidedness, forces that form their own human body. Zoology leads to imaginative understanding of the formative forces that are also working in the human body.

10 A TRUE UNDERSTANDING OF NATURE LEADS TO RELIGIOUS FEELING

This is a form of understanding that leads to religious feeling through its all-embracing quality and depth. In observing the animal kingdom, the young person can say: "Those forces that form the animals are also working in me." They build the foundation of my physical existence in such a way that they work together in harmony. "In the human being the animalistic has been enhanced for higher purposes," says Goethe. With our body we feel rooted in those world powers that manifest themselves in the forms of the animal kingdom. This feeling has the depth of religious sentiment; in it the young person experiences something of the fundamental powers of their existence.

Similar things can happen when children learn to see the soulful aspect of the earth in pictorial form as we described earlier. As these same soulful qualities that manifest themselves through the plants are experienced by the children, they feel themselves connected and related to the plant world. This also means that their soul forces become more enlivened.

The innermost aspect of the young person, their eternal being, is strengthened when religious feeling is kindled in them by learning to imaginatively see in the forms of earthly life the laws and forces of the cosmos.

If the teaching is expanded to become an imaginative means of understanding nature, then it awakens religious feeling in which the young person feels themselves carried in their bodily being, enlivened in their soul, and strengthened in their spiritual being. Here, the true nature of religion reveals itself: it is a source of strength and rejuvenation. The antithesis of an understanding of nature and religion exists only so long as one interprets nature only with the intellect. As a consequence of this intellectual interpretation of nature, theology assigns the divine to a domain beyond the natural world, or it comes into an unsolvable contradiction with the current interpretation of nature. Without expanding our perception of nature to include imaginative cognition we will not be able to bridge this polarity – to resolve this contradiction. To the imaginative perception those depths of nature are revealed in which God's spiritual essence lives. Nature is not spiritless nor ungodly. Its spiritual essence is only veiled or disguised in its physical form. It brings its forces and laws to expression in the material-physical; this obscures the spiritual essence for superficial observation. Nature is spiritual essence clothed in outward materials. This is why imaginative perception leads into the domain of religious experience. What the growing person can win in the way of religious understanding cannot be replaced in any way by an imaginative understanding of nature. Nevertheless, without a deeper understanding of nature, an essential condition for the effectiveness of the contents of the Gospels is missing. For out of a materialistic understanding of nature there arises the forces of anti-religious sentiment. In the upbringing of children the cultivation of a religious sense requires both the *Book of Revelation* and the "Book of Nature."

²³ Rudolf Steiner described these fundamental laws of the human bodily development from many viewpoints: for example in *The Eternal in the Human Soul*, GA 67, Dornach, 1962, p 338, in *Study of Man*, GA 293, Dornach, 1973, p 172, in *Fundamentals for the Extension of Medical Science*, GA 27, chapter 5. Only a little later did this law attain significance through the Dutch anatomist L. Bolck. See L. Bolck: *The Problem of Human Development*, Jena, 1926. Later objections (Hibsheimer, Slogger, Stareck) against the 'fetalization' theory of Bolck concerned details and one-sided aspects, but not the essence of his discovery.

The "Taste Spectrum,"

as indicated by

ARISTOTLE

elaborated and applied to the use of certain herbs.

Umbelliferae

Seeds (dried)

Aniseed

Fennel

Dill

Cumanin

Cardaway

Corriander

HEAVENLY FORCES

predominant in the plant

(as exposed in the sweetness
from flower-fruit to seed)

THE SEVEN TASTES

SWEET

OILY

Here taste moves from
sweet to sharp.

Umbelliferae

Leaf or stalk (fresh)

Fennel

Dill

Chervil

Parsley

Celery

Lovage

Archangelica

Earth

and heaven equally
active in the plant and
discernible in the taste
though differentiated
according to the species.

BITTER SWEET

Labiatae

Leaf (fresh or dried)

Balm

Mint species

Basil

Marojam

Sage

Lavender

Hyssop

Thyme

Savory

Rosemary

Juicy leaf, smooth,
somewhat heavy, lively
green

SHARP

Dry leaf, (in sage) velvety,
greenish-grey.

HERB

Leaf Substance Harder
dark green

Very Dry Leaf, (in
Rosemary) leather-like,
blue-green.

ACID

EARTH FORCES

predominant in the plant

BITTER-SALTY

(as expressed in the bitter-salty taste of root, stem, stalk.)

In speaking of "salt," in former times not only was "table salt" and what is by chemistry called "salt" indicated, but also the densifying processes of the earth. This earth and salt had one and the same meaning.

EXPERIMENTS

Rainbows (for 7th and/or 12th grade)

A rainbow can often be seen from an airplane window in the clouds below. To recreate this artificially, use a cylindrical glass of water to act as a large raindrop. Place the glass on a piece of white paper in the early morning or late afternoon sunlight. To make the rainbow more visible, place two books upright, leaving a space a little wider than the glass between them, so the sun shines on the glass, but shading the white paper (see figure). The rainbow will be seen on the backs of the books. You will find that light making the left side of the rainbow entered the glass on the right, and vice versa.

Elizabeth A Wood, *Science for the Airplane Traveler*, Houghton-Mifflin, 1968.



Fig. 1. Rainbows

Burning Ice (for 8th grade)

In Jules Verne's *The Adventures of Captain Hatteras*, Dr. Clawbonny was able to light a fire in -48°F weather (saving stranded travelers thereby) by shaping a piece of ice into a lens form and imaging the sun on a piece of tinder. If ice is clear, the sun's image is created with little scattering. You can make an ice lens by freezing water in a round-bottom bowl. Use boiled, distilled water, if possible, to minimize problems due to gas bubbles in the ice. Measure the focal distance of the lens and relate this to the radius of the bowl.

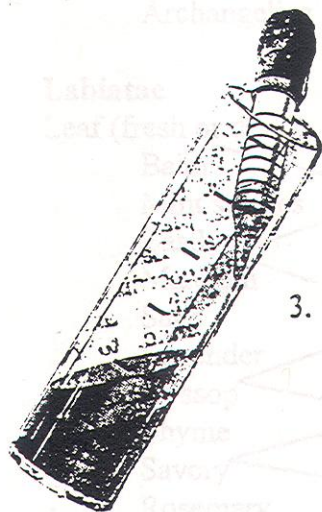
Y. Perelman, *Physics for Entertainment*, Foreign Language publishing house, Moscow, 1936.

EXPERIMENTS

Making a Density Column

Equipment: a tall narrow clear glass test tube or other tall cylinder, red food coloring, a medicine dropper or turkey baster, dark Karo Syrup, glycerin, Dawn dish washing liquid soap (blue), water, vegetable oil, rubbing alcohol, small pieces of the following: rubber, oak, cork, pine, plastic, lead, and Styrofoam.

- Procedure:**
1. Fill a glass container with water and add the red food coloring.
 2. Take the cylinder and use a grease pencil to mark it off in sixths (or approximate). Using the medicine dropper or baster, tip the cylinder and slowly, down the side, add the liquids to fill a sixth of the cylinder in the following order:



Karo Syrup
glycerin
Dawn blue dish washing liquid soap
water
vegetable oil
rubbing alcohol

3. Carefully add the pieces of cork, plastic, etc., and observe what happens.

Each of the liquids have a different density. Syrup has the highest density, it will stay on the bottom. Rubbing alcohol was the least dense, it stayed on the top. The solid objects have different densities, as well. The greater the object's density, the lower it sank. Have the students observe and draw what they observe.



EXPERIMENTS

The following several experiments are part of a still unpublished book co-written by David Mitchell and Douglas Gerwin. The book strives to show how "threefold" lessons can be constructed. The first step is to awaken the "feelings" for the subject in the students and involves some activity by the teacher. This then leads into an activity and judgment phase where the students' will is activated. When the review happens the next morning the "concept" is discovered by the class.

Goal: Why is there a need for Algebra? What is its origin?

ALGEBRA

Lesson Initiation

Tell the students the following:

Mohammed Ibn Musa al-Khwarismi gave to each of his three sons 7 silver talents. The first son went out and spent all 7 on a horse and 5 pigs.

The second son bought 3 cows and 4 pigs but did not spend all 7 talents.

The third son spent the same amount as the second, and he bought 2 horses and 3 cows.

"What was the price of 1 pig?" the three sons asked of their old father who loved riddles and began to solve it in this way.

- (1) If the first son had paid for each animal with a bag of talents containing the animal's price, and these bags were put on one side of a balance scale, they would weigh seven talents (because he had spent all his money).



- (2) Mohammed did not know exactly how much the other 2 sons spent, but he knew they spent the same amount so their purchase would look like this on a scale.



- (3) Mohammed noticed that 3 bags representing the cost of the cows were on each side. He removed the 3 from each side and the scale still balanced. Thus the cost of 4 pigs = the cost of 2 horses.



- (4) He then added the 7 talents from the first son's scales to the right-hand scale and his 5 pigs and 1 horse to the other scale to keep it balanced.



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EXPERIMENTS

Algebra - CONTINUED -

- (5) Next old Mohammed removed the horse bag from each side. There were 7 talents balancing the 7 pig bags.



- (6) Mohammed knew this simply meant that each pig bag weighed (and therefore contained) 1 talent.



Active Learning Experience

- (a) Ask the students to try to solve this problem in other ways. Ask them to try to find a shortcut way of solving it.
- (b) Mohammed solved this problem by using ALGEBRA. In Algebra today, we don't draw the scales and bags. The equal sign "=" replaces the scale. Instead of bags we simply use letters.

Therefore: Picture #1 $h+5p = 7$
 #2 $4p+3c = 2h+3c$ (take $3c$ away from both sides)
 #3 $4p = 2h$ (divide both sides by 2)
 $2p = h$

(Add picture #1 to #3)

#4 $h+7p = h+7$

(Now take an "h" away from both sides)

#5 $7p = 7$

(Divide both sides by 7)

#6 $\frac{7p}{7} = \frac{7}{7}$ to get $p = 1$

(Therefore each pig cost 1 talent)

Lesson Notes

The students have a mental picture of ALGEBRA, and they learn the concept that whatever we do to one side of an equation, we must do to the other. The scales must always be kept equal.

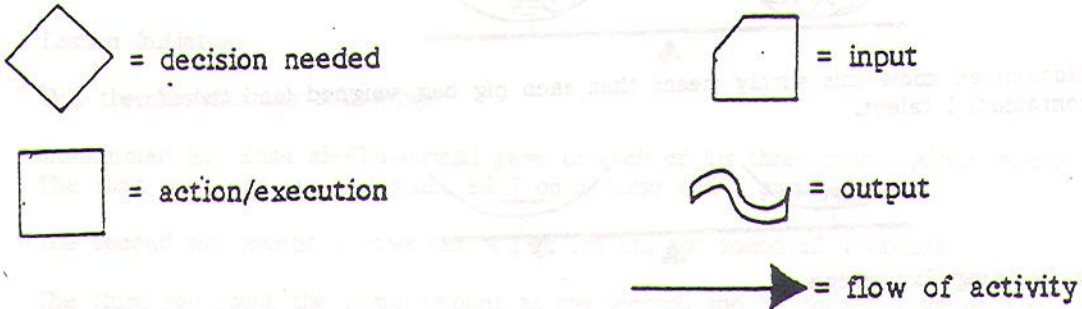
EXPERIMENTS

Goal: How do you make a flow chart?

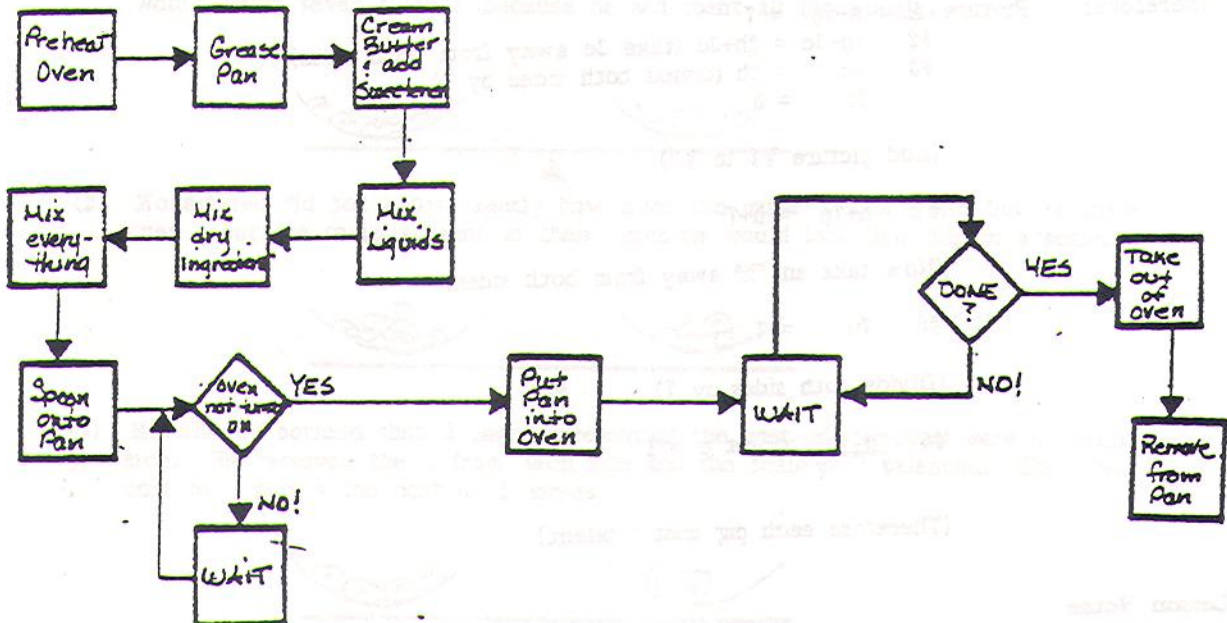
COMPUTER SCIENCE

Lesson Initiation

Introduce the symbols used in setting up flow charts to the class:



Ask the class to prepare a flow chart for baking cookies.



EXPERIMENTS

Active Learning Experience

COMPUTER SCIENCE, con't

Ask the class as a group to prepare a flow chart for starting a car.

For homework, ask each student to flow-chart the activities of a checkout clerk in a supermarket.

Additional homework: Ask the students to think of and flow-chart another familiar process. In class the next day, in pairs critique each other's flow-chart. Are proper symbols used? Is it clear? Would the process function properly?

An example of the check-out process in a supermarket:

