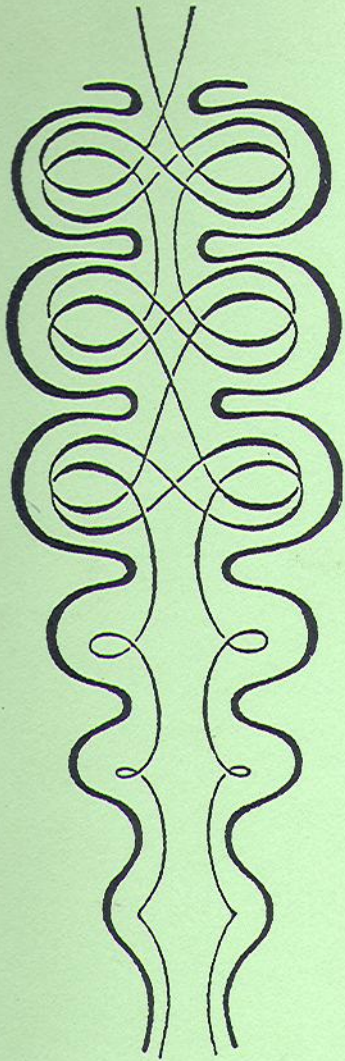


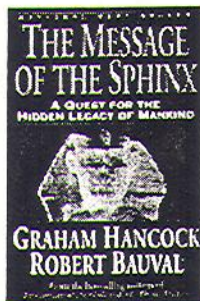


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WALDORF SCIENCE NEWSLETTER

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



Have you ever read something that you really wanted to share with someone? As I read *The Message of the Sphinx* by Graham Hancock and Robert Bauval I had this feeling several times. For those of you fascinated with the mathematics and craftsmanship of the pyramids I attach a section from the book to whet your appetites. The above named gentlemen stake their claim, and present evidence, that the Sphinx originates from 10,500 BC not from 2,500 BC as Egyptologist say. As the authors attempt to validate their claim they report many fascinating details which will enliven any elementary or high school history or math class. If such things interest you, then this book is a must read.

- DSM

The Pyramids

"The dominant features of the Giza necropolis are, of course, its three great Pyramids - those conventionally attributed to Khufu, Khafre and Menkaure. In a sense they are what the entire, vast enterprise proclaims itself to be all about, what the causeways lead towards, what the 'solar boats' are buried beside. Sprawling diagonally across the meridian axis of the site, it is they, above all else, that the geometrical 'Horizon of Giza' appears to have been designed to circumscribe. Nothing about them is accidental: their original constructed heights, their angles of slope, the measurement of their perimeters, even the pattern in which they are carefully laid out on the ground - all of these things are purposive and laden with meaning."

"Because we have described the Pyramids in such detail in other publications - where we have also looked in depth into many of their technical and engineering puzzles - we will not trouble the reader with superfluous details here. Some basic statistics and a few points of analysis are, however, unavoidable at this stage."

"The Great Pyramid was originally 481.3949 feet in height (now reduced to just a little over 450 feet) and its four sides each measure some 755 feet in length at the base. The second Pyramid was originally slightly lower - with a designed height of 471 feet - and has sides measuring just under 708 feet in length. The third Pyramid stands some 215 feet tall and has a side length at the base of 356 feet."

"When they were built the second Pyramid and the Great Pyramid were both entirely covered in limestone facing blocks, several courses of which still adhere to the upper levels of the former. The Great Pyramid, by contrast, is today almost completely bereft of its casing. We know from historical accounts, however, that it was once clad from bottom to top with smoothly-polished Tura limestone which was shaken loose by a powerful earthquake that devastated the Cairo area in AD 1301. The newly exposed core masonry was then used for some years as a crude local quarry to rebuild the shattered mosques and palaces of Cairo."

"All the Arab commentators prior to the fourteenth century tell us that the Great Pyramid's casing was a marvel of architecture that caused the edifice to glow brilliantly under the Egyptian sun. It consisted of an estimated 22 acres of 8-foot-thick blocks, each weighing in the region of 16 tons, 'so subtly jointed that one would have said that it was a single slab from top to bottom'. A few surviving sections can still be seen today at the base of the monument. When they were studied in 1881 by Sir W. M. Flinders Petrie, he noted with astonishment that 'the mean thickness of the joints is 0.020 of an inch; and, therefore, the mean variation of the cutting of the stone from a straight line and from a true square is but 0.01 of an inch on a length of 75 inches up the face, an amount of accuracy equal to the most modern opticians' straight-edges of such a length.'"

"Another detail that Petrie found very difficult to explain was that the blocks had been carefully and precisely cemented together: 'To merely place such stones in exact contact at the sides would be careful work, but to do so with cement in the joint seems almost impossible'"

"Also 'almost impossible', since the mathematical value pi (3.14) is not supposed to have been calculated by any civilization until the Greeks stumbled upon it in the third century BC, is the fact the designed height of the Great Pyramid - 481.3949 feet - bears the same relationship to its base perimeter (3023.16 feet) as does the circumference of any circle to its radius. This relationship is 2π (i.e. $481.3949 \text{ feet} \times 2 \times 3.14 = 3023.16 \text{ feet}$)."

"Equally 'impossible' - at any rate for a people like the ancient Egyptians who are supposed to have known nothing about the true shape and size of our planet - is the relationship, in a scale of 1:43,200, that exists between the dimensions of the Pyramid and the dimensions of the earth. Setting aside for the moment the question of whether we are dealing with coincidence here, it is a simple fact, verifiable on any pocket calculator, that if you take the monument's original height (481.3949 feet) and multiply it by 43,200 you get a quotient of 3938.685 miles. This is an underestimate by just 11 miles of the true figure for the polar radius of the earth (3949 miles) worked out by the best modern methods. Likewise, if you take the monument's perimeter at the base (3023.16 feet) and multiply this figure by 43,200 then you get 24,734.94 miles - a result that is within 170 miles of the true equatorial circumference of the earth (24,902 miles). Moreover, although 170 miles sounds quite a lot, it amounts, in relation to the earth's total circumference, to a minus-error of only three quarters of a single per cent."

High precision

"Such fine errors are within the general margins of tolerance found at the Great Pyramid. Indeed, although it has a footprint of over 13 acres, and consists of some six and a half million tons of limestone and granite blocks, the sheer mass and size of this monster of monuments are not its most impressive characteristics. More astounding by far is the incredible high-tech precision that is built into every aspect of its design."

"Before going into the details, let us consider the implications of very fine precision in very large monuments."

"An analogy with the simple wrist-watch helps. If you are after an accuracy of, say, a few seconds per week, then an ordinary quartz watch costing fifty dollars or less will do the trick. If you want accuracy to within a fraction of a second per year, however, then the quartz watch will no longer serve and you will have to turn to something of the order of an atomic clock."

"A similar situation applies in the construction industry. If you are building a brick wall that is to appear straight within plus or minus 1 degree per 100 meters and the whole roughly directed due north, then any good bricklayer should be able to meet your specification. However, if your requirement is for a wall that is straight within 1 arc minute per 100 meters and directed *exactly* due north, then you are going to need a laser theodolite, an ordnance survey map accurate to 10 meters, and a highly qualified team of professionals including an expert setting-out engineer, an astronomer, a surveyor, several master-masons and a week or so to ensure that the precision you are aiming for has in fact been achieved."

"Such 'atomic clock' precision was achieved by the builders of the Great Pyramid more than 4500 years ago. This is not a matter of historical speculation, or of theory, but of plain, measurable facts."

"For example the earth's equatorial circumference of 24,902 miles works out at around 132 million feet, with the result that a degree of latitude at the equator is equivalent to approximately 366,600 feet (i.e. 132 million feet divided by 360 degrees). Each degree is divided into 60 arc minutes, which means that 1 arc minute represents just over 6100 feet on the earth's surface, and each arc minute is then further subdivided into 60 arc seconds - with the result that 1 arc second is equivalent to a distance of about 101 feet. This system of measuring by degrees is not a modern convention but rather an *inheritance* of scientific thinking, connected to 'base 60' mathematics, that dates back to the remotest antiquity. Nobody knows where, or when, it originated. It seems, however, to have been employed in the geodetic and astronomical calculations that were used to locate the Great Pyramid - for the monument is positioned barely a mile to the south of latitude 30, i.e. almost exactly one third of the way between the equator and the north pole."

"It is unlikely that this choice of location could have come about by chance. Moreover, because no suitable site for such a massive structure exists a mile or so to the north, it would be inadvisable to assume that the fractional offset from the thirtieth parallel could have been caused by a surveying error on the part of the Pyramid builders."

"This offset amounts to 1 arc minute and 9 arc seconds - since the Pyramid's true latitude is 29 degrees 58' 51". Interestingly, however, as a former Astronomer Royal of Scotland has observed:"

"If the original designer had wished that men should see with their bodily, rather than their mental eyes, the pole of the sky from the foot of the Great Pyramid, at an altitude before them of 30 degrees, he would have had to take account of the refraction of the atmosphere; and that would have necessitated the building standing not at latitude 30 degrees, but at latitude 29 degrees 58' 22"."

"In other words the monument turns out to be situated less than half an arc minute to the north of *astronomical* latitude 30 degrees, uncorrected for atmospheric refraction. Any 'error' involved is thus reduced to less than half of one-sixtieth of one degree - a hair's breadth in terms of the earth's circumference as a whole."

"The same obsessive concern with accuracy is found in the orderly /evenness of the Pyramid's base:

Length of West side:	755 feet 9.1551 inches
Length of North side:	755 feet 4.9818 inches
Length of East side:	755 feet 10.4937 inches
Length of South side:	756 feet 0.9739 inches"

"The variation between the longest and shortest sides is therefore less than 8 inches - about one tenth of 1 per cent -

quite an amazing feat when we consider that we are measuring a distance of over 9000 inches carpeted with thousands of huge limestone blocks weighing several tons each. There is no sign that the ancient Pyramid builders were in any undaunted by the task of maintaining such fastidious standards of symmetry on such a grand scale. On the contrary, as though willingly seeking a additional technical challenges, they went on to equip the monument with corners set at almost perfect right-angles. The variation from 90 degrees just 0 degrees 00' 02" at the north-west corner, 0 degrees 03' 02" at north-east corner, 0 degrees 03' 33" at the south-east corner, and 0 degrees 00' 33" at the south-west corner."

"This, it must be conceded, is not just 'atomic clock' accuracy but the Rolex, BMW, Mercedes Benz, Rolls-Royce and IBM of building engineering all rolled into one."

"And there is more."

"It is fairly well known that the Pyramid was aligned by its architects to the cardinal points (with its north face directed north, its east face directed east, etc., etc.). Less well known is just how eerily exact is the *precision* of these alignments - with the average deviation from true being only a little over 3 arc minutes (i.e. about 5 per cent of a single degree)."

"Why such meticulousness?"

"Why such rigor?"

"Why should even the most megalomaniac of Pharaohs have cared whether his massive 'tomb' was aligned within 3 arc minutes of true north - or indeed within a whole degree of true north? To the naked-eye observer it is virtually impossible to determine such a deviation. Indeed most of us could not spot a misalignment within 3 whole degrees (180 arc minutes), let alone within 3 arc minutes (and some people have trouble telling the general direction of north at all). So the question has to be asked: what was all this incredible precision for? Why did the builders burden themselves with so much extra work and difficulty when the effects of their additional labors would not be visible to the naked eye anyway?"

"They must, one assumes, have had a powerful motive to create what is truly a miracle of the surveyor's art."

"And what makes this miracle all the more remarkable is the fact that it was not performed on a perfectly flat area of ground, as one might expect, but with a massive natural mound, or hill, left exactly in the middle of the site on which the Great Pyramid was being erected. Estimated to be almost 30 feet high - as tall as a two-story house - and positioned dead center over the base area (of which it occupies approximately 70 per cent), this primeval mound was skillfully incorporated into the lower courses of the growing edifice. No doubt its presence has contributed down the epochs to the structure's legendary stability. It is extremely difficult, however, to understand how the ancient surveyors were able to square the base of the pyramid in its early and most important stages with the mound so solidly in the way (squaring the base normally involves taking repeated diagonal measurements across the corners). All that we can say for sure is that the base is square and that the monument is locked into the cardinal axes of our planet with great care and precision."





Ancient Indo-Europeans Discovered Honey

by

Charles Perry

Los Angeles Times

Honey is beloved throughout Africa and Eurasia, though it couldn't have been the least obvious of foods to begin with; the first person to break into a beehive must have been either incredibly brave or incredibly stupid. But once the principle had been grasped, it could be taught. The ancient Indo-Europeans, not otherwise big shots in food history, apparently introduced honey to the Turks and Mongols, because their word for it, *teal*, seems to come from the Indo-European *merit*. Some linguists have even speculated that the Chinese word (*ml*, which was *miet* in Old Chinese) comes from another Indo-European word for honey, *medhu*.

Only four of the 20,000-odd species of bee make honey. Besides the familiar honeybee, *Apis mellifera*, there's a variety (*A. indica*) domesticated in some parts of Asia and two wild honeybees. The giant honeybee of India and Indonesia (*A. dorsata*) makes honeycombs up to 9 feet in diameter.

No honeybee is native to the Americas. In fact, a Native American who saw a honeybee would shrewdly conclude that foreigners were moving into the neighborhood. However, it has been claimed that there are two native species of honey-producing wasps in California.

That would be strange, since one big difference between bees and wasps is that the latter feed their young insects and spiders, rather than pollen and honey. But if you do find a honey wasp nest and want to break into it, I'll gladly stand way over here and hold your coat.



Letters To The Editor

Dear Editors,

Accompanying this letter is a diagram (Fig 3) in connection with the reprint of my article "To Infinity and Back in Class Eleven" which appeared in the Spring 1997 issue of the Waldorf Science Newsletter.

As it happens, the diagram was not printed fully in the Newsletter edition. The text for the diagram stated that it "shows a triangle whose apex is extended along a line to infinity, then taken beyond infinity to return and form a triangle whose sides now extend over infinity."

I attach the complete original diagram here in case any readers of the Spring issue were still waiting for the "return" of a piece of the triangle from infinity, or might have thought it had got stuck there.

Warmest greetings,

Norman Davidson

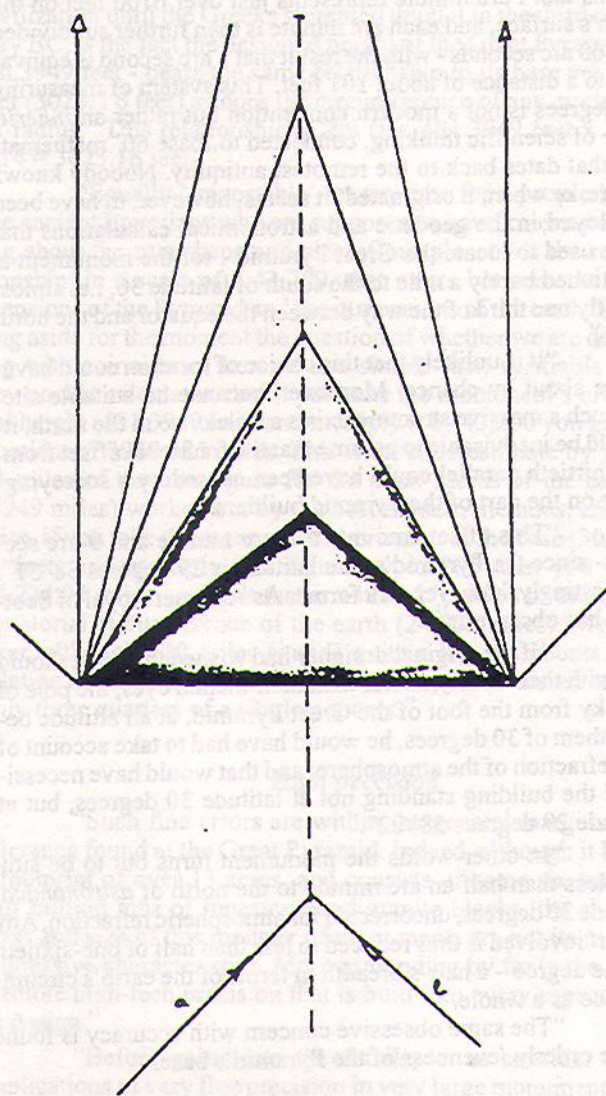


Figure 3

Cell Cosmology

In his lectures on the teaching of cell biology in the upper grades of the waldorf schools, Rudolf Steiner suggested that cell biology be described from a cosmological perspective.

Cell structures

In his course on the relation of the different sciences to astronomy, when talking of cells, he mainly points to the cell as a cosmos and the inner relation between structures in cell and structures in the solar system (solar systems) (first lecture).

Not so much was known in his days as today about the subtle and intricate inner structures of the cell as today. Much more can surely be developed in this field today.

Cell biographies - cell cycles

Another perspective is however the temporal perspective on the life of the cell.

Here, I feel, it is much easier to come to an understanding and picture of the development of cells as a mirror of the development of cosmos. If you look at the cell cycle with its interphase and its division stages (mitosis and meiosis), it is difficult not to feel enjoyment at the beauty of its inner order. This is clear in a number of aspects for interphase and mitosis. I have not worked on with meiosis, yet.

The Perspective of Isolated Stages

This is the way one part of the life cycle of an animal cell; mitosis, rather normally is depicted in biology books. The picture is taken from "Cell and Molecular Biology" by Robertis and Robertis (1979, p 384). The accompanying text describes the stages depicted in its details.

A, *prophase*, the nucleoli and chromosomes, shown as thin threads; in the cytoplasm the aster with pairs of centrioles are shown.

B, *prophase*, a more advanced stage of this phase in which the chromosomes have shortened. The primary constriction with the centromeres is shown; in the cytoplasm the spindle is formed between the asters.

C, *late prophase or prometaphase*, the nuclear envelope disintegrates and the chromosomes become attached to the spindle fibers.

D, *metaphase*, the chromosomes are arranged along the equatorial plane.

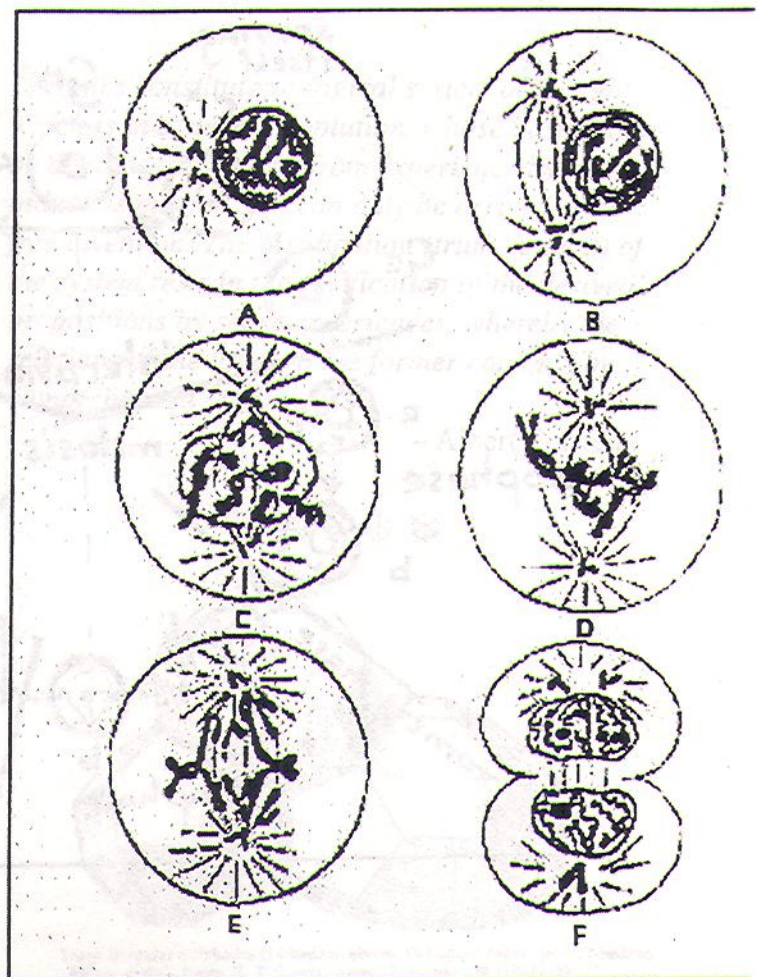
E, *anaphase*, the daughter chromosomes, preceded by the centromeres, are moving toward the poles.

F, *telophase*, the daughter nuclei are in the process of reconstitution, cell cleavage has started. At times the cycle is really depicted as a cycle, but the normal way of depicting the stages of mitosis is that of separate stages, in a way that is very difficult to look through.

The basic order of the cell cycle is that of its two phases; *interphase* and *division*.

Viewed from the perspective of anthroposophy, you can experience this as a reflection of the *pralaya phase* of cosmos - when it has withdrawn into itself, and is not as easy to come to an experience of for the clairvoyant researcher - and the *manvantara phase* - when cosmos appears again, developing through a number of stages, more visible in an external form.

The common terminology for the cell cycle today looks at it as consisting of two main stages, one when the cell is synthesizing and doubling its DNA, the so called S-phase and the phase when it falls apart into two new cells (in mitosis). The stages between these two stages are viewed upon as "gaps" and have therefore been termed Gap one and Gap two.



Interphase: If you look at the interphase from a more "balanced" perspective, you see too that it depicts an inner polarity between the so called G zero phase and the S phase.

During the G zero phase, the cell, viewed from this perspective, lives through a completely "altruistic" phase, completely serving the organism, in which it is embedded.

During the S phase, the cell has completely withdrawn from its service to the organism, and is dedicated only to blowing itself up, "egotistically", making its DNA double as "big" as before.

To what possible extent this regularity reflects the inner stages of the pralaya stage of cosmos, I have as yet no picture of.

The G zero stage falls into two parts. One is the one following the telophase and cytokinesis of the cell at the end of mitosis, before the cell takes up its service to its host organism. In the figure this has been termed the G one a phase. The other is the stage when the cell has stopped serving its host organism, but has not yet started to synthesize DNA during the S phase. In the figure this stage is marked

as G one b. This stage constitutes the symmetry point of interphase.

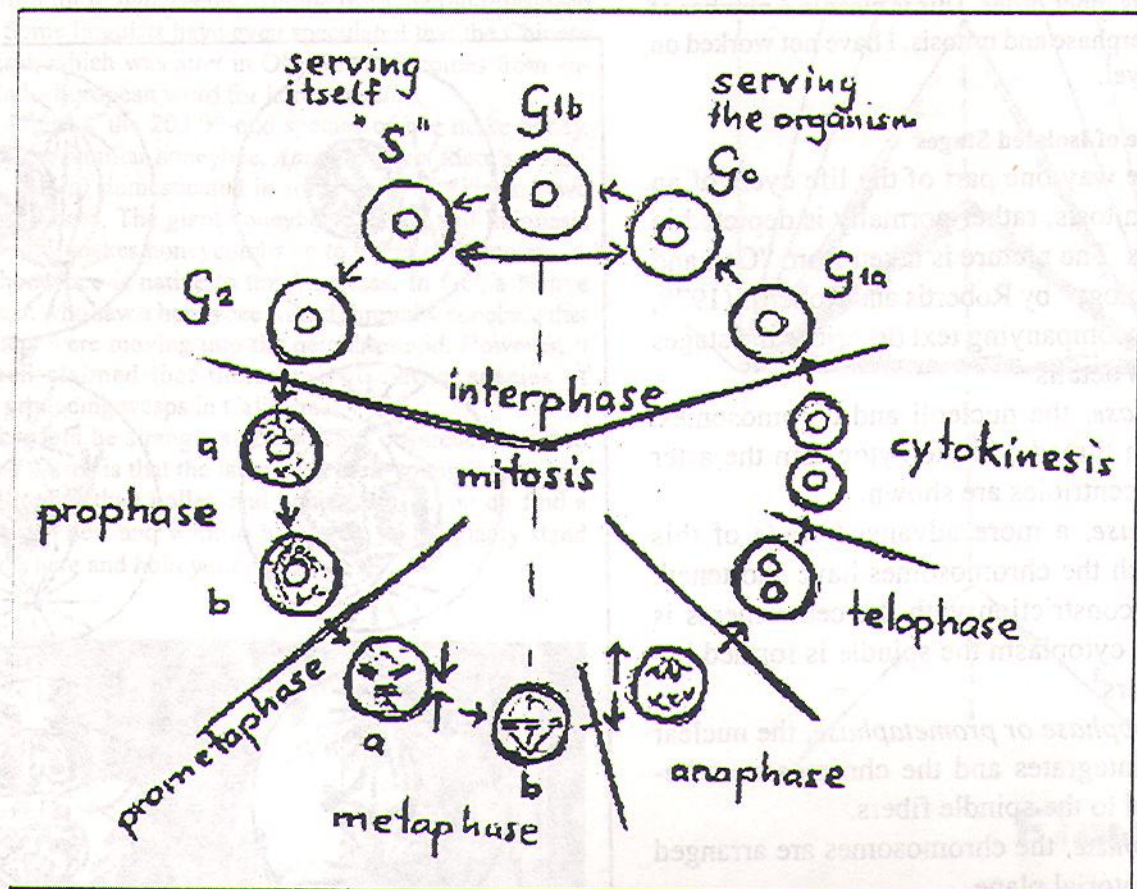
The S phase is followed by a phase when the cell is no longer synthesizing DNA, but has not yet started the mitosis. This phase is termed two, also in the figure.

MITOSIS

Mitosis starts with the appearance of the chromosomes as thin threads inside the nucleus, at the same time as the cell becomes spheroid. They approach the nuclear envelope, and the nucleoli shrink and disintegrate. This is the *prophase* of mitosis.

At the end of prophase the nuclear envelope too disintegrates, mixing the nuclear material with the cytoplasm. This event has its mirror in the renewed formation of nuclear envelope from parts of the endoplasmic reticulum at the end of anaphase, as a beginning of telophase.

The *telophase* is characterized by this forming of the two nuclear envelopes around the two groups of chromosomes that have been gathered at the two poles of the cell at the end of anaphase.



The telophase goes over into *cytokinesis*, when not only the two nucleuses are formed as separate units, but also the cytoplasm is divided into two parts by the formation of cell walls dividing the structure into two completely new cells.

The telophase and cytokinesis constitute two distinct phases at the end of mitosis. If there is a strict inner order of mitosis, this implicates that the prophase preceding prometaphase also should be characterized by two distinct phases, in the figure termed prophase a and prophase b. I think this is also the case and that the clue to them are to be found in the polarization of the centrioles during prophase a, and among other things the forming of the spindle during the second part of prophase, in the figure termed prophase b.

The stage when the chromosomes have formed and constitute the equatorial plate during metaphase is the symmetry point of mitosis. In the figure this has been termed metaphase b.

This is preceded by the collecting of the chromosomes by the spindles and the moving of the chromosomes to the equator of the cell.

This process has its mirror in the separation of the double chromatics during the anaphase.

To what extent this stage b of the metaphase also constitutes a separate stage in the same sense as the other stages of mitosis is not yet clear to me. But I have the feeling it does.

Parts of this reasoning may seem speculative, but I feel it has a sound ground in what can be seen in the microscope when looking at dividing cells.

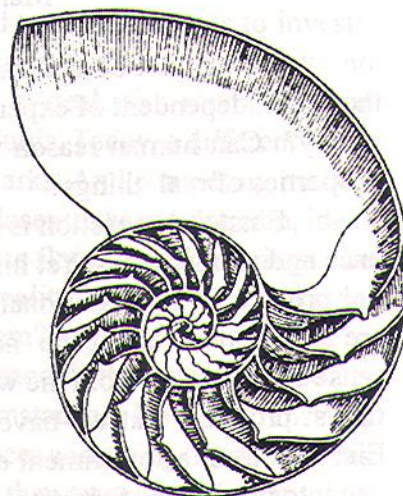
A problem that has to be more investigated and meditated upon is of course the finding of the essence of and turning points between the stag of mitosis that are not yet clear from the above description; i.e. the two sub phases of prophase and of metaphase.

One of the many other problems is of course the question of the dynamics of the process and the not altogether clear relation between the tim the cell spends in each stage.

Well, this has been a suggestion at least, to a partial answer to what could be meant by "describing the cell from a cosmological perspective".

As a summary, I would say that what can be seen and has been described above of the cell cycle as a reflection of the evolution of cosmos seems to support Steiner's suggestion to develop cell biology from a cosmological perspective.

The author would appreciate any comments e-mailed to her at thebee@hem.passagen.se

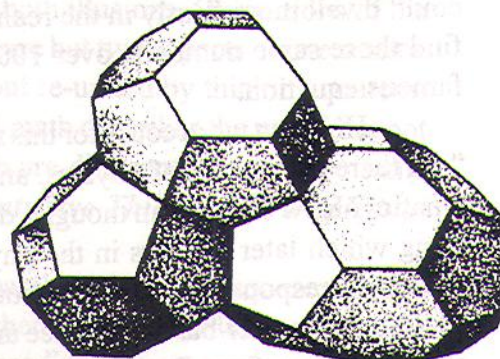


The shell of *Nautilus pompilius*. From J. C. Chenu.



"Physics constitutes a logical system of thought which is in a state of evolution, whose basis can't be distilled, as it were, from experience by an inductive method, but can only be arrived at by free invention. The justification (truth content) of the system rests in the verification of the derived propositions by sense experiences, whereby the relations of the latter to the former can only be comprehended intuitively."

— Albert Einstein.



Three irregular polyhedra (14-hedron above, 13-hedron below, left; 15-hedron below, right). From F. T. Lewis, *Amer. J. Botany*, 30 (1943), 77.

Einstein's Question

by
Marisha Plotnik

How can it be that mathematics, being after all a product of human thought independent of experience, is so admirably adapted to the objects of reality? Can human reason without experience discover, by pure thinking, properties of real things?

Einstein's question is a fundamental one about the very nature of science and mathematics. Yet his formulation of this question reveals the essential problem with traditional, "model based" science. Implicit in his words are assumptions about the nature of reality which have lead to our modern sense of alienation from the world. We have progressed so far with the reductionist program that we have lost our sense of the whole and can feel, as Einstein does, astonishment at the fact that mathematics is inextricably woven into the fabric of physics. Yet a shift in perspective reveals the fundamental depth of that weaving and brings us to a new participation with the reality of the world.

A careful look at Einstein's words reveals his assumptions. To him, mathematics is divorced from any experience of the tangible world and is fabricated entirely within the human mind, it is a "product of human thought independent of experience". Moreover, mathematics is not in itself real but rather "admirably adapted to the objects of reality". Contained within these words is the modern mind/body dichotomy: reality is "out there" in the world while thoughts are "in here", a pure product of an independent human mind. And yet, as Einstein is pointing out, there is a remarkable connection between the two.

The facts stand before us; the book of nature seems to be written in the language of mathematics. A stone dropped in a vacuum will move inexorably down, ever revealing Galileo's simple relationship $d = 4.9 t^2$. Whether I throw a ball for my cat or Steinbrenner pitches at 100 mph both objects follow that abstract parabola in the air. Even more mysterious history recalls to us the most abstract kinds of mathematical ideas eventually finding an application in the world of things.. Gauss, in the nineteenth century, inventing imaginary numbers, could hardly have dreamed for an application. What mathematics could dwell more firmly in the realm of the impractical? How astonishing to find those same numbers, over 100 year later, necessary for Schroedinger's famous equation.

How can we account for this remarkable coincidence between the world "out there" the world of physics, and the world "in here", the world of mathematics? How can human thought, dealing in the purely abstract, invent something which later appears in the physical world as well? I would like to explore two responses to this question. The first emerges as a consequence of traditional "model-based" science and the second from a "phenomena-based" science arising from Rudolf Steiner's undemanding of the nature of reality.

The direction of "model-based" physics has been to place ever less value on the tangible world and search instead for the non-perceptible reality behind the appearances. With this approach, what I perceive is an illusion, an accident of my particular physiology. The golden color of this wooden table is not real, merely an interaction between electromagnetic radiation and my eye, interpreted by my mind as color. The "real" world has been driven away to the "thing-in-itself". This is the approach which Steiner calls "transcendental realism."

Thus the aim of "basic" science, as opposed to technology, is to investigate the thing-in-itself. However, its very nature is such that we can have no direct perception of it, and so physics has chosen to deal with models. In the nineteenth century, the standard model was one of fluids. Today, a different Standard Model holds sway, fluids being replaced by quarks. And competing models lurk, sometimes more on the periphery, sometimes closer to the mainstream, ideas of superstrings and the like. These mechanisms, these fluids, quarks, strings, are the "thing-in-itself" behind every sort of tangible reality. Of course, quarks are imperceptible to us, so how does one "discover" them?

Working from a mathematical-mechanical model, the scientist predicts how his model would respond under certain circumstances. He then translates these "model circumstances" into tangible circumstances and, using these, achieves tangible results in his lab. These tangible results are then translated back into the model, and compared with the "model results" predicted at the beginning of the experiment. The scientist claims that he is checking the validity of *his* model against experimental results, as if he were holding two lists side by side and comparing them, item by item, for discrepancies. In fact, he is engaged in an elaborate web of translation.

Thus is Einstein's question answered: it is no surprise that imaginary numbers describe the kinematics of elementary particles because the particles too are imaginary. Both the math and the model are creations of the human mind, so that there is no wonder when they agree.

The implication of this is an impassible divide between the world as I experience it and what I understand reality to be. Opening a physics text, I enter a fascinating world of shapeless, colorless, tasteless quarks (it is revealing that physicists describe quarks as have "color", "flavor," and "charm" when in fact they have nothing of the sort) that are supposed to be behind the round, fragrant, golden peach in my hand. There can be no connection made between those quarks and my experience of rain in the gutters, a cool wind in August and gray clouds over the city. In addition, the fact that these models are constantly changing convince us that we actually know nothing at all about reality.

There is, however, another option. One might see it as the converse of the preceding view: math and phenomenon are not both illusions, fabrications of the human mind, but they are both real. Indeed they are but two aspects of one reality, separated by the condition of our humanness, but re-united by thinking contemplation of our world. Again, it is no surprise that math describes the world but not because they are both fantasy, but because both are different views of the same reality. This is Steiner's view as he writes in *Intuitive Thinking As a Spiritual Path*:

"That the stone moves precisely in a parabola is a consequence of the given conditions, and follows necessarily from them. The parabolic form belongs to the whole phenomenon, like all its other aspects" (p.81).

This view of thinking and perceiving is the converse to what is common in our present society. Einstein, in his quote, clearly sees thinking as something personal, individual, and unique to each person. He would say that his thoughts, including his mathematics, come out of his mind alone. The physical world, on the other hand he sees as universal, objective, and the same no matter who perceives it. Steiner reverses this and put the concept as the universal:

"There is only one concept "triangle." It makes no difference to the content of this concept whether it is grasped by A or B - by this or that human carrier of consciousness. . . . In thinking, we are given the element that unites our particular individuality with the whole of the cosmos" (pp. 83-84).

There is something universal about math; any other person can follow my mathematics and come to the same inescapable conclusion. Although we may disagree about politics, religion, and pizza, we will agree on a mathematical truth. To answer Einstein now is a trivial matter indeed: mathematics "is so admirably adapted to the objects of reality" because it is an object of reality.

This understanding of reality puts the human being in an entirely different relationship to the world instead of being permanently cut off from reality, imprisoned forever within the illusions of his mind, the human being now gains the power to know the world. It becomes the task of science not to create an alternate reality in models but to observe the phenomena of nature in a careful and exact way and to seek the concepts which naturally belong to those phenomena.

Still, I have the profound experience that mathematics is a consequence of my own activity. Difficult concepts do not float down effortlessly into my mind, but require enormous concentration and work to attain. How can something so personal be universal? Talking about the triangle, Steiner goes on to write "But each bearer of consciousness will grasp it [the concept of triangle] in an individual way" (83). And later, in his chapter on *Human Individuality*, "We think universal concepts in our own special way" (103). What then is a concept that it is universal, and somehow, when it is "grasped" or "thought", individual?

Perhaps Steiner is talking about the experience every teacher has, of standing at the blackboard trying to explain a particularly difficult concept when a single student suddenly lights up and exclaims, "I get it!". If the teacher is lucky it may be more than one or the faces may light up one after the other. At that moment, it is clear that what is happening for each student is a very individual process indeed. It is the mystery of teaching that one can lead, nudge, hint, and suggest, but, in the end, the student either "gets it" for himself or doesn't. Calling this process of uniting concept with percept "Cognizing", Steiner writes: "Cognizing is not the business of the world in general, but a transaction that we must each accomplish for ourselves" (107).

A nagging doubt remains; how do I know that I have connected the right concept to the phenomenon? Steiner is very clear that it is indeed possible.

"The follower of a monistic worldview knows that everything necessary to explain a given world phenomenon must lie within this world. . . . It follows from the concept of cognizant as we have defined it, that we cannot speak of limits to cognition" (107).

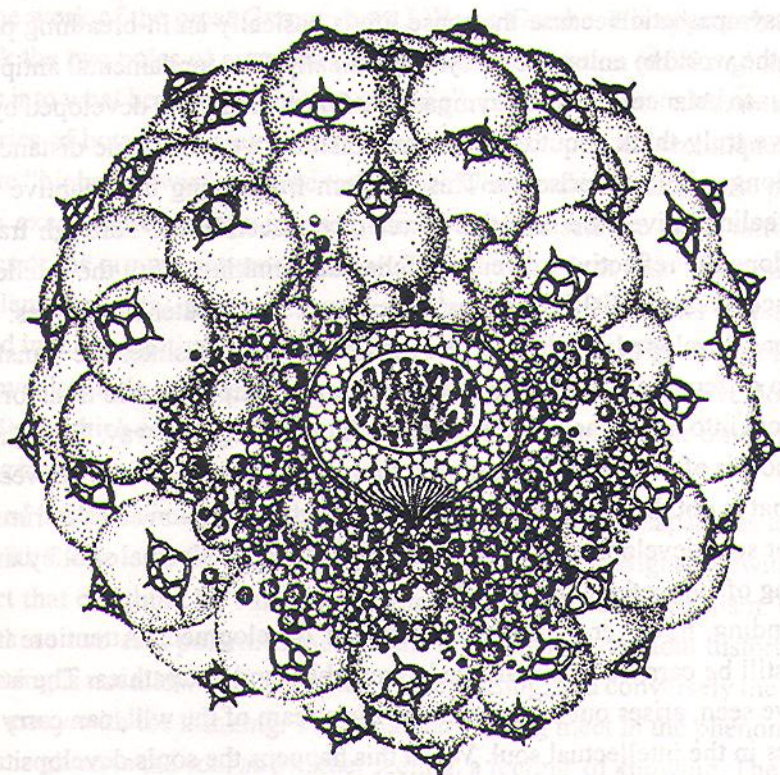
In other words, I must be able, in principle to connect every precept to its appropriate concept. But how do I know if I have chosen the right concept? Perhaps it doesn't matter as long as I have made the connection, it exists.

Nevertheless, a concept is an elusive event. The next day, or even the next moment, the clouds may descend again, and the student wails, "I thought I got it but

now I'm totally confused". A concept is less like a pebble that can be grasped than it is like a movement: present only in the doing of it and then vanishing. If one has really grasped it, then the movement can be repeated when desired, but it cannot be put into one's pocket and stored, immobile and heavy, forever. Knowing the world is an act of creation, an act of weaving together again the mathematics with the phenomenon, which every individual must do for himself. Thus we are very much participants in reality, not merely objective observers.

Source Steiner, Rudolf. *Intuitive Thinking as a Spiritual Path*. Trans. Michael Lipson. Hudson, New York; Anthroposophical Press, 1995.

This paper fulfilled a course assignment written during the summer session of New England Waldorf High School Teacher Training's graduate program.



Dictyochoa stapedia Hkl. From K. G. Grell, *Protozoologie* (Berlin: Springer-Verlag).

"We are made of dust and the light of a star."

– Loren Eiseley.

WHAT IS GOETHEAN SCIENCE?

Dennis Klocek

A basic human response to any situation is either to feel "I like it" or "I don't like it". The name for the "I like it" response is sympathy. The name for the "I don't like it." response is antipathy. These feelings color every response in normal everyday life. As such, they represent a fundamental ground of the soul. They provide the soul with sentience or the capacity to experience sensations and feelings. A soul filled with such feelings and sensations is fundamentally oriented towards the outer world as if it were constantly breathing the sense information inward towards the center of the being. To a soul devoted to sentience, life is an unending series of likes and dislikes. These perceptions plunge the soul into alternating states of elation and despair, with much loss of energy. What is needed is balance.

Balance is achieved by blending antipathy and sympathy in the soul. We do this by developing the antipathy in the soul into the capacity to think. This antipathetic development balances the life of sensations and feelings in the soul which are primarily sympathetic. They are sympathetic because the sense life is basically an in-breathing process, where we allow the world to enter into us sympathetically. The fundamental antipathy in thinking allows us to balance the overly sympathetic forces in the soul developed by sense activity. When we truly think about our likes and dislikes we gain some distance from them. They no longer hold us prisoner. This freedom from being held captive by our sensations and feelings gives the soul the power of transcendence. Through transcendence soul develops the reflective power of intellectual thinking. With the intellect it is possible to balance likes and dislikes and transform them into greater soul forces. Within the soul which has developed intellect, or the intellectual soul, dislikes are transformed into the power to differentiate, known as discrimination. Sympathies are transformed in the intellectual soul into the capacity to direct the will in a thoughtful way. Thought-filled will is the soul power of attention. Through discrimination one can choose between what is correct and what is not. Discrimination is willed thought. Attention and discrimination form the basis for soul development. They are formed in the intellectual soul by the transcendent blending of sympathy and antipathy.

This blending, however, is not the end of our development. Attention and discrimination can still be carriers of unbalanced sympathies and antipathies. The attention which, as we have seen, arises out of the sympathetic stream of the will, can carry a residue of sympathies in the intellectual soul. When this happens the soul develops tremendous forces of will to support its own viewpoint. The forces of discrimination which are needed to balance one-sided attention become negative and discrimination "between" becomes discrimination "against". In negative discrimination the sympathies are too strong in support of one's own views. This, state is best described as fundamentalism.

The opposite effect in the intellectual soul can be observed when the discursive, dividing power of discrimination gains upper hand in the soul. The discursive intellect results from this imbalance. The discursive intellect wanders from subject to subject, finding relevance primarily in the power of its own argument. Reasoning and calculating take the place of direct experience. The ground of the soul shifts into abstracts, laws and machine-like thought patterns. The discursive intellect loses the balance of discrimina-

tion and in its antipathetic imbalance grows divisive, cold and calculating. Like the fundamentalist, the abstract thinker becomes gradually convinced that he has achieved the ultimate "truth" about existence. The difference between the fundamentalist and the abstract thinker lies in the source of their "truths". For the fundamentalist coming out of the will/sympathy pole, the truth lies in one's identification with a Supreme Being, the source of all truth. For the abstract thinker the truth lies in the capacity of the intellect to draw knowledge from the realm of universal concepts of "laws". Neither of these two positions is actually incorrect unless one becomes addicted to the power of being "chosen" by God as "special" or totally convinced by a "terrible certainty", of experiment and a pragmatic technology that one's view is absolutely correct. From this we can see that for both attention and discrimination the danger lies in becoming fixed in an addiction to power available to an intellect which is wedded to the will. When this happens all warmth, compassion and intuitive capacities are diminished. Rampant technologies and holy wars are not far behind when the soul loses warmth and compassion.

To heal the split between thinking and the will is the urgent task of the last decade of the millennium. To do so requires that the soul once again unite the poles into a transcendent union. In today's world this union is most vigorously addressed by the sciences which can be grouped under the name "Phenomenalism". The science of phenomenism was developed out of the work of the great German poet J.W.von Goethe. His approach to studying the world took the two poles of attention (will) and discrimination (thinking) and blended them together into what he called a "higher viewing". Goethe's famous *Metamorphosis of Plants* is a series of botanical essays which he wrote based upon the techniques he developed to initiate "higher viewing." These techniques were, called "exact sense perception" by Goethe. In exact sense perception one pictures to one's self the exact unfolding of a series of leaves or the growth patterns in a rose. The picturing is at first "discursive" in that it breaks the plant into parts. In time, however, regular practice of the inner picturing results in a heightened inner perception of the flow of energies in the plant. The flow or life gesture of the plant reveals subtle patterns of growth not perceptible to a discursive, logical intellect. It is this flow which connects the plant to its environment and to the other members of its species or genus.

By means of "higher viewing" we can develop in ourselves the capacities to unite the thought pole with the pole of the will in a harmonious, warm way. Higher viewing seeks to develop a heart that can think by balancing abstract logic with sensationalism. Once they are balanced, these two soul polarities meet in the phenomenon, without distortion or desire. The reasoning is not allowed to get ahead of the sensing, and conversely the sensing is not allowed to away with the thinking. Thinking and sensing meet in the phenomenon and this experience is given to the soul as a higher feeling, a feeling of knowing. The feeling of knowing is a fruit of the intuition. As such, its appearance in the consciousness is a symptom that supersensible knowledge is beginning to form capacities for higher cognition in the soul. Goethe's phenomenism, then, is the root from which anthroposophy grows into the world.

To study nature and her phenomena in this way develops what Rudolf Steiner called heart soul. Heart soul in the vehicle for warmth and compassion in the human being. The times require that the heart soul be explored and developed. To study and practice Goethe's phenomenism can transform our soul life and create within us the space into which moral forces can flow through us and out into our deeds in the world.

Thoughts on a Prototype Computer Program for Waldorf High Schools

developed

by

David S. Mitchell & Andrew Linnell

Objectives:

The primary objective of this course is to familiarize the student with the internal operation of the computer, that is, how the computer works and what is going on inside the computer as programs are executed. To achieve this objective the course will initially focus on computer hardware and binary arithmetic.

Once the internal operation and its concepts are understood, then the course will proceed on to uses of the computer, namely, programming. Microcomputers will be used to develop programming skills.

This course seeks to help the student to overcome the mystery or fear of computers where it exists. It should challenge the students to think about the social and moral implications of computers. In fact, a deeper understanding and appreciation of the human being as a threefold being is possible through a study, in the right way, of the computer.

It should also be realized that there will be effects of such a course on the thinking, feeling and willing aspects of the individual. It is a challenge to Waldorf schools to find the right way to balance this work. Meeting this challenge has benefits for all of life, for when a balance is found in the schools, a balance can then be realized for the thousands who work in developing the computer, or for the many millions more who use the computer.

Course Outline

Section 1: Introduction to the Computer

Show and explain terminal and CPU

Word processing ideas (pre computer)

Word processing activities on our computers

Intelligibility Index

Computer Vocabulary

Computers and the Social Question

Privacy – who should see my data and data about me?

Who should control the computer?

How and why to curb computer addiction?

How can the computer help to do something complex? (Modeling)

What is computer intelligence? (Artificial Intelligence)

The History of computers, past, present and future direction

Tools: telegraph, telephone, television

People: Von Neuman, Atanasoff, Boole, Lady Lovelace, Babbage

Processes: electricity, magnetism, manufacturing, etching materials (Silicon, etc., that allow for packaging.)

Eniac, Illiac, 380, P

Field trips to local University or Computer Museum

Applications:

Military/government, scientific, commercial, artistic,
education, accounting, entertainment, communication
publications, merchandising, artificial intelligence
Field trips to industry and computer orientated communication (motel
chains reservation hubs, magazines, etc.)

Section 2: Computer Literacy

Practical work on the computers

Learn how machine language works
Dissect a program - learn what is happening
Write flow charts
Build up an understanding of Structured BASIC , C, and C++
Write many simple programs given by teacher
Develop individual programs

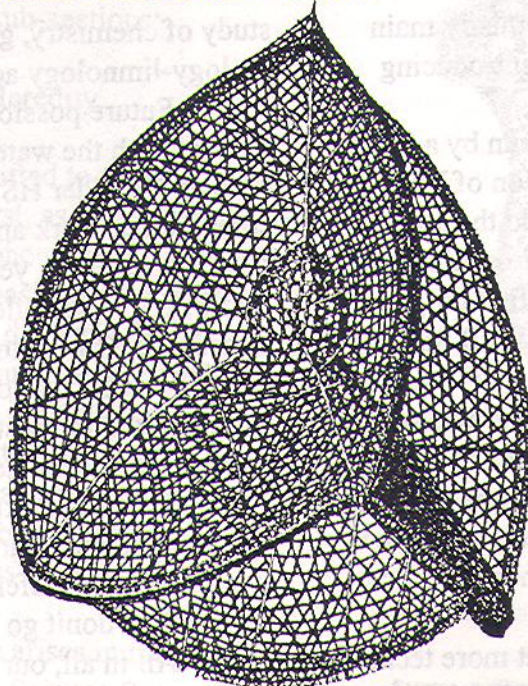
Section 3: How does the Computer Work?

The architecture of a Computer

Learn Boolean Algebra
Review Binary number system
Boolean expression for binary addition
DeMorgan's Law

Practical Laboratory Work

Introduction of logic circuit design symbol
Introduction of prototyping breadboards, chips and wiring
Build a one-bit adder
Build a R-S flip flop using only NAND gate
Build a 4-bit J-K shift register



A Naselliarian skeleton, *Collimira agnesae* Ilk1. (0.15 mm. diameter).

Classroom Activity

Getting Wet with Water Watch

by
John Petering

In Autumn 1996, after participating in a training seminar in a beautiful mountain setting (Snow Mountain Ranch in Winter Park, Colo.), the Shining Mountain Waldorf School joined the Colorado Rivers "water watch" program. The pilot group worked quite hard, learning proper collection techniques, how to analyze for key chemical and biological parameters for stream water, and finally had to pass a q/c test on their water analysis skills to become full-fledged "trout."

Technically our group learned collection techniques for heavy metals sample analysis, and the protocols to do key water quality wet chemistry tests, including Dissolved Oxygen titration (Winkler method), Total Hardness, and Alkalinity (BGMR-Phenolphthalein) titrations. These skills are a very nice complement to the work we do at SMWS in our 10th grade chemistry main lesson ("Salts, Acids, and Bases") introducing acid-base titration.

This network of schools is run by a group within the State of Colorado Division of Wildlife; the training is free if you agree to do the sampling work. And, many programs provide equipment for the testing work! I believe the first programs were developed from work done by Bill Stapp in the late 70's, working on environmental education using the Rouge River drainage in the area of Ann Arbor, Michigan. Since then, the idea of having students do professional level water quality assesment of local streams and waters has grown, and there are similar programs in most of the 50 states

In addition to learning about more technical aspects of analytical water chemistry, the group attended several seminars on water quality,

studying the "stream continuum" concept – an approach to understanding the whole reach of a river as a totality, and its stages of life. This material actually formed a very good complement to the theme for grade 10 geography: "the earth as a morphologic and dynamic whole."

Work at SMWS Monitoring Lefthand Creek

Shining Mountain began monitoring Left Hand creek in the upper foothills west of town in November 1996, and has been collecting data for submission to the "water watch" database at the Colorado Division of Wildlife. Once our sampling team became established, we are expanding to monitoring additional sites, comparing the water quality above and below our school to

monitor the effects of housing and development on our streamis quality. Soon, I hope to expand the work, as the lead students take on training other SMWS students. I am organizing river field trips in the Spring and a "stream walk" project where we camp along most of the reach of our Left Hand creek, combining a

study of chemistry, geography, geology and biology-limnology activities.

Future possibilities include a cooperative festival with the water watch teams at nearby schools (Boulder HS and Lyons HS) where we compare our work and data, and also socialize. Also, we have not yet been able to start collaboration with a local college (Naropa Institute) who joined at the same time we did, but I hope to do this soon. I believe our students will benefit from working with older students. Perhaps this can counterbalance the desire of Seniors to "just be done" and instead experience from individuals who have found a direction in life, much more is awaiting them in life's journey after high school – even if they don't go directly on to college.

All in all, our involvement in the program has been very rewarding and enriching; I found it valuable to make connections to other local



Thoughts about Curriculum Standards

by
John Petering

While examining the various science curriculum reform initiatives, I have noticed some interesting patterns. I wonder what the implications are for our work in Waldorf schools.

The first effort, *Benchmarks for Science Literacy*, ©1991, 1993, by Project 2061, a Committee of the AAAS, seems to be the broadest and includes the most "holistic" themes. For example, their section 5 The Living Environment starts with a suggested survey, 5A: Diversity of Life. Some of the topics within 5A, including "body plans" details of internal and external structure (anatomy) and "two interconnected global food webs, from ocean plankton, and land plants" corresponds well to main themes in the Waldorf middle school curriculum. Then, however the topics for senior high school emphasize a more reductionistic approach, a study of "diversity and similarity at the molecular level," "kinship between organisms estimated from similarity of their DNA."

The somewhat holistic approach of the "Benchmarks" standard, is in contrast to a later project by the National Research Council, which produced the "National Science Education Standards (NSES) in 1995." The NSES begins their section C Life Science with the sub-sections:

- C1) The Cell,
- C2) Molecular Basis of Heredity,
- C3) Biological Evolution.

Here the emphasis has clearly shifted to teaching about the "fundamental units" first, as a basis for understanding the larger macro-phenomena. This curriculum has been adopted in basically the same form by the State of Colorado as the basis for the "standards-based" graduation requirements which are being implemented here (and in many other states, I believe). It is interesting that the educational methodology has received so much attention (Constructivism), but the scientific epistemology of the bottom-up, the whole is the sum of its parts, is largely ignored.

Another interesting theme arises in the adaptation of the NRC's National Science Standards which has been worked out by the National

Science Teacher's Association in their "Scope Sequence and Coordination (SS&C)" project. They have recommended that we move away from the traditional "layer cake" curriculum of 1 year of general science in 9th grade, 1 year of biology in 10th, a year of chemistry in 11th and a year of physics in 12th. Instead, the NSTA's SS&C model recommends having an interleaved, coordinated curriculum with carefully selected topics from all four subject areas: physical science (geography), chemistry, biology, and physics, studied in each of the four high school grades. For Waldorf teachers, this should be quite interesting as it closely follows the arrangement of main themes in our main lesson curriculum. However, the methodology has some differences. Most importantly, the underlying scientific paradigm is very reductionistic, life as a product of cells, matter as a result of atomic structure and so on. However, it may be we can learn something from the teaching methodology which is emphasized in all these curricula: "Constructivism." For students who are not automatically interested in learning, this approach emphasizes beginning with the "Engage & Explore" stage – more or less starting with the phenomena. Again, this should be quite interesting to readers of this Waldorf Science Newsletter, as this phenomena-based approach is inherent in the Waldorf educational philosophy.



Stentor, a ciliate infusorian: from Saville Kent.

science teachers and learn about their programs. And, I found it very compatible with our work at the Waldorf HS, and helped promote the sort of hands-on work I had wanted to develop more, which seems increasingly needed by today's students. I would be interested to hear if other teachers have done similar work, whether it was connected to one of the "water watch" programs or set up independently.



For those interested, there is a lot of interesting information in the following environmental publications:

WOW! The Wonders of Wetlands ©1995, and Project WET (Water Education for Teachers) ©1996, both developed by The Watercourse Project, 201 Culbertson Hall, Montana State University, Bozeman, MT 59717-0057; (406) 994-5392.

Project WILD – Aquatic Education Guide ©1992 by Project Wild, 5430 Grosvenor Lane, Suite 230, Bethesda, MD 20814-2142, (301) 493-5447; url e-mail and web address: <http://eelink.umich.edu/wild/>

If you simply want to focus on water quality testing, get a copy of the "first and best" *Field Manual for Water Quality Monitoring* by Mark Mitchell and William B. Stapp, available from Project Green (Global Rivers Environmental Network) 721 Huron St., Ann Arbor, Mich 48104; (313) 761-8142. A thick catalog describing a wide variety of test equipment and kits, as well as a free *Water Analysis Handbook*, may be obtained from HACH Company, P.O. 608, Loveland, CO 80539-0608; (800) 227-4224.

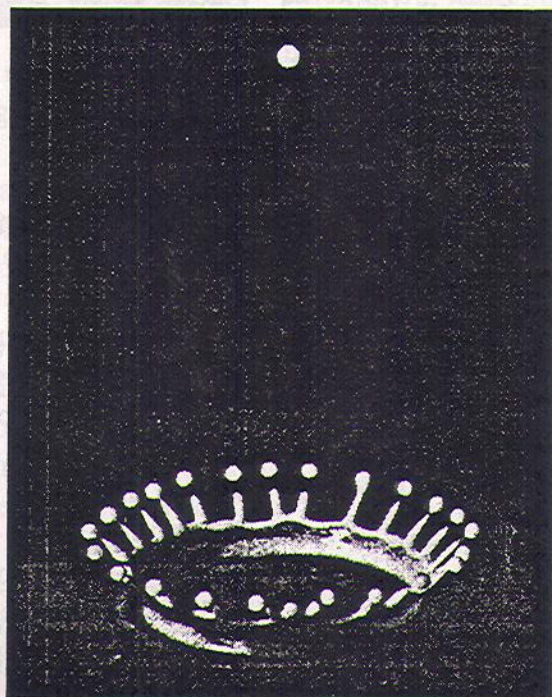


Environmental News

The environment is a high priority for everyone. How to get the best information on controversial environmental issues, however, is often a problem. One of the most impartial and reliable of the sources I have found is the non-profit foundation Resources for the Future. Their Center for Risk Management Newsletter is sent free to individuals and institutions. To receive copies contact John Mankin, Center for Risk Management, Resources for the Future, 1616 P. Street NW, Washington, DC 20036-1400. Phone 202-328-5060. FAX 202-939-3460. E-mail: mankin@rif.org.

A good source for hands-on help in establishing ecological restorations in your schoolyard or on your campus is the University of Wisconsin-Madison Arboretum. They have a free newsletter, *Earthteaching News* that they will send you free of charge on request. Write Earth Partnership Program, University of Wisconsin-Madison Arboretum, 1207 Seminole Hwy., Madison, WI 53711. Phone 608-262-9925. They also have an active Web site where you can find more information: <http://www.wisc.edu/arboretum/>

— David Mitchell



An instantaneous photograph of a "splash" of milk. From Harold E. Edgerton, Massachusetts Institute of Technology

Comments on the Building

of a Waldorf School

by

Felix Durach

Translated by Dr. Erna McArthur

A good teacher can impart atmosphere to every room, but her gifts will be enhanced if the spatial arrangement as such can help her.

Children actually experience all of their surroundings: room, wallpaper, furniture, colors, and even the air in the classroom. All this can be either friendly or oppressive. This fact has recently led to very noteworthy efforts towards a new solution to the task of building schools. Above all, the builder seriously considers the child and what he experiences while in school. One-storyed, brightly-lit buildings are dispersed on the building site. The surrounding nature is carefully preserved and used in the landscaping of the grounds.

Should the Waldorf school movement simply adopt these new ideas? The movement will be in the following position: it can wholeheartedly affirm these efforts to create a new style in the building of schools. It will strive for something just as modern, or even more modern. But this can be done only in the spirit of harmonizing spatial formations and Waldorf school pedagogy. It can create building forms only out of the original impulse also pervading this pedagogy. Then we shall build in an essential and truthful manner. This applies to the fundamental part of all school buildings. Even though, in many cases, local or timely conditions may necessitate measures that do not correspond to the Waldorf pedagogy; in the present essay, we are interested in the fundamental principle of building a Waldorf school in such a way that the artistic space formation is in harmony with the Waldorf pedagogy. Of course, the art of architecture wants to carry out every commission in an artistic way, and the more so, where the art of education is already an artistic demand. This characterizes the point where parents, teachers, and architect may meet. This must be the primary consideration among all the others, and should be emphasized as decisively as possible! A Waldorf school will be built in an essential and truthful way if it emerges out of the spirit working in the art of this pedagogy. Then this spirit will find its true home in such a building.

If parents, teachers, and architect share this insight and direct their common volition to this aim, the spirit of harmony with the Waldorf idea will be at work. For then, understanding and will forces can realize a deed born out of a free spiritual life.

Even though, in many cases, local or timely conditions may necessitate measures that do not correspond to the Waldorf pedagogy, in the present essay we are interested in discussing this problem only in a general way. The orientation stands on common ground with the aim of Waldorf pedagogy: insight into the being of the human being gained by means of Anthroposophy.

We do not intend to indicate a new style or give recipes for the building of Waldorf schools. Also, a Waldorf school must be compared with other

school buildings with regard to spatial needs and the arrangement of rooms. The differences to be considered by the builder are approximately the following:

- (1) Identical concepts must become flexible and thus have a different effect.
- (2) The quantitative element must be enlarged through the qualitative.
- (3) General concepts must be made concrete by grasping the articulation of each separate building.

Let us take, for instance, the general concept of "space." Then we can state that "space" is by no means given to us as a receptacle for vague ideas of a theoretical kind. Concretely, we can speak only of a differentiated experiencing of spatial relationships.

To begin with, we must notice that, in reality, our relationship towards the three spatial directions is differentiated, in contrast to mathematical thinking where the three coordinates can be arbitrarily interchanged. Moreover, we observe the effects of the three spatial coordinates in their characteristic relationship to the three-foldness of our soul life – thinking, feeling, and willing. If an architect knows these relationships and takes them into account, then the Waldorf teacher will understand him, for the teacher, in his turn, needs rooms in which thinking, feeling, and willing can be harmonized. These indications should not be considered as something supplementary. The threefoldness of the human organization, with its important and weighty consequences, has been discovered by the investigations of Dr. Rudolf Steiner. For the architect, these facts lead to an exact understanding of space and the translating of this research into the artistic field. He cannot build a school for growing children without these insights. The Waldorf teacher will be grateful and help him in these endeavors.

The architectural principle, in this fundamental form, shows us how to transpose intellectual concepts into mobile applications. This is the path from the quantitative to the qualitative and the concrete articulation of a general and abstract idea.

What the child experiences as above and below, as summit and abyss, enters into his feelings. What is in front or behind either spurs on his will forces or represses them. Right and left stimulate comparisons, the faculty of judging. In each of these coordinates are counter directions, which must be experienced in different ways. Feeling "lifts itself" toward what is above and becomes oppressed when descending to that which is below. Right and left have an influence on destiny. If the architect is told by the teacher that, in Waldorf education, four temperaments are observed in the pupils, then the three spatial coordinates, with their respective counter directions, are experienced in a fourfold coloration: the choleric child is active and something of a rowdy; the sanguine child many-sided, but possibly superficial; the melancholic child brooding on the past and, at the same time, cautious; the phlegmatic child indifferent and slow. These 24 possibilities result in an infinitely differentiated interplay of spatial experiences, within which one or the other dimension and one or the other temperament may dominate. The nature of a building intended for a Waldorf school demands the qualitative understanding of the dimensional correspondences.

Now this question arises: what results from these insights when they are applied to practical solutions? The question can be answered through the

consideration that such insights belong already to the domain of a free spiritual life, which can be trusted also in regard to practical applications.

Symmetry

Starting out from the axis or middle, we compare the one side with the other. Comparison is possible only because of the fact that we ourselves are, in a certain degree, symmetrically built. Our body has a right and a left side. Comparing, pondering, and considering leads to the statement that we are confronted with either identical or non-identical objects. Identical things can be assimilated without effort, while the non-identical disturbs us until such a time when we can also assimilate it through our own activity, in a higher sense. Thus, asymmetry stimulates our will power. We must do something about the asymmetrical, while symmetry does not excite us, but only mediates a feeling of concordance. In Waldorf school, both elements are present. Symmetry provides community feeling through an act of passive acceptance; asymmetry, by stimulating the will, tends to overcome the non-identical! When the child encounters asymmetry, he must find an equivalent in another place. He experiences in his feeling the path leading from one to the other. In the symmetrical, he experiences, without effort, a static balance; in asymmetry, he produces this balance through his own activity, thus establishing a dynamic equilibrium. This interplay of the statically given and the dynamically achieved symbolizes, in architectural form, the child's experiences in the school community: on the one hand, things come to meet him, while, on the other hand, he must contribute something to the life around him.

The Class Room

This is essentially the school within the school. Just as Goethe saw in the leaf the plant's fundamental organ, so the classroom is the fundamental space of the whole school. The rooms are arranged along a corridor like leaves on a stem. Each classroom contains the potentiality of a whole school. However, we must not look at them singly, but as a continuity. Just as the leaf's fundamental form is transformed, so the simplest fundamental shape of the rooms should be changed as the children change from year to year. This change can take place almost imperceptibly by means of the subtlest nuances. Then the rooms accompany the growing child. This spatial accompaniment, corresponding to the metamorphosis of the plant, is more important than the "organic" and individual form, although this too may be needed. The organic form is artistically truthful only if it can be understood as directed by the tendency towards metamorphosis.

A classroom should not have a so-called perfect architectural form. Architecture should only stimulate a dialogue – one that is as varied as possible. For the teacher, it should be something like a spatial friend of education. Actually, however, the room consists only of six planes: floor, ceiling, and walls. Moreover, the Waldorf school will retain the customary measurements: 10.5 ft. high; approximately 20 ft. wide; and 22 ft. deep, starting out from the windowed wall. So, where is the freedom of design? Apart from color, light sources, arrangement of tables and chairs, etc., just the seemingly elementary norm of six planes constituting space provides the architect with an archetypal motif: the inclination of the planes towards one another! This inclination is present in a normal, rectangular construction through the customary choice of

the rectangle, but it produces a static and neutral effect. However, if we depart from the rectangle - which is undoubtedly correct in the right place - we achieve effects that could be called dynamic. They "induce movement"! Let me clarify this statement by a few examples.

A classroom, which widens itself out towards the teacher through a slight divergence of the longitudinal wall, will affect the children spatially in such a way that they open themselves to the teacher. If the ceiling ascends in the same direction, then this spatial gesture induces attention. The children look up the teacher. Both gestures awaken the children!

Such a space formation helps the teacher in a way that he will experience as beneficial. Towards the rear, the space will close up through the converging walls and the descending ceiling. Thus, he feels himself united also with those who sit in the rear.

In the upper grades it may be correct if the longitudinal walls indicate a convergence, while the ceiling ascends towards the blackboard. All this heightens attention and concentration.

However, such spatial gestures should remain almost imperceptible. An exaggerated use of such devices would make the space a one-sided-something which we should avoid at all costs. It helps neither the educator nor the pupil if they have to spend a whole year in a pointedly oblique space, unless a marked asymmetry is balanced by compensatory forms. In the case of specific rooms, such as instruction in natural science or in eurythmy, this could be done in a conscious way. Both the architect and the teacher should reflect on the relationship of rooms with a static or dynamic effect. Both concepts could be worked out in such a way that they would become filled with an almost obvious reality. They are not merely aesthetic and superficial concepts.

The window wall and the arrangement of lights demand the most thorough artistic consideration. It is not enough to use standard units. In order to live in the "many-colored afterglow," we must provide light and darkness. Color can be truthfully experienced only if the deeds and sufferings of light are experienced within the medium of color. Then color is "weaving" within the manifested secret. In a Waldorf school, light should never become "obnoxious." The wealth of summery light should be transformed into the life of color.

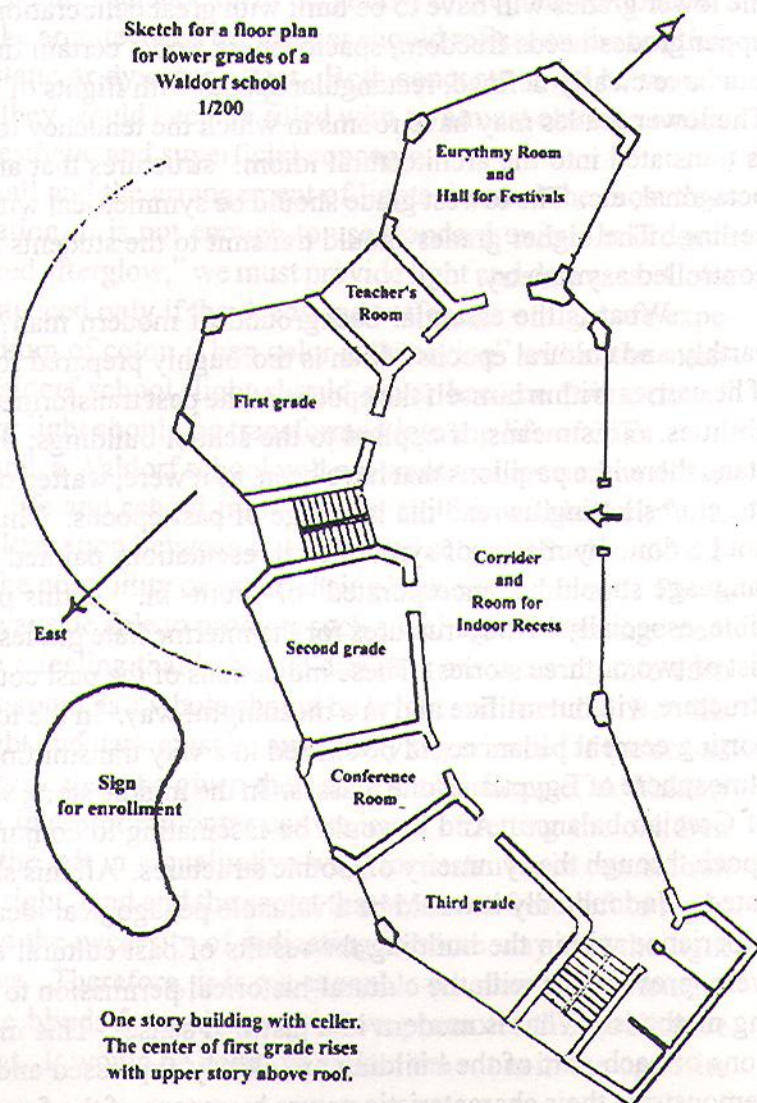
On the other hand, a Waldorf school will not want to wipe out the difference between outdoor life and school life. For the child it will be helpful to experience a definite alternation between outdoors and school. Such lucid differentiations increase the possibility of experiencing both environments. Pavilion schools will not always be able to produce such a feeling. The arrangement of lights should arouse a feeling that light and darkness are weaving into each other, although the classroom as a whole should be bright and friendly. But this weaving together of light and dark must be artistically experienced if the colors - also as colored shadows - are to be given their artistic significance. A Waldorf teacher will be able to interpret the outer convenience of letting the children receive the light from the left in a qualitative way, for instance, in connection with the activity of the right hand and the secret that we write from left to right. He will also understand the necessity of indicating in some way that the light shines down from above. Therefore, it is questionable whether the customary way of letting down the blinds from above to below promotes this qualitative experiencing of the light. It would be better to darken the room in the opposite direction.

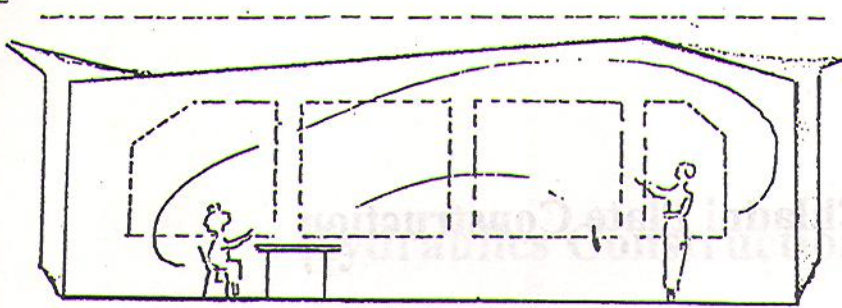
What possibility does the fundamental form of the classroom give for the metamorphosis we have mentioned? There is the interplay of two components: one creates a community through the fact that teacher and pupils gather in this space; the other component is given through teaching and learning. The latter function will provide the room with a variously tinged orientation. Thus, the room will be subject to change, depending on the predominance of one or the other motif and the evolution of the pupils. This, however, should not be laid down as a rigid scheme. Here again an articulation is needed, which will not only maintain the unity of the school but make it more characteristic. This articulation, which could even include a division into three buildings, starts out from the lowest grade with the little children. The next group, as mainstay of the school, consists of the intermediate grades, to be followed by the smaller group of the upper grades. The intermediate grades are the ones who have been best "incorporated" into the school. These include grades six to eight. The teacher will have to decide the exact division of the grades. The littlest children must gradually learn to participate in the school life. The older pupils already anticipate their departure. The intermediate grades are in the middle; they provide the firm support of the school. This intermediate stage cannot be equated with the other common and central halls, such as that for gymnastics or eurythmy. It is the intermediate element in the whole evolution of the school. Here, on the whole, a symmetrical design will be appropriate. The structure for the lower grades will have to be built with great deliberation, while that for the upper grades needs freedom, spaciousness, and a certain tinge of elegance. It can have clearly defined, rectangular spaces with flights of stairs, terraces, etc. The lower grades may have rooms in which the tendency towards the rounded is translated into the architectural idiom: structures that are almost square or octagonal, etc. The lowest grade should be symmetrical with a slightly vaulted ceiling. The higher grades should transmit to the students a spatial gesture of controlled asymmetry.

What is the essential background of modern man? It is the layers of earthly and cultural epochs! Man is thoroughly prepared for his own age only if he carries within himself the epochs of the past transformed into concentrated abilities. This means, if applied to the school buildings, that they should not stand there like pavilions that have been, as it were, wafted onto the sand, but as structures letting us read the language of past epochs. This, however, should not be done by means of symbolic representations painted on the walls. This language should be "incorporated" or "built-in." Is this possible? It is possible, especially in the structures for the intermediate grades, which might consist of two or three stories. These indications of the past could be built into the structure without artifice and in a meaningful way. In the lower story, the supporting cement pillars could be shaped in a way transmitting something of the atmosphere of Egyptian stone masses. In the middle story, we could give a hint of Grecian balance. And it would be fascinating to conjure up the Medieval epoch through the symmetry of Gothic structures. All this should be only indicated. Undoubtedly it would be a valuable pedagogical idea to let the children experience within the building the results of past cultural epochs. This, as it were, provides us with the cultural-historical permission to use modern building methods. What is modern in a justified sense? This means that the functions of each part of the building are clearly expressed and that the materials demonstrate their characteristic nature by means of the forms, etc.

Now we must allude to something that is extremely subtle and yet most significant: reverence joined to the fullest affirmation of a healthy joy of life! What place in the building will lead the children to reverence? That is the threshold, the door, the portal. For reasons of safety, we avoid high thresholds. Yet the architect must observe with artistic accuracy how he opens a door. Here, too, we can use purely architectural methods without painting proverbs on the wall. For instance, the ceiling could be slightly inclined towards the door. We can surround the door with a form speaking to the child's feelings. We can form the door latch in such a way that the child palpably feels: I may not enter unless I am duly prepared, and I am looking forward to entering this room. Moreover, the child should leave the school every day differently from the way he entered it. Also, this difference should find its artistic expression by means of the door.

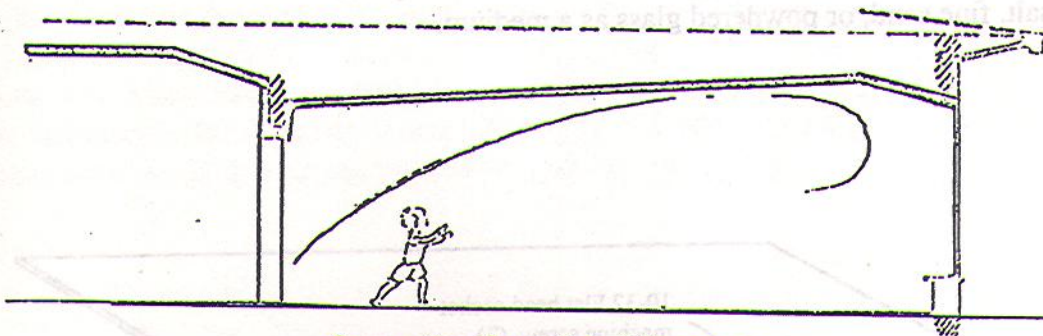
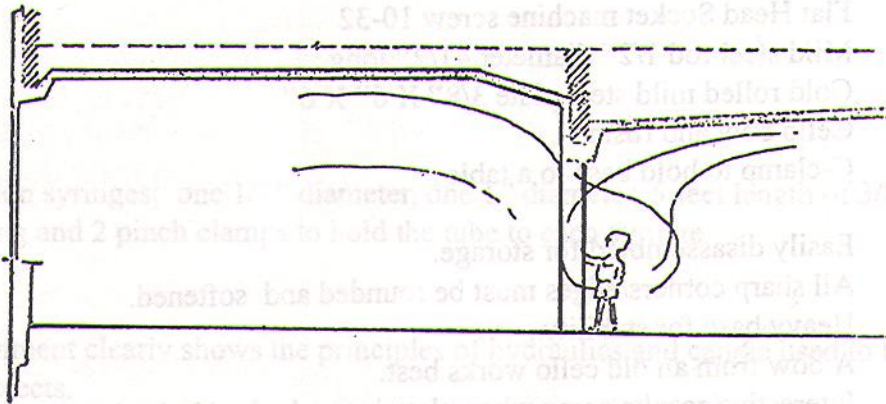
What has been indicated in this essay could also contribute to the building of schools for retarded children in need of special care and institutions for curative pedagogy. In constructing such buildings, the architect would be able to promote those forces in the child which point upward and which could bring thinking, feeling, and willing into a healthy equilibrium.



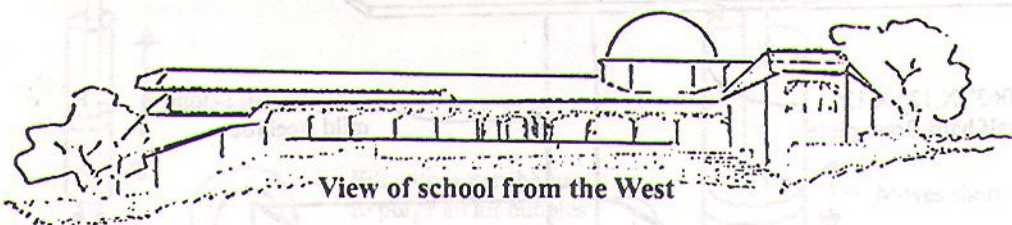


Direction of ceiling
in classroom

Crosssection
through classroom
connected with
hall for terrace



Crosssection through hall for recess



View of school from the West

Experiment 1

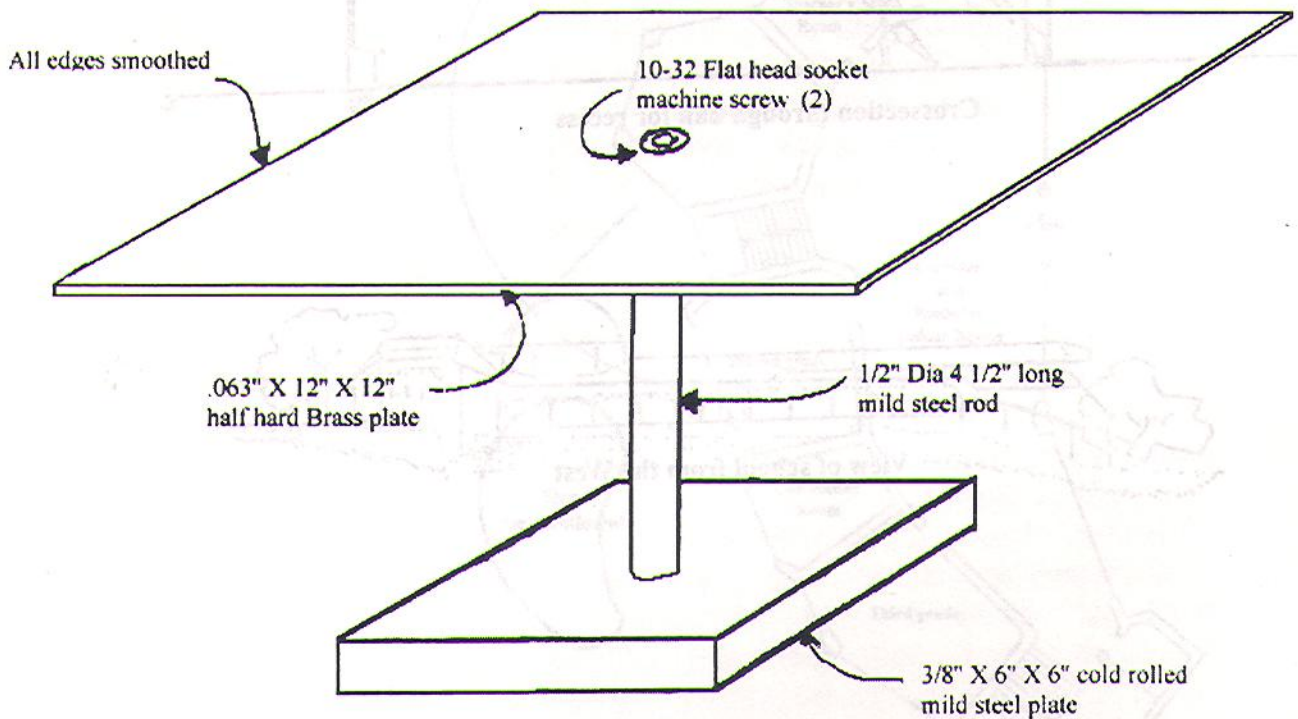
Chladni Plate Construction

Materials:

Brass plate .063" X 12" X 12"
Flat Head Socket machine screw 10-32
Mild steel rod 1/2" diameter 4 1/2" long
Cold rolled mild steel plate 3/8" X 6" X 6"
Cello bow and rosin
C-clamp to hold base to a table

Notes:

Easily disassembled for storage.
All sharp corners/edges must be rounded and softened.
Heavy base for stability.
A bow from an old cello works best.
Interesting results come when plate is touched with dry ice.
Use salt, fine sand, or powdered glass as a medium.



Experiment 2

Hydraulics Construction

Materials:

Pair of nylon syringes; one 1/2" diameter, one 1" diameter, 5 feet length of 3/8" OD Vinyl tubing and 2 pinch clamps to hold the tube to each syringe.

Procedure:

This experiment clearly shows the principles of hydraulics and can be used to lift books or other objects.

Procedure:

1. Open the pinch clamps so that water flows through the upper cans and into the lower cans. It will then run out through the holes. The rate should be adjusted to 2 or 3 drops per second.

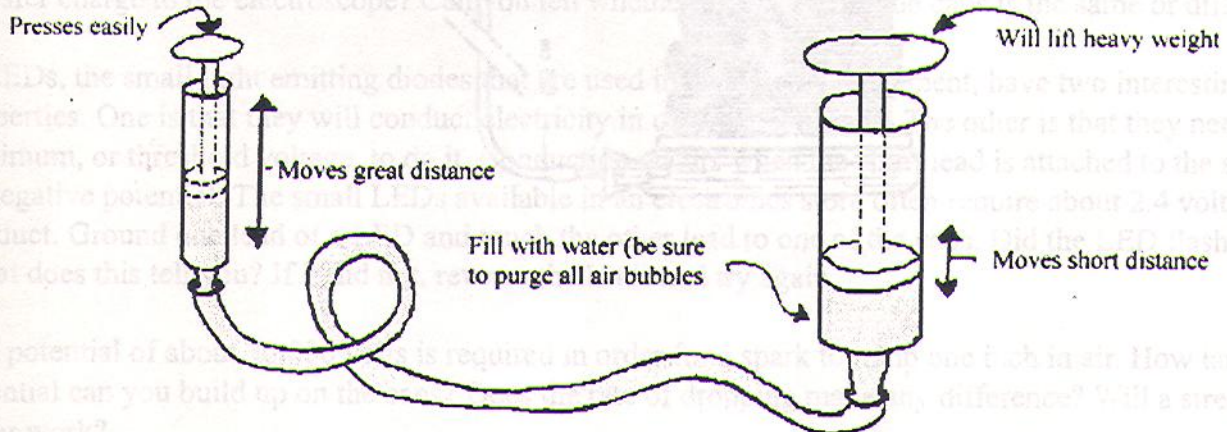
2. Bring an electroscope near one of the cans. Can you detect the presence of static electricity? Can you transfer charge to the electroscope? Can you tell whether the charge is the same or different?

3. LEDs, the small light emitting diodes, are used in many electronic circuits. They have two interesting properties. One is that they will conduct electricity in only one direction. The other is that they need a minimum, or threshold, voltage to conduct. Below this voltage they do not conduct. Ground the negative terminal of the battery and connect the positive terminal to the anode of the LED. What does this test tell you?

4. A potential of about 1 volt is required in order to make a diode conduct. How much voltage is required to make a diode conduct? Can you build a simple circuit to test this?

5. A potential of about 1 volt is required in order to make a diode conduct. How much voltage is required to make a diode conduct? Can you build a simple circuit to test this?

6. A potential of about 1 volt is required in order to make a diode conduct. How much voltage is required to make a diode conduct? Can you build a simple circuit to test this?



Experiment 3

Raising heavy weights by water pressure

Materials:

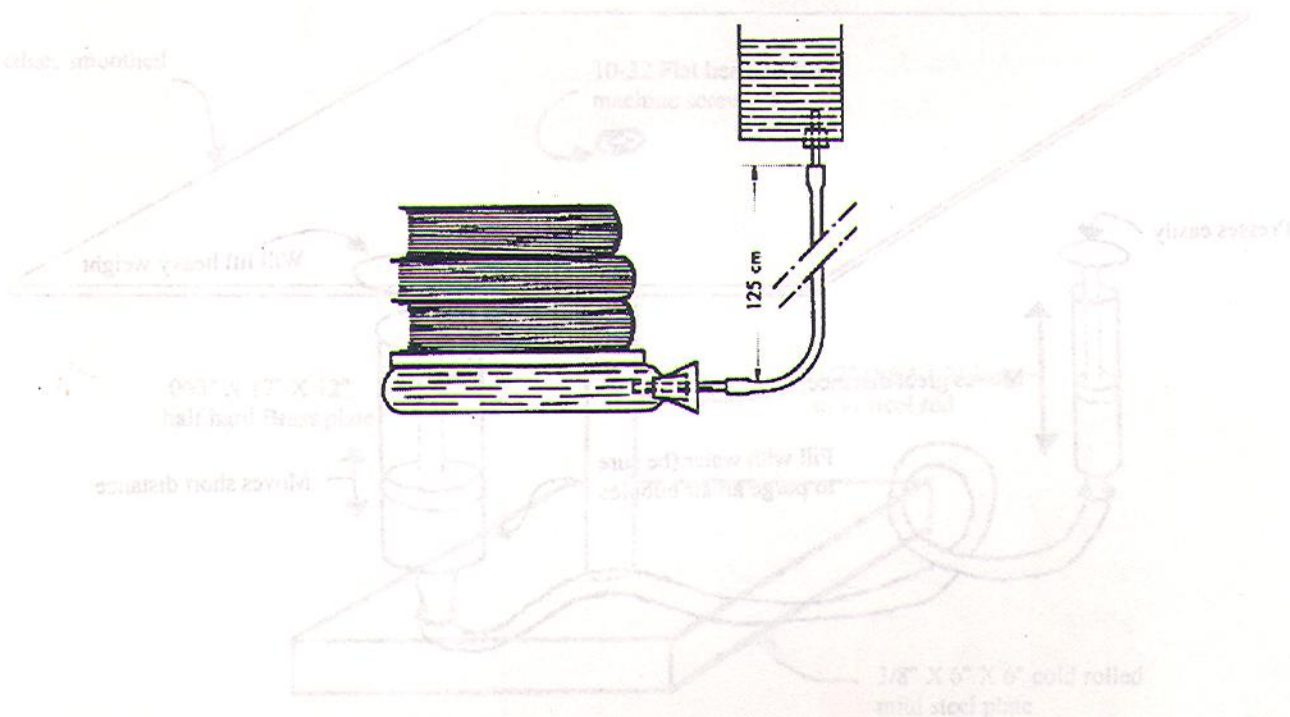
Brass plate .063" x 12" x 12"
Flat Head Socket machine screw 10-32
Mild steel rod 1/2" diameter 4 1/2" long

Materials:

Hot water bottle, and 6 feet of garden hose, funnel or bottle, rubber stoppers, glass tubing

Procedure: The hot water bottle will easily lift 300 pounds!

Obtain a rubber hotwater bottle. Put a one hole stopper carrying a short glass tube tightly in the neck. Punch a hole in the bottom of a tin can and make it large enough to take a one hole stopper. Put a short length of glass tube through the stopper. Connect the water bottle and the can with a length of rubber tube at least 1.25 meters in length—it will be wise to wind wire around the connection at the bottle. Fill the bottle, tube and can with water. Place the bottle on the floor and put a length of board on it. Place books or other heavy objects on the board. Now raise the can above the level of the floor and observe the weights. See how heavy a weight you can lift by raising the can as high above the floor as possible.



Experiment 4

Lightning Observation

How often have you walked across a carpet or slid across a car seat, reached for the door handle, and, ZAP, recoiled from a jolt of static electricity? Do you realize that each time you were hit by a miniature lightning bolt? The lightning was not produced by the rugs or car seats; drops of water seem to be the culprits. An easy-to-build system for generating static electricity from water drops is described below. It was originally devised by Lord Kelvin nearly 150 years ago.

Materials:

1. A square of pegboard or corrugated cardboard 40 x 50 cm, 4 metal cans (soup cans work well), some insulated copper bell-wire, some rubber or plastic tubing, a 2 hole rubber stopper to fit a 2 liter plastic soda bottle, the soda bottle, some glass tubing, and two pinch clamps.

Fasten the pegboard to a base so that it stands vertically. Cut one end out of two of the cans and make a 1/2 inch hole in the remaining ends. Cut both ends out of the other two cans. Fasten them to the pegboard as shown with the two open-ended cans above the cans with one closed end. Attach wires as shown. (It helps if the wires are soldered to the cans.) Cut the bottom from the plastic bottle and connect the tubing as shown. Put the pinch clamps in place and fill the reservoir with water.

Procedure:

1. Open the pinch clamps so that water drops through the upper cans and into the lower cans. It will then run out through the holes. The rate should be adjusted to 2 or 3 drops per second.
2. Bring an electroscope near one of the cans. Can you detect the presence of static electricity? Can you transfer charge to the electroscope? Can you tell whether the charge on the cans is the same or different?
3. LEDs, the small light emitting diodes that are used in electronics equipment, have two interesting properties. One is that they will conduct electricity in only one direction. The other is that they need a minimum, or threshold voltage, to do it. Conduction occurs when the short lead is attached to the source of negative potential. The small LEDs available in an electronics store often require about 2.4 volts to conduct. Ground one lead of a LED and touch the other lead to one of the cans. Did the LED flash? What does this tell you? If it did not, reverse the leads and try again.
4. A potential of about 30,000 volts is required in order for a spark to jump one inch in air. How large a potential can you build up on the cans? Does the rate of dropping make any difference? Will a stream of water work?

Raising heavy weights by water pressure

