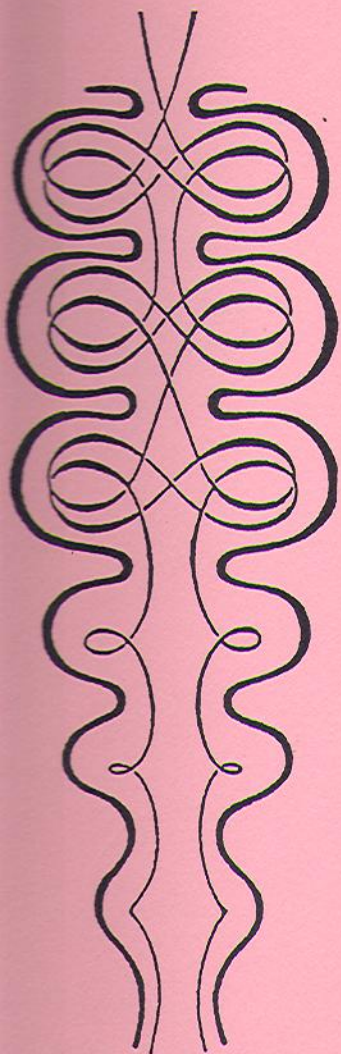




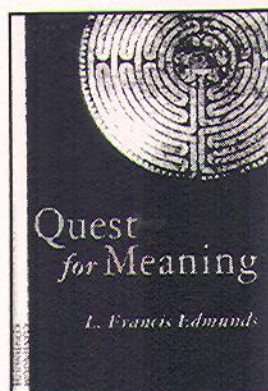
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WALDORF SCIENCE NEWSLETTER

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BOOKS



Quest for Meaning, by L. Francis Edmunds,
Continuum Publishing Company, New York, 1998.
372 pp, \$27.50, hard cover: ISBN 0-8264-1070-7

Francis Edmunds, the founder of Emerson College in Forest Row, England, presents a readable account of the last 500 years of scientific exploration in the Western world. He presents an incisive critique of contemporary scientific mores, and offers a spiritual alternative for those who wish science to be harnessed to moral and spiritual values.



Chronobiologie und Chronomedizin - Biologische Rhythmen, Medizinische Konsequenzen By Gunther Hildebrandt, Max Moser and Michael Lehofer Hippokrates Verlag, Stuttgart, 1998
141 pp., DM 58 Paperback. ISBN 3-7773-1302-5

This book, published in German, is unfortunately not yet available in English. It is an important work giving a coherent, well-referenced review of human chronobiology. It is a testament to the work of Gunther Hildebrandt of Marburg University, a pioneer of the discipline. Chronobiology has spawned its own journals including International Journal of Chronobiology, Chronobiologica and Chronobiology International. Reviews and symposia are available in English. 1-3 The new book, co-authored by a physiologist and a clinician from the University of Graz, is accessible and extensively illustrated by graphs and charts.

Anatomy deals with organic relations in space whereas physiology is concerned with organic function, including responses and interactions in time. Chronobiology could be seen as an essential, though somewhat neglected aspect of physiology. It attends specifically to the time dimension - our 'time body'. Our living organism is composed in time of a spectrum of interacting, more-or-less resonating processes and cycles. Variations of nerve potential, heart rate, respiration, blood pressure, temperature, wakefulness, metabolic function, endocrine secretion and so on, occupy characteristic frequency bands of the overall spectrum, each interacting, more or less, with other bodily cycles, activities and environmental changes. On the whole, lower frequency functions tend to correspond with environmental cycles, notably day and night, whereas higher frequencies are endogenous, but modulated by lower

frequencies and altered during activity. There is a tendency, easily over-ridden in wakefulness, for oscillations such as heart-beat and breathing to adopt whole-number, harmonic ratios. Frequency and phase coordination become more marked during deep sleep, perhaps allowing a degree of co-action for functional economy and regeneration. Time is clearly an essential biological dimension. In human biology and medicine, knowledge of cyclic changes with time has clinical importance, for example in interpretation of blood pressure measurements or in research into causes of events such as myocardial infarction whose incidence varies through the daily cycle. Knowledge of natural cycles allows avoidance of potentially harmful stress, and may have relevance to the timing and nature of therapeutic interventions. The book contains nearly a hundred graphs or charts documenting variations and relations of many different parameters with time. Each graph is based on hundreds or thousands of measurements. I am left with a sense of gratitude to Gunther Hildebrandt and other researchers for their patience in mapping this otherwise invisible field of study. Disciplined objectivity may be a limitation, but it is certainly a strength of Hildebrandt's approach. Like the work of anatomists, his investigations provide information through which to strive towards insight. No investigative approach gives access to more than an aspect or fragment of reality. To gain inklings of living reality, it may be necessary to adopt complementary approaches, amongst which awareness of developments, cycles and relations in time should not be neglected.

— Philip Kilner

1. Hildebrandt G. Reactive modifications of the autonomous time structure in the human organism. J-Physiol-Pharmacol. 1991; 42(1): 5-27
2. Trends in chronobiology. Hekken WTJ, Kerkhof GA, Reitfield WJ (eds). Pergamon Press, Oxford, 1988
3. Chronobiology and chronomedicine - basic research and applications. Gutenbrunner C, Hildebrandt G, Moog R (Eds). Peter Lang, Frankfurt, 1993



Famous Scientists

Popular Science magazine ranked the 10 top scientists up to 1923. You will find interesting information about them on-line at

> <http://www.popsci.com/context/features/scientists/index.html> <



Compare the following recent thoughts by Geologists, with Steiner's indications about the 'Mountain Cross': the East-west complex of Alps, etc. and the North-South American mountains, (for Grade 8, *Conferences* 9/25/19).

"East-West chain...continuing subterraneously, encloses the earth like a ring, which is crossed perpendicularly by the [Rockies]-Andes Corderilla which forms another ring. Two cruciform rings which give a structure to the earth. You get a picture of the earth as a body with an inner organization" (*Conferences* 9/22/20).

Also, you might consider the influence of the North-South cordillera on the etheric body.

"The Globe Inside Our Planet"

by Richard Monastersky
from *Science News*, Vol. 154,
No. 4, July 25, 1998

In Dante's *Inferno*, the outcast Florentine poet took literary revenge on his political enemies by sentencing them to an eternity of torture without parole. They served their time locked inside Earth, writhing away in a circular, split-level hell, where the suffering grew more intense with each successively deeper and smaller layer.

Although modern geologists might scoff at Dante's portrayal of the world underground, the 14th-century writer was actually correct about the basic architecture of the planet. As geophysicists know today, the globe's interior consists of several spherical shells—an outer crust, a rocky mantle, and a metallic core, with the heat and pressure growing progressively more excruciating as the depth increases.

It turns out that researchers could have used a bit of Dante's imagination. Recent discoveries depict the inner core as a bizarre world locked inside our planet, where scientist's expectations often prove wrong. "It's become clear that the inner core is a lot more complex than we've given it credit for," says seismologist Kenneth W. Creager, of University of Washington in Seattle, reporting at a Boston meeting of the American Geophysical Union (AGU) in May, 1998.

Xiaodong Song and Paul G. Richards of the Lamont-Doherty Earth Observatory at Columbia University in NY exposed some of the core's curiosities in 1996 which their study of seismic waves pulsing through the deepest section of the planet (SN 7/20/96, p. 36). The waves came from earthquakes in the South Atlantic and passed through the inner core on their way to recording stations in central Alaska, taking about 20 minutes to make the journey.

The two researchers noticed something peculiar in recordings made over a 30-year period. The seismic waves took progressively less time to cross through Earth, even though they were traversing exactly the same distance. Vibrations leaving a spectacular spot in the South Atlantic arrived at the recording station about three-tenths of a second sooner in the 1990s than in the 1960s.

One of the biggest questions nagging researchers today concerns the orientation of the iron crystals in the inner core. This issue surfaced a decade ago when seismologists found that earthquake waves traveling north-south, cross the

inner core faster than those going east-west – a property called "anisotropy." The explanation they offered was that iron crystals line up to form a distinct pattern or fabric, which quickens waves going with the weave.

Seismologists first assumed that the entire inner core had a uniform crystalline design. Japanese and U.S. scientists are now discovering, however, that the strong pattern appears in only half the inner core.

Satoru Tanaka and Hiroyuki Hamaguchi of Tohoku University in Sendai, Japan, first uncovered this rent in the core's fabric by studying two classes of seismic waves from earthquakes. One group dives through the mantle and outer core, ultimately passing through the inner core before heading back to the surface. The other group travels almost exactly the same path in the mantle but bends around in the outer core and never reaches the inner core. By comparing the travel times of the two types of waves, Tanaka and Hamaguchi isolated the effect of the inner core.

Tanaka and Hamaguchi noticed that seismic waves going under Asia and Australia took the same to crisscross the globe, no matter if they were traveling east-west or north-south. But for waves crossing under the Americas, Europe, Africa, and the Eastern Pacific – a region that corresponds roughly with the Western Hemisphere – the north-south path took less time than the east-west path. The difference was roughly 3 seconds out of about 18 minutes. The scientists published their results in the February 10, 1997 *JOURNAL OF GEOPHYSICAL RESEARCH*.

Creager found similar differences in his study of the core-crossing waves. The anisotropy in the Western hemisphere is about 3 to 4 times the strength of the anisotropy in the Eastern Hemisphere, he reported at the AGU meeting this spring.

The two-faced nature of the inner core has so far stumped researchers. "It's very surprising," says Creager. "It's hard to think of a physical mechanism that would cause these variations."

One answer might be that the temperature or chemistry of the eastern core differs from that of the western half. But when Creager averaged waves going in all directions across each hemisphere, he found no marked differences between the two sides of the core, indicating that they have the same general properties.

Instead, it appears that the pattern of the iron crystals in the Western Hemisphere lines up strongly in the direction of Earth's axis of rotation, whereas those in the Eastern Hemisphere show a more helter-skelter fabric, pointing in all different directions, with perhaps a slight bias toward the rotation axis, he says.

In laboratory experiments, Bergman is testing an alternative hypothesis: The iron anisotropy develops because the crystals align themselves as they solidify from the molten alloy of the outer core. As liquid metal hardens, he says, it forms treelike crystals that grow outward into the remaining liquid. Theory suggests that the crystals should orient themselves parallel to Earth's equator because heat escapes fastest in that direction. Bergman is now testing that idea using a rotating sphere filled with salt water, cooled down to the point where ice crystals start to form, he reported at the AGU meeting.

By using an icy stand-in for the core, the physicist is unknowingly following *The Inferno*. Dante pictured the circles of hell leading down ultimately to a vast lake. In the

middle of the basin sat Satan, beating his three wings so fiercely that they froze the water into a block of solid ice at the very center of the planet. Today's scientists don't expect to find anything so fanciful inside Earth, but they would agree that the inner core is turning out to be devilishly hard to fathom.

* * * * *

MUSIC

(taken from the Anthros/Science list)

Here is more thoughts about music and numbers (It is not very original -- Pythagoreas, Plato, Theon of Smyrne have all said a lot about this). It's just the way I presently see the problem, and it could be incorrect, but I hope it will be of some interest. First of all you have:

Name	the tonic	the fifth	the fourth	the octave
ratio	1 : 1	3 : 2	4 : 3	2 : 1
quality	a sin function	It sounds pleasing	It sounds pleasing	It sounds pleasing
(period/ levels)	1 T/2	2 T/4	3 T/5	2 T/3

The reason it sounds pleasing is regularity, if you consider either the fifth or the fourth in their temporal waveform, you may observe a very short periodicity, and very few number of extremes i.e., a big regularity of the waveform pattern in time)

If you perform the addition of two pure tones which are not in a rational ratio, the result is not periodic. And you can heard it, if you pay attention.

So suppose that now, we want to build a scale in order to play music, and that you want to keep the fifth, the fourth, and the octave in your scale. It seems logical, because you feel unconsciously this numerical harmony.

So you have the following scale.

1 4:3 3:2 2

This is not sufficient, and want to go farther in adding more tones into your scale. So, you ask "What [additional] interval(s) could I choose?" You look carefully, and you say "Why not choose the interval between the fourth and the fifth? Ok let's try $(4:3) \times (9:8) = (3:2)$ the interval is 9:8 and you decide to subdivide the octave with this interval, that you call a "whole" tone (W). So, you start from the tonic

1 9:8 81:64
 W W

And there, you stumble into a problem: because, if you go on with whole intervals, you miss the fourth. And you don't want to lose this beautiful regularity from your scale. So, you choose the fourth and you get the following new interval, as follows: $(81:64) \times (256:243) = 4:3$. So, you introduce 256:243, and you call it a Half-tone (H)

1 9:8 81:64 4:3 3:2
W W H W

You continue after the fifth

1 9:8 81:64 4:3 3:2 27:16 243:128
W W H W W W

And then what I call a numerical miracle occurs (because I do not see the deep reason); the last interval to

get to the octave is *again* 256:243, the half-tone that you introduced to reach the fourth from the second tone of the scale. So you have built the diatonic scale with 7 tones like this:

Do	Rè	Mi	Fa	Sol	La	Ti	Do
C	D	E	F	G	A	B	C
1	9:8	81:64	4:3	3:2	27:16	243:128	2

[the *correct* ratios are given for comparison below:

1	9:8	10:9	4:3	3:2	5:3	15:8	2
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If now you want to go farther and look what is happening if you subdivide the octave with *half-tone* intervals, you get the following beginning: 1, 256:243 etc.

Here, there is a problem once again: if you want to reach the tone 9:8, you need a shorter interval which is 2187:2048 since $(256 : 243) \times (2187 : 2048) = 9:8$, so you have to define a new kind of half tone $H1 = 256:243 = 1.0535...$, and $H2 = 2187:2048 = 1.0679...$ in the end, you can obtain the following scale (it is not a unique solution because there is two ways to cut the whole tone):

Note	Ratio	Interval
C	1	
C#	256:243	H1
D	9:08	H2
D#	32:27	H1
E	81:64	H2
F	4:03	H1
F#	729:512	H1
G	3:02	H2
G#	768:486	H1
A	27:16	H2
A#	16:09	H1
B	243:128	H2
C	2	H1

So, this scale has a problem for transposition. You may wish to define a more useful scale based on an other idea: you decide to choose an *equal* subdivision of the octave. Why do not choose a uniform subdivision in 12 parts, as previously. It seems natural. So you have to solve the equation: $12 = 2$, (or $12_2 =$), and you get = the half tone interval of the temperate scale = $\exp(\ln_2 12)$, which is not a rational number. So, strictly speaking all the tones of the temperate scale are 'wrong,' but now there is an other numerical miracle. 12 subdivisions was a really good choice. Tones are wrong (only a little) and in particular the major third, the fourth, and the fifth, are very near to the Pythagorean scale.

Note	Pythagorean	Temperate
Maj 3rd	1.265625	1.259921
Fourth	1.33333	1.33483...
Fifth	1.5	1.4983...

You now have no problem for transposition.

If you want to go farther you can suppress tonality, choose a finer subdivision of the octave, use micro intervals.

"Analogy analogy from where comes your strength?" (Analogie Analogie, d'o viens ta force?)

— Andra Sklaerti

A Response

I'm sorry to say, but the construction of a major scale suggested by Andra is *not* correct:

1	9:8	81:64	4:3	3:2	27:16	243:128	2
W	W	H	W	W	W	H	
Do	Rè	Mi	Fa	Sol	La	Ti Do	
C D	E	F	G	A	B	C	

The given ratios have to be changed at some places according to the following principle: The key 'C major' is built up from the 'C major chord', so first of all we have the tonic CEGC, with the frequencies of: $1f$ ($5:4$) f , ($3:2$) f , $2f$.

The tone 'D' has the *function* of being contained in the dominant, and then should be considered so. The dominant is starting from G, and then following the known major pattern: GBDG, again with the same proportions as above. So (after multiplying with the starting point $3:2$) that gives ($3:2$) f ($15:8$) f , ($9:4$) f , $3f$, and from this we can collect D and B. The tone D is one octave too high, and therefore needs a division by 2, so we get ($9:8$) f . The tone B is correct as it is.

Now, there remains F and A. They are both contained in the subdominant and should therefore be considered so. We get F by going down 5 tones from C, this gives the ratio $2:3$. Starting from there, we get the frequencies ($2:3$) f , ($5:6$) f , $1f$, ($4:3$) f . This gives us ($4:3$) f for F and, taking one octave up gives ($5:3$) f . We arrive at:

Do	Rè	Mi	Fa	Sol	La	Ti	Do
C	D	E	F	G	A	B	C
1	9:8	10:9	4:3	3:2	<u>5:3</u>	<u>15:8</u>	2
W	W	H	W	W	W	H	

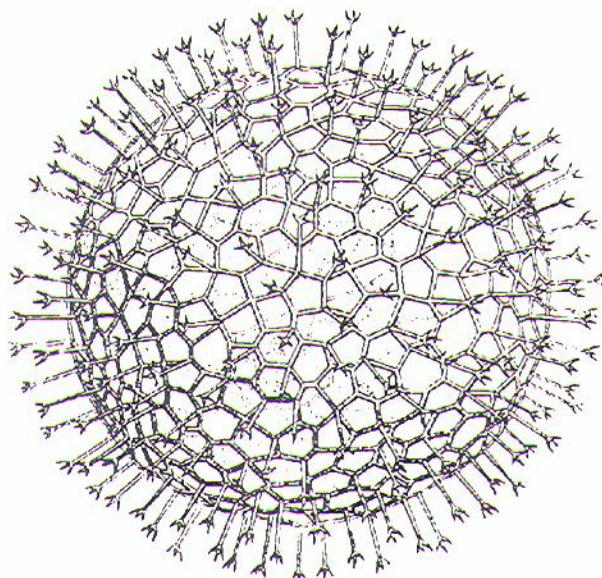
[The incorrect ratios are given for comparison below]

1	9:8	<u>81:64</u>	4:3	3:2	<u>27:16</u>	<u>243:128</u>	2
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It is well known that these are the actual ratios; however, the above given explanation is mine. I think it is the 'right' explanation, because it focuses at the "function" of the tones in the given scale. Following the same principle, one has to examine the function of sharp and flat tones if one needs to compute their frequencies. For example: an inserted G[#] followed by an A-major chord (in a previously C-major key song) has the function of a dominant and should have the frequency ($15:16$)($5:3$) f .

As Andra remarks, this scale is not comfortable if one likes to play in several keys (for example on a piano). The logarithmic solution given is correct (used by synthesizers) but "well-tempering" (in several ways) is preferred by most classical musicians. This follows a complicated rule of tuning the piano. 'Das wohltemperierte Clavier' by Bach is *not* composed for logarithmic tempering, but for some kind of 'well-tempering' which is not known nowadays. Thus anyone playing it on a synth or modern piano misses what is actually celebrated by it! Ha!

– Jesper Carlström



Understanding Blood and Hemoglobin

Blood is a complex fluid composed of cells suspended in plasma, which is the liquid part. Red cells, which make up the vast majority of the blood's cell population are responsible for delivering oxygen throughout the body.

Hemoglobin is the part of the red blood cell that captures oxygen in the lungs.

Think of it as a semi-trailer truck hauling cars. The oxygen (the cars) is loaded into the hemoglobin – that's the trailer part of the rig. Then, the red cells – the truck – carries the oxygen to the body's tissues, where it is released.

Hemoglobin is a protein made up of four separate peptide chains called globins. There are two identical pairs of chains. Each globin combines with an iron-containing component, called heme, to form the hemoglobin molecule, allowing four oxygen molecules to bind to each hemoglobin molecule.

Blood transfusions require complex cross matching, called typing, to avoid potentially fatal reactions. Everyone has a specific combination of naturally occurring antigens – these are enzymes or toxins to which the body reacts by producing antibodies – on the surface of each blood cell. Blood is typed by antigen as A, B, AB, or O and RH+ or RH-. A transfusion of unmatched red blood cells can cause serious and even fatal systemic reactions.

Standards in Science

The Department of Education has offered possible reasons behind America's poor performance on the TIMSS test.

The percentage of high school seniors taking math and science during all four years of high school is lower in the United States than in other countries. In addition, U.S. students spend an average of 1.7 hours per night on homework, as opposed to the international average of 2.6 hours. The report also showed that more than half of American students hold a job, working about three hours a day, while only one-fifth of students in other countries juggled both school and job.

What should be done to improve curriculums in U. S. schools? Should voluntary testing be implemented and would this lead to a national curriculum? Should math and science be required for all four years of high school? Is the problem really the curriculum, or a lack of interest in school from American students? What can be done to assist teachers?

Why is it important for our students to score higher than foreign students in Math and Science?

Jeanne Allen, president of the Center for Education Reform, responds:

"While the US may be a technological powerhouse, most of the students coming out of the educational pipeline are not. National Science Foundation data has found one-fourth to one-third of the doctoral students enrolled in engineering in the US over the last 10 years have been foreigners. What international statistics do is demonstrate that which is possible and that which we should know about how our students compare, particularly as more foreign involvement occurs in American companies and businesses begin to set up their offices elsewhere to take advantage of a more educated labor pool. Going forward into the 21st century the American economy will continue to move more and more away from blue-collar manufacturing jobs and toward the technical sector.

Furthermore, US students' weak showing against their international peers in math and science is symptomatic of more pervasive weakness in our educational system, characterized by low expectations and a watered-down curriculum. American students' academic shortfalls begin with the most basic literacy skills, reading and writing, that can't help but dictate their weaknesses in not only science and math, but history geography and preparing them for college and for life."

One last note – local schools by school comparisons, and district by district, and then state by state, would be very effective and very helpful in informing parents about what most don't know – that is, how much their children actually know and can do. But that requires real academic standards and practices in schools that work to meet those standards, and such accountability is something that is in serious jeopardy right now.

Science Literacy – Are We Below Average?

Summary of Editorials on TIMSS Results

by John Petering

There has been a great deal of discussion around scientific literacy recently, and the results of the Third International Mathematics and Science Study (TIMSS) has intensified that discussion since publication in February '98 of the secondary-school results.

Compiled by the International Association for the Evaluation of Educational Achievement (IEA), which is headquartered at Boston College, TIMSS is the result of successful collaboration among research centers in 45 countries. More than half a million students were surveyed in more than 30 different languages. Surveys were done at five grade levels (third, fourth, seventh, eighth, and final year of secondary school) and in 15,000 participating schools. Complete reports and executive summaries are available at the IEA Web site (<http://www.csteep.bc.edu/timss>) or by U. S. Postal Service from TIMSS International Study Center, Center for the Study of

Testing, Evaluation, and Educational Policy, Campion Hall, School of Education, Boston College, Chestnut Hill, MA 02167.

The interesting comparisons of countries, and the various implications of TIMSS data cannot be summarized here; look carefully at the reports.

Some provocative ideas about what could be done to improve students' performance, generated as a result of a National Public Radio program, are available at http://www.pbs.org/newshour/forum/march98/education_3-24.html.

Several key thought-provoking findings contained in the TIMSS reports are:

1) The U.S. scores "were significantly below other countries' average in both math and science – third from the bottom in the former. Of 16 countries reporting scores on the advanced tests, the U.S. ranked next to last in math and last in physics."

2) The overall trend in U.S. scores, from well above average in third and fourth grades to average at middle-school level and to well below average in the final year of secondary school, has also generated heated discussion.

4) In mathematics, there was no significant gender differences in performance in Hungary, United States and South Africa. However, in science, pervasive differences had boys significantly outscoring girls in physics, chemistry, and earth science.

3) More than 80% of U.S. students reported that they usually did well in math and science – a perception that seems off the mark, considering their poorer scores relative to other countries, where only 70% reported doing well.

"On homework overall, U.S. students spend an average of 1.7 hours per night, as opposed to the international average of 2.6 hours. By subject, internationally students reported spending an average of about 1 hour/day on math outside of class time and between half an hour and an hour on science, while U.S. students reported studying for less than one hour per day, compared with two to three hours averaged over all countries." Perhaps this is because U.S. students are working at a paid job more often. The report showed that "more than half of American students hold a job, working about three hours a day, while only one-fifth of students in other countries juggled both school and job."

5) "Home factors were strongly related to achievement in every country." Math and science scores were strongly correlated with educational resources in the home (computer, dictionary, child's own desk, and 100 or more books).

6) The percentage of high school seniors taking math and science during all four years of high school is lower in the United States than in other countries.

The TIMSS "Highlights from the Final Year of Secondary School" includes other interesting details.

Ability to apply knowledge: The physics test for final-year students having taken physics covered mechanics; electricity, and magnetism; heat; wave phenomena; and modern physics - particle, quantum and astrophysics, and relativity. One item required an understanding of refraction of light as it passes through a semicircular glass block into air (Example Item 5). The high performers included Norway (581), Sweden (573), and the Russian Federation (545), where slightly more than half of the students chose the correct answer. U.S. Students scored lowest (423).

This seems to agree with 1995 data in the NSF's biennial Science & Engineering Indicators. Most adults in the US keep abreast of scientific developments through news accounts. Yet only about 23 percent of adults polled understand the nature of scientific inquiry well enough to make informed judgments about those science stories. Even though most adults polled said they "were interested in the environment and pollution," yet *only about 1 of 9 could offer even a "minimally correct scientific explanation" of environmental concepts such as global warming.* (Sci. News Vol.119, June 8, 1996).

The emphasis in the science literacy items in TIMSS was on measuring how well senior HS students can apply their knowledge in addressing real-world problems having a science component. On one question requiring an understanding of how the flu is transmitted (Example Item 1), an average of 67% of final-year students responded correctly. Correct responses included specific mention of the transmission of germs; reference to transmission by sneezing, coughing, or close contact; or

simply the statement that Jose got influenza from someone who had it. Approximately 11% of the students, on average, across countries responded incorrectly that Jose got influenza from getting too cold. U.S. students (480) scored statistically below average (500) on science literacy.

In the PBS web site, the link-entry "Are there better teaching techniques?" mentions only Montessori. It's a shame Waldorf schools are not mentioned also; it seems we should have a lot to say on the themes of the "What should be done to improve curriculums in U. S. schools?" The PBS Forum themes, and some possible answers follow:

1) Should math and science be required for all four years of high school?

* The majority of Waldorf high school curricula, since 1919, includes all four science subjects, organized over the 4 years, also following the National Science Teachers recent SS&C recommendations.

2) Is the problem really the curriculum, or a lack of interest in school from American students?

* In the follow-up lectures to the founding teachers ("A Meditative Study of Man" GA302A , Part I), Steiner addresses the question "how can we help the children retain what we teach" and, out of a real knowledge of human nature, answers to call upon *all* aspects of the person (feeling and willing) not just the intellect. This is now being recognized in the Constructivist movement, and see also Dee Coulter's article on multiple portals, elsewhere in this issue. But, this is a human art, not a technology.

3) What can be done to assist teachers?

* Having independence, to form and guide school policy from the local level, out of practical classroom experience, has been a cornerstone of Waldorf schools since their inception. The College of Teachers takes on guiding how each school implements the common ideals of Waldorf education, in the school's own local setting.

4) Should voluntary testing be implemented and would this lead to a national curriculum?

* A top-down national curriculum depends crucially on the methods of assessment, to indicate whether it is being followed and producing the desired 'learning.' But, as many recent mainstream educationists acknowledge, pencil-and-paper tests inherently will miss much of the real-life knowledge everyone is so interested in seeing students achieve. Thus, alternative assessments are being proposed, for example, portfolio assessments. Waldorf students should be very familiar with this, as they make their own Main Lesson notebooks since 1st grade. However, I suspect we could also expand notebook portfolios to include many other hands-on performance measures as well.

Note:

The illustration and poem on the next page is an example from a Waldorf teacher's presentation of a Geology/Geography class for Northern California.

Song of the Rain

—by Howard Schrager

Masses of air and surges of sea
In unsurpassing time
Mingle ceaselessly.
Over the Pacific huge clouds emerge
By the hand of the wind
Landward they are urged.
Reaching first the sandy shores
They cross the coastal hills
Hurrying past the valleys wide
They tumble up foothills.
Fueled by the breeze they would just hurry by
But to climb the High Sierra they cannot decline.
Higher, ever higher, stormclouds gather and grow
Colder, ever colder
Rain droplets, or snow.

First a pitter then a patter
Little drops begin to splatter
All about the High Sierra.
Every dimple in the granite
Catches water, then it scatters
Then the scores of tiny droplets
As if scared run down the mountains
Then the trickles turn to ripples
As they scamper ever downward
Thrilling over stone and gravel
Meet like playmates as they travel
Forming creeks they skate and swirl
Down cascades they plunge and curl
Bubbling, gurgling, roaring, purring
Over rock and root they wheel
Sweeping twigs and leaves and pebbles
And then pausing in the eddies.

All these swiftly moving streams
From their own self-carved ravines
Now they join the booming tide
In deep gorges trenched in time
Of the mighty thundering rivers
On the floor of their own canyons.

Kings and Kern, Mokelumne
Stanislaus, Tuolumne
Feather, Bear, American
Merced and Yuba surge ahead
Through the Mother Lode
With its horde of gold
Downward, ever downward to the valleys below
Joining now the San Joaquin and the Sacramento.
Slower now, and broader
Past the Delta, rich, the flow
Through the Straits, into the Bay
Out the Golden Gate and home.

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Cognitive Channels, the Learning Cycle, and Middle School Students

by

Dee Coulter, PH.D.

I was invited to offer a brief discussion of the mind of a middle schooler and how the science teacher might use that information to enrich the teaching and learning experience with 6th through 8th graders. That sounded like a simple enough task until I tried to select what to explore. Shall we take a tour of the brain and talk about the significant neurological changes that are occurring during those years and how that relates to cognitive stage changes, and the fixity or fluidity of their intellect? Shall we link those changes to their shift of focus – from the mind in 6th grade to the will and body in 7th grade to the heart and emotions in 8th grade? Shall we look at stress and the enormously varied responses learners can have toward it? We could consider "learned helplessness," and how to help them recover from that, or from the posturings of a reptilian response, and the emotionality of a limbic response, and help them learn how to engage the layers of the brain constructively.

While all of these seemed worthy topics, it seemed that before we could discuss any of them in depth, we had to come to a common picture of how the brain worked with information in general and of how much that can vary from student to student. So, I've chosen to talk about the level of cognitive complexity that exists in the middle school classroom, regardless of the exact age, the stage, the stress level, or the fixity or fluidity of their intellectual makeup. This knowledge is immediately useful, once learned; it makes it easier to understand the obstacles each student faces and to know what can help. It also becomes possible to bring this body of information directly to the students, and to help *them* begin to think about *their own* thinking. If they can achieve this overview, they can begin to create better study habits, learn to be stronger at taking in and remembering what they learn, and be more successful at fully expressing what they know.

PORTALS TO THE WORLD

We will be discussing the three basic channels – auditory, visual and kinesthetic – and what it means when one or more of those channels doesn't operate well. Interwoven into that discussion will be a consideration of which phase of the learning cycle is involved. Is the problem largely an input problem, a storage or retrieval problem or an output problem with either oral or written expression? My perspective in this discussion is that of a cognitive evaluator and college teacher on neurological issues and former public school special education teacher. It is tempered by my long study of Steiner, by my son's rich journey through 12 years of Waldorf education, and by my evaluations of over 40 Waldorf students over the past 8 years.

INPUT ISSUES

When one or another channel is unavailable to a learner, because they have a particular obstacle to learning, their needs go beyond style preferences. Either they receive the information in the modality that "works" for them, or they do very poorly in the class. As the teacher, you would do best to dip back into the guideline from lower grade school of appealing to all of the modes: head (auditory), heart (visual) and hand (kinesthetic), in presenting every key idea. Everything you teach needs to be presented to all three channels if you are to reach the entire class. In the upper grades (6-8) and in high school, this gets progressively difficult. The ideas in a given subject don't all lend themselves to movement or hands-on activity and some will not even be particularly visual. Therefore, it is helpful to understand what the obstacles are to successful listening and language processing, and how to reduce those obstacles as much as possible.

Some students have poor **auditory discrimination** skills. If they miss a key word in your lecture, their mind fails to use context cues to guess what it was. Instead, they either try to interrupt you and ask you to repeat it, knowing they are lost if you don't, or they give up and wait until you start a new idea to try to step back in. You may think these students were simply not paying attention, when in fact, they may have been paying more attention than most students. They just can't compensate when auditory distractions occur or you mumble a bit.

Sitting near the front of the room and away from background noises like the hallway, the pencil sharpener and the heater can help. It can also help them to tape the lecture so they can listen again and stop the recorder when they need to think about something before going on. However, this can be very time consuming for them so they can't do it in every class or they would be up all night reviewing their classes. You can also help them by putting key words on the board so they can pair what they hear with what they can see.

Often the student who can't fill in when they hear words incompletely will also have more difficulty with phonics and you can observe that when they try to read aloud and stumble on new words and when they write and make unusual spelling errors that aren't phonetically correct. They may even have a tendency to pronounce common words incorrectly or be unsure of proper grammar at times. One final clue that this area is difficult for a student would be their tendency to 'talk too loud'. They simply can't whisper for very long and they fail to modulate their voices appropriately because they don't hear how loud they are getting. Because their voice is usually the loudest, they get blamed for talking more than is fair. They are rarely the only chatterbox; rather, they are the ones you hear first because the others are speaking more softly.

Some students can hear you just fine, but they are weak in **auditory processing**. This is more accurately regarded as a language problem than a hearing problem, so it is frequently referred to as a language processing difficulty rather than an auditory processing one. These students can only take in a small amount of language before they need some "down time" to translate it into meaning for themselves. Frequently, teachers have the desire to get the whole idea out in one presentation and then go back over it

to clear up any confusions. This approach overwhelms the student whose language processing skills are weak. They need "sound bites" rather than whole gestalts.

Many of these students have a two step process to their listening and it shows up in their reading as well. They need to take in the words, then wait until their brain translates the words into their own inner voice as if they were processing a foreign language, and then they can think about the meaning of the words. They are not thinking as they go the way other students are. Even if they manage to do this two step processing throughout a presentation, they simply cannot tell you what they think about the information until later. They need extra time to digest it first. Very often, these students are extremely bright, but they won't appear to be if you judge them according to the speed of their responses. They need more time on tests if you want to see what they really know because they take twice as long to handle the test questions, too. And, if they happen to be storing their ideas kinesthetically as a felt sense, as pure thought in other words, they will need even more time to produce their best thinking. (This is also the way Einstein worked so they are in good company. He explained that his ideas typically arose first as muscular sensations, then transformed into shapes and geometric images and then finally into words.)

MEMORY STORAGE AND RETRIEVAL ISSUES

There are several very different kinds of memory available to the learner. The most obvious ones are auditory, visual and kinesthetic (or motor) memory and these can be weak or strong at either short or long term storage. There is also a crucial, but fleeting, trace memory called working memory that is essential for skillful verbal reasoning. However, the inability to recall information is not necessarily a memory problem at all. Sometimes, the student is storing the information adequately, but for one of several reasons has not found a way to retrieve it on demand. They will say they have forgotten, but once another student begins to speak about the topic, it comes back to them, too. When that happens, the student has a retrieval problem rather than a memory storage problem.

Visual memory challenges – I have seen a recurring memory profile among the Waldorf students I have evaluated. While they usually have very strong memories as long as they are allowed to talk about the information, they often have very weak strictly visual memories. It is not uncommon for a Waldorf high school student to have a visual short and long term memory ability at the 2nd grade level and a visual-auditory combined memory at the college level. I sometimes wonder whether the richly visual education they have been given has so developed their visual imagination that the visual channel is less available for memory work.

If these students try to study by silently looking over their notes, they are asking a 2nd grade memory system to do the job for them. It is no wonder they do poorly on tests, then. And they never realize they have this pattern until we do the testing so they tend to choose this weak study strategy until then. In class, if they are only allowed to listen, but not given the opportunity to talk about the information, again they are seriously compromised. It is not enough to call on them once or twice in a teacher led

discussion. They need to break into dyads or triads and really discuss the information, in order to embed it well.

Auditory memory challenges – You can expect at least one third of your students to be struggling with auditory processing and auditory memory problems during their middle school years. This isn't just a Waldorf problem, it is a general problem in education and seems to be particularly acute during early adolescence. Many of your students, then, are relying on visual and felt sensing of the ideas you bring to them. These students often flounder in classes where the teacher uses a heavily auditory teaching style, where there isn't much to look at, where answers tend to be longwinded, where the teacher's voice doesn't hold much emotional energy, where the teacher hasn't embodied or lived into the information richly and uses few gestures while speaking. Ordinarily, the best recommendation for teachers who have these traits is to shift to either a visual or activity based mode of teaching. While these strategies will enrich any teaching, they are only a semi-satisfactory solution in the upper grades and high school where so many of the concepts simply cannot be explored as deeply with so little language.

Fortunately, Waldorf teachers have the background needed to convert from mere language to the art of elocution. Steiner had so much to say about elocution, and how it is more than just talking or lecturing. He offered eurythmy to awaken the body connection to speech. He clearly named the difference between language and thought and asked the teachers to realize just how dead information could be and to breathe life into it before bringing it before the students. And he insisted that teachers cultivate their artistic life regardless of what they taught so their soul could meet the students more fully. If you revisit these teachings and let your thoughts arise and move into speech rather than concentrating only on bringing terminology and language itself to the students, even the visual and kinesthetic student will be able to "hear" you. The visual one will be able to tap into your mind's eye as you work with your thoughts. The kinesthetic student will be able to entrain with your body as you bring forth speech, much like the Waldorf kindergartner, who commits long stories to memory by entraining to the body choreography of the teacher who tells the story with inward eurythmy in the oral tradition.

Kinesthetic memory challenges – Occasionally you will encounter a student who is very weak in kinesthetic memory. It shows up as poor ability to imitate movements, as confusions with three dimensional drawing and perspective, and a lack of grace. More often, you will find that the kinesthetic memory is an important back up strategy for the student with significant learning obstacles.

Students who favor kinesthetic storage strategies, need to squirm about while taking information in, and to gesture more than most when trying to bring it back. Furthermore, when they are asked a complex question, they need much more time to bring their thoughts into language since it isn't stored in language like the auditory processor, or in pictures like the visual one. Rather it is stored as 'thought' (a felt sense, an inner choreography).

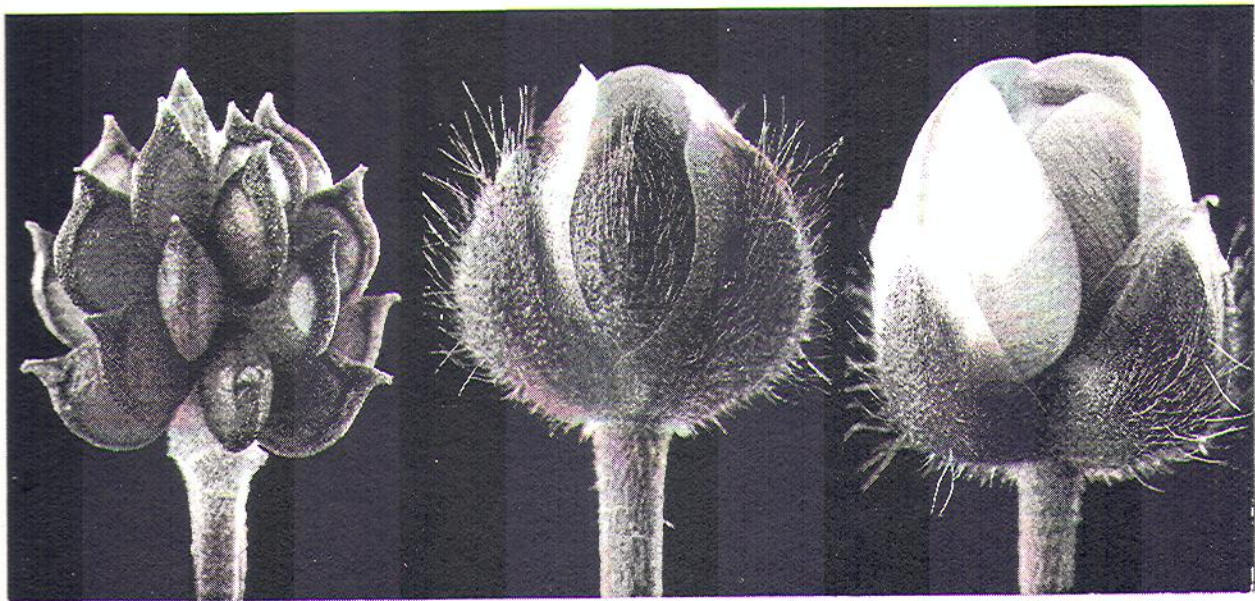
When you ask a kinesthetic thinker to answer a question they go through a very slow process that involves more steps than visual or auditory recall. Remember Steiner's connection of the sense of thought to the sense of life? These students must breathe life into your question, awaken their own liveliness about the question, convert that into thoughts, search for words much like a poet does to bring those thoughts into language and then they can finally answer you. This won't likely happen in quick question and answer patterns in class. When they know you don't have the time to wait, they will usually simply say "I don't know" rather than begin the search. To engage them, you will need to ask them to think about a question ahead of time and get back to them later during the class, once they've brought to language what they think about it. Many children with phlegmatic temperaments tend to store information in this almost "vegetative" way and need this extra time to bring the idea to the surface. For them, still waters indeed run deep.

OUTPUT ISSUES

Oral expression challenges – We touched on several issues related to the need to talk in class and the difficulties some students face in bringing thoughts into words. This is compounded by the age group you are addressing. The emotional pain of embarrassment is acute at these ages and many students live in fear of being called upon and finding their minds going blank from anxiety. The ones I have met find this to be one of the most stressful aspects of school. They anguish over the gap between what they know and what they can bring forth when called on. Do whatever you can to soften the questioning process for them. You could, perhaps, ask the whole class to take a few minutes to jot down their answer to a question you pose, and then let them volunteer to answer. That way the silent ones, who try to become invisible when you are about to call on someone, can offer to answer now that they have their thoughts on paper and won't forget. Well structured dyads where the students talk to one another instead of to the teacher in front of the whole class, will also reduce the stress and improve their oral language skills.

Written expression challenges—Here is another puzzlement I encounter primarily with Waldorf students in my evaluations practice. The battery of testing I use includes sub-tests measuring writing speed, measuring spelling, punctuation and grammar understandings and measuring the richness of thought and composition. Invariably, Waldorf students will score several years above grade level on the richness of their composition. Their reasoning skills, their creative and colorful descriptions, and the complexity of their composition are remarkable. However, I rarely encounter a Waldorf student who approaches grade level in the mechanics of writing. It is as if the quick thinking, analytical, rule based mind qualities have not been drawn forth as well as the dreamier, more creative and artistic mind qualities. This has great relevance for your work as science teachers. You must bring these two sets of skills forward in a balanced way if the student is to live into scientific thinking. The mathematics and foreign language teachers face the same dilemma. How can Waldorf find a way to support the wide awake, faster thinking that in biofeedback terms would be

called thinking in Beta, as well as it supports the slower, main lesson picturing that biofeedback practitioners refer to as Theta. Cumulative learning seems to need to occur in Beta, as if there is a minimum speed below which the information simply isn't retained well in the conscious mind. If we consider the balance between form and freedom that is so crucial for middle school students, a strengthening of the form principle will strengthen the Beta capacities. You might think about putting extra energy into offering the forms for science, precise formats for writing up experiments, exact vocabularies to use and a posting of the correct spelling of those words, careful measurement practices, and hands on activities that work with nuance and balance in exacting ways. If you can make these activities engaging, you will be awakening their minds to an important set of cognitive qualities that can match their creative artistry. This would significantly enhance their already remarkable education.



Suggestions for a Grade 8 Physics Block: A Letter to a Young Class Teacher

by
Walter Kraul

(translated from "Erziehungskunst," Vol 2, 1988)

Dear Colleague,

As I promised, here are some thoughts about the physics block in the 8th grade which lies before you. First, let's look back on the path you've led your dear children, in keeping with our curriculum, to introduce physical natural phenomena. During the 6th grade, children were brought into the realm of sciences, via the artistic element as the starting point. Music led them to acoustics, watercolor and veil painting led to the color spectrum and optics. You looked at all the other areas of physics with your children such as heat & cold, magnetism, and electricity. All these areas are part of the first introduction to physics. The only area of physics *left out* in the 6th grade curriculum was mechanics, the very topic serving as entry-point to the world of physics for many conventional students. In the Waldorf curriculum, mechanics is not introduced until the 7th grade for a very specific reason: to avoid mechanical thinking prevalent today. Natural phenomena such as heat, magnetism or electricity are usually described and explained in mechanistic terms: thus, heat is simply reduced to the movement of molecules, a magnet is made of tiny molecular magnets, and electricity is a flow of electrons. Such theories are doubtless useful – people advanced their knowledge of natural laws through them. But they don't lead to meet the being of nature. Bringing such theories prematurely might draw a curtain in front of the essence of natural things. A mechanical explanation would take away the wonder, and makes the phenomena appear less fantastic. Close observation, wonder, and astonishment bring the children closer to nature and natural phenomena.

Then, in the 7th grade, mechanics is a foundational theme in the block. This was taken up by studying the "technology of lifting" which includes the lever, the inclined plane, the winch, screw, block & tackle, as well as gear mechanisms. Mathematical formulae have been introduced in their algebra block, so now the children are also able to calculate everything and apply their algebra

skills in another way. The highlight of the 7th grade physics curriculum is the understanding of a clockwork mechanism.

The 8th grade curriculum indications point to a study of weather, climates, and currents in fluids. To me, it almost appears as if these areas offer a counterpoint to the precise calculations and mechanical processes studied in 7th grade. Weather, climates and currents are not completely predictable. Thus, the 8th grade physics curriculum seems to undermine the physics knowledge acquired during the 7th grade.

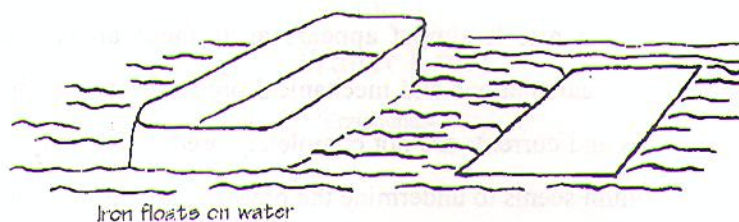
In summary, the Waldorf curriculum approaches middle school physics the following way: In 6th grade the artistic is used to draw the children into astonishment at the wonders of natural phenomena, avoiding the use of mechanical theories for explanation. In the 7th grade, the children are introduced to the logic behind mechanics, and everything can be determined through calculation. In 8th grade, then, the children realize that not everything is so easily calculated and predictable as in mechanics; but that there is real wonder in physics also.

The following is a sketch of one possible 8th grade physics block, based on these foundations. This physics block can be divided into five broad sub-topics: hydrostatics (the study of resting water), hydrodynamics (moving water), aerostatics (the study of resting air), aerodynamics (moving air), and meteorology (the study of weather) is the culmination.¹ Eighth graders are proud when their main lesson books can include such beautifully unusual words, such juicy technical terms.

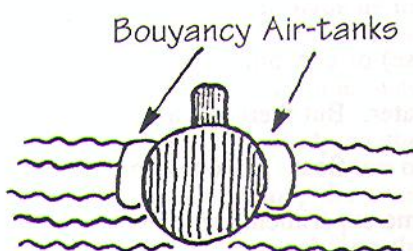
Hydrostatics is a bit of a reminiscence of the 7th grade physics curriculum. The key question of hydrostatics where we start is: *what floats?* Then to clarify this question further, we will need to demonstrate qualitatively different ways of floating. The teacher needs to carefully select a variety of common objects and materials for classroom experiments in an aquarium or wash tub. For example, preferably using a piece of ebony (dense) or coconut shell, the teacher can demonstrate that woody material floats on water. But there are also wooden objects (like wet wood or a wooden block) that do *not* float. So, one cannot state that "wood floats" by nature. Then, you make some experiments with rocks. The students will expect all rocks to 'drown,' because rocks naturally sink in water.

the curriculum also calls for electricity and magnetism. Ed.

However, pumice stone and sprayed concrete stay afloat! Consequently it cannot be stated that all rocks & stones sink in water.



Next, we experiment with metals, using screws, money or even the teacher's wedding ring. This time it can be safely noted that all metals sink. However, a nice and flat empty sardine can will float like a boat, even though it is made of metal. How can the metal can float? Floating devices need to have a *particular shape*: the can is hollow. When we tilt it to let water get in, the can will sink to the bottom of the aquarium. Now, the students can understand why iron ships can float: the hollow space below decks allows them to. (By the way, the sardine can will float also upside down.) The next step is to take a nice, flat, thin piece of metal. It also floats on the water (see figure). (Practice ahead of time, laying the metal piece on the water!) The surface tension of the water carries the metal, until a student gets the idea of tilting it or pushing it down on one side with a finger. Then, the metal sheet glides to the bottom of the aquarium in zigzag-fashion. Many times I fooled my students with a matchbox that sinks to the bottom of the aquarium – because I had filled it with lead. Then, we try out luck with a selection of synthetic materials like rubber or glass. Experiment with a thin glass plate, an empty glass bottle, a glass bottle filled half way with water, etc.. With lots of patience this glass bottle filled with water can be maintained just 'afloat' or "awash" in the water, which is a state between floating and sinking. Fish can 'hover' under the water; ships that can hover at a given depth under the water are submarines.



But, how is it that submarines can manage then to surface, to go up and float on top of the water? Bouyancy tanks (see picture 2), situated on each side of the submarine's hull, are blown out with compressed air, and lift it up to the water

surface. Can rubber float? Try different rubber balls; I've surprised classes with a ball that sinks rapidly (filled with lead shot).

Finally, we come to the question whether the human being is able stay afloat. Lying on our back with a lung-full of air, people can float on the water, but just barely; only eyes, nose and mouth are above the surface. To really float above the water, we need to move, and that is part of *hydrodynamics*.

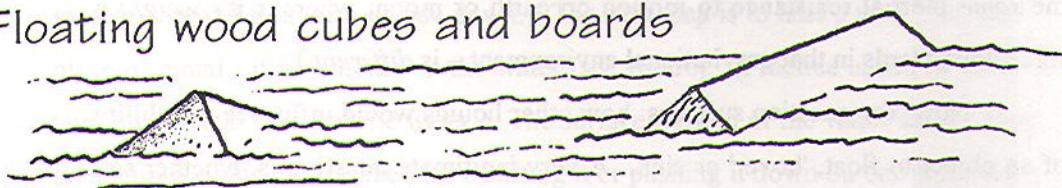
Offering the students the insight that we, as human beings, are very similar in weight to water, we can attempt to summarize all previous experiments. We say: *all materials whose specific weight is less than water, can float; and objects whose specific weight is greater than water, will sink*. Materials of similar or the same weight as water will remain afloat. Hollow and flat objects, however, are exceptions. I leave out details about deriving the overall density or "specific gravity" of an object in g/cm^3 by measuring its weight divided by its volume. I only mention that specific weight is based on the weight of 1 cm^3 of a substance; water's specific weight is 1 g/cm^3 . In 8th grade, I can be allowed to somewhat incorrectly speak of 1 gram (unit of mass) as a unit of 'weight' [A given *mass* has the *same* inertial resistance to motion on earth or moon; whereas it's *weight* – force downwards in that gravitational environment – is *different*.]

Now, the question surfaces: how other liquids would influence the ability of an object to float, 'hover' or sink. A very legitimate question is, whether salt water buoys us up better than 'sweet' water. Anyone who has been at the ocean knows that salt water "carries" better than fresh water. (In the Dead Sea, or the Great Salt lake, people can even "sit" afloat and read a newspaper!) Salt water is heavier than sweet water and ships lay higher in salty ocean water than they do in a freshwater lake. Under normal circumstances, mercury is a liquid, and 13.6 times heavier than water. That's why iron can float on quicksilver. With great precaution this can be demonstrated in the classroom. You just have to put a large pan underneath to catch eventual quicksilver drops splattering out. [HAZARD - MERCURY IS POISONOUS.] (But, please, don't use your wedding ring this time, because it will not only sink but will even dissolve in quicksilver.) In mineral spirits, many objects that normally float on water will sink. Now, we need to expand our earlier statements the following way. An object floats, 'hovers' or sinks depending on its weight (whether it is lighter, the same weight, or heavier than the liquid). Now, we can establish a table for the main lesson notebook, in which we note the specific weight of various liquid and solid substances. Then one can predict easily which substance would float on another.

Table of specific weights (in g/cm^3)

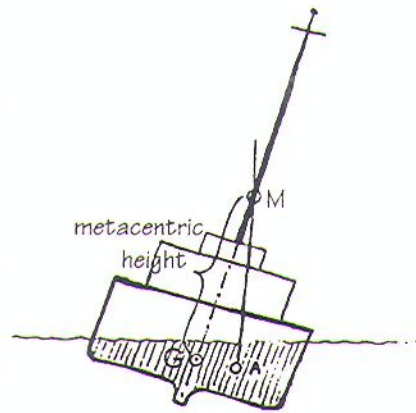
water	1.0	coconut shell	1.4
gasoline	0.7	concrete	2.2
alcohol	0.8	brick	2.6
oil	0.8 - 0.9	basalt	3.0
glycerin	1.3	aluminum	2.7
mercury	13.6	iron	7.8
packaging foam	0.03	lead	11.3
cork	0.2	gold	19.2
spruce	0.5	ice	0.9
oak wood	0.8		

Floating wood cubes and boards



The question about various *qualities* of floating, posed in the beginning, still remains un-answered. For example, a foam cube floats on one side of the cube, while a cube of oak floats on a corner! This phenomena can be observed particularly well when the two cubes, one of foam and the other of oak, are placed inside an empty aquarium, which then is filled with water. The foam cube will be simply lifted up by the water, remaining in the same position, yet on top of the water surface. The oak cube, however, will turn onto one of the edges, then, it will turn onto a corner and as the water level rises, it lifts up in the corner position and floats. A board floats on its largest surface and a square beam floats on it's side edge, unless it is out of very light material (see picture 3). A totally homogenous sphere floats in any position equally well, however deep it sits in the water.

Floating position is very crucial for ships, because a ship needs to be able to "right itself" (self-correct its floating position from a temporary imbalance). This is a question of stability of position. The stability of floating position stays in direct correlation with the "metacentric height." The metacentric height is calculated from the distance between the center of gravity of the ship (G) and the



center of gravity of the ship (G) and the metacenter (M). The metacenter is established by the intersection of the perpendicular up from the center of buoyancy (A) with the symmetry axis of the ship. The center of buoyancy A is our best guess at the mid-point of the cross section of the ship which is under water at that moment. The deeper the center of gravity lies in the hull, the easier the ship rights itself. That's why in the olden days, knowledgeable sailors tied rocks to the lowest part of the keel in sail boats.

This is a good point to bring in the story of Archimedes of Syracuse, who needed to prove whether his king's crown was made out of pure gold or not. The king had weighed the gold given to the metalsmith beforehand. The finished beautifully-worked crown weighed the same as the gold provided, but it seemed a bit more shiny. Is he stealing from the king by using a mixture of less precious silver & gold? The king's 'scientist' Archimedes finally solved the puzzle. People say he stumbled on the solution as he sat in the bath, and saw how water spilled out as his body went in. So Archimedes weighed the crown again, but under water. The crown on one pan was balanced on the other pan with a piece of pure gold of the same weight. See, the pan with the crown had risen! The crown weighed less under water than the gold. The lighter silver mixed in with the metal requires more volume to make the same weight, and therefore produces more buoyancy in water. The thievery of the goldsmith was uncovered, and he was beheaded – the poor man.

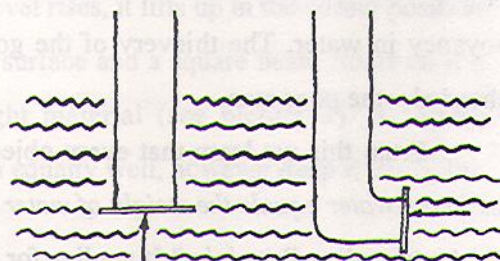
From this we learn that every object in water loses weight. *The weight loss in the water equals the weight of water displaced by the object.* This is called the "Archimedian Principle." It applies for other fluids as well, even for air – as we will see. What can we calculate with this wonderful law? Now, the students can get to work measuring length, width and height of a matchbox, pondering the

question of how much weight can be loaded onto this object, so that the object can float above the water or stay just 'afloat' in the water. Or, a life-sized question: some boys discovered a water-proof box and want to use it for a boat trip. The average weight of 1 boy = 40 kg. Find how many *other* boys can also climb in to that box-boat? Or else: a raft already carries 3 children. If we found 3 canisters in the trash (with specific given measurements), and tie them to the bottom of the raft, how many children can *now* ride on the raft safely? Before we attempt to answer these questions, we need to clarify the difference between a boat and a raft. A raft carries only because of the specific weight of its material, which needs to be smaller than 1 g/cm³ (that of water), while a boat carries because of its shape, primarily. Peruvian reed-boats are actually a raft, not a true boat.

Now, another lovely mystery occurs to me, that uses the principle of Archimedes. There are bridges used by ships that transport cargo that cross another river (i.e. water canal). How does this "water bridge" work? To be able to answer this question we need to look at underwater phenomena. We talk about water pressure which increases with the depth of the water. At a depth of 9-10 meter underwater, the water pressure is equivalent to the air pressure, namely 1kg/cm², which can also be referred to as "1 atmosphere." Although the measurement in atmospheres is not completely scientifically precise, I have used it in my classes without scruples, for the sake of simplicity. Imagine that 1kg or 2.24 lbs press on each cm² in 10 meter water! In 20 meter deep water, the pressure is twice as great, etc.. No wonder, then, that it is extremely difficult to escape a drowning car. The pressure on the door is enormous! It depends on the size of the door and the depth of water, and can be easily calculated. The only chance for survival is to take a deep breath, roll down or break a window, and escape though the window of the car.

Water pressure exists in all directions, as the following experiments demonstrate. You need a glass tube (3-5cm in circumference) and a thin glass plate. Place the glass plate on the bottom of the tube and submerge them in an aquarium, without

water pressure experiment



immersing the entire length of the tube. When we submerge the covered glass tube to the bottom of the aquarium, the glass cover stays attached to the tube. When we lift the glass tube slowly toward the water surface, however, the cover stays on for a while, but then detaches and falls off. The cover falls off whenever the water pressure is not strong enough to hold the two objects together. Now, we repeat the same experiment with a glass tube bent to the side, and can observe that the cover on the bent tube stays attached to the tube for the same distance as with the straight tube. This demonstrates that water pressure expands in all directions (see picture 5).

The stone walls of a dam have to be very thick. Their thickness is not dependent on the size of the lake, but solely from the depth of water it retains. When concrete walls are built, we use molds that are very thick and stable. The same principle as for the dam construction is at work here, only that concrete is 2.2 times heavier than water. That's why the forms for poured concrete walls need to be supported with such heavy boards and iron rods.

Now let's turn to **aerostatics**. Keeping our observations close to home, initially, we talk very generally about the differences between water and air. Water has well defined boundaries because at the top there is air and at the bottom there is sand or rock (the bottom of the sea, ocean, lake, river, etc.). Air, on the other hand, has only one sharp border at its lower edge, namely the landscape. It's upper air limits are very loosely defined. With increasing altitude, air simply becomes thinner. But where air ceases to exist is difficult to establish. It simply fades out into space. Going high up into the mountains, one can feel a shortage of air because the air is thinner. Commercial airplanes fly higher than 10,000 m (30,000 feet), so that passengers and crew have to be supplied with air and the airplane's body needs to be airtight. Another difference between water and air is that water cannot be compressed, but air can. This characteristic, the compressability of air, is used in tires for vehicles (cars, bicycles, etc.). A tire filled with water would be very hard and less flexible (as well as heavier).

Air pressure can be measured with a barometer. A barometer shows changes in air pressure and is therefore useful in forecasting the weather (details about the function of a barometer should be extracted from a physics book). Airplane pilots, air balloons and serious mountain climbers use an altimeter, which functions much like a barometer, because it essentially measures the changes in air pressure. Air pressure diminishes with increasing altitude while

water pressure increases with water depth. Furthermore, water pressure increases with regularity and at the same rate, but air pressure follows a different set of laws. Water pressure is consistent, stays the same at a particular level (depth). But, changes in air pressure occur because we are confronted with air currents, air pockets or air holes, mounds of cold or hot air (as discussed in meteorology), etc.

Observing some soap bubbles or dandelion parachutes closely, dancing through the air, we become aware that they are falling to the ground (bound by the principle of gravity), in reality. However, they fall so slowly that the smallest breeze of air uplifts them, changing their course. Other examples are dust particles "dancing" in a beam of sun light entering a room, or clouds descending to the ground (fog), hovering over a meadow and lifting or dispersing when the sun breaks through. Although all these things appear to be "floating" in the air, they are actually just falling very slowly.

Finally, we know that objects cannot float *on* the air like they do on water; they rather 'hover' *in* the air. However, floating in the air is far from being a natural phenomenon. The only objects that do float in the air are balloons – helium as well as hot air balloons. Of course they don't go wherever you want them to go, they go wherever the wind takes them.

How do balloons "fly," anyway? Let us remember the principle of Archimedes which holds also true for air: The weight loss of an object (in this case, of the balloon) is equal to the weight of air replaced by the object (balloon). What does air weigh? In 9th grade this is demonstrated in form of an experiment, but for now, we can just say that 1 liter of air weighs 1.3 g. However, hydrogen weighs only 0.07 g per liter. And 1 liter helium weighs only 0.14 g, twice as much as hydrogen, but still 1/10th of the weight of air. Hydrogen and helium, then, rise in the air because they are lighter.

If you want to calculate the buoyancy of a balloon you need to know the relative weight of the displaced air. That is easy once we establish that the volume of a ball equals $4 \cdot r^3$. A balloon with the diameter of 10 m has $4 \times 5^3 = 500 \text{ m}^3$ volume. Since 1 m^3 of air weighs 1.3 kg, the air replaced by this balloon weighs $500 \times 1.3 \text{ kg} = 650 \text{ kg}$. Calculating, that the weight of the balloon's canvas amounts to 100 kg, another 100 kg for the ropes and the basket, and yet another 50 kg in utilities, there are still 400 kg remaining for the crew, starting with 650 kg of buoyancy. Estimating 80 kg for each adult, the balloon is just able

to carry 5 people. So, with just 4 passengers, the hot air balloon can still rise high into the air.

Going beyond calculations, let us take a look at *hydrodynamics*, the study of *moving* water. You can start by observing a dripping water faucet with the following questions in mind: How do the drops form? How do they fall? (Here you can use Theodore Schwenks' drop pictures.) If you open the water faucet further, the drops develop into a jet stream of water. The keen observer will notice that the jet stream is thick as it exits the faucet and becomes thinner toward the bottom. This water flows in a "laminar" stream. When you open the faucet all the way, the water literally splashes out as a turbulent jet stream. With these simple experiments we introduce *three types of water flow*: dripping, laminar and turbulent. These three forms can all be observed in a mountain stream, separately as well as simultaneously, existing next to and alongside one another.

Looking at a strong, powerful river, we can see that it winds and meanders through the landscape like a snake, unless it is forced by mountains, hills or dams to change its course. In a river bend the water collides with the embankment on the outer side of the bend and carves into the edge of the bank. Sand and small debris are carried away by the current, and washed ashore on the opposite side of the riverbed (the inner side of the bend). Big rocks drop to the base of the embankment and are washed round by the water. If you want to maneuver rowing boat through the currents of this meandering river, you need to calculate your course down the river bends carefully. You need to stay close to the embankment, following the water current, so that you are not pulled backwards by a swirling eddy current. Along the embankment the water is turbulent and flows fast. In a straight river, the water current is the strongest in the center of the riverbed.

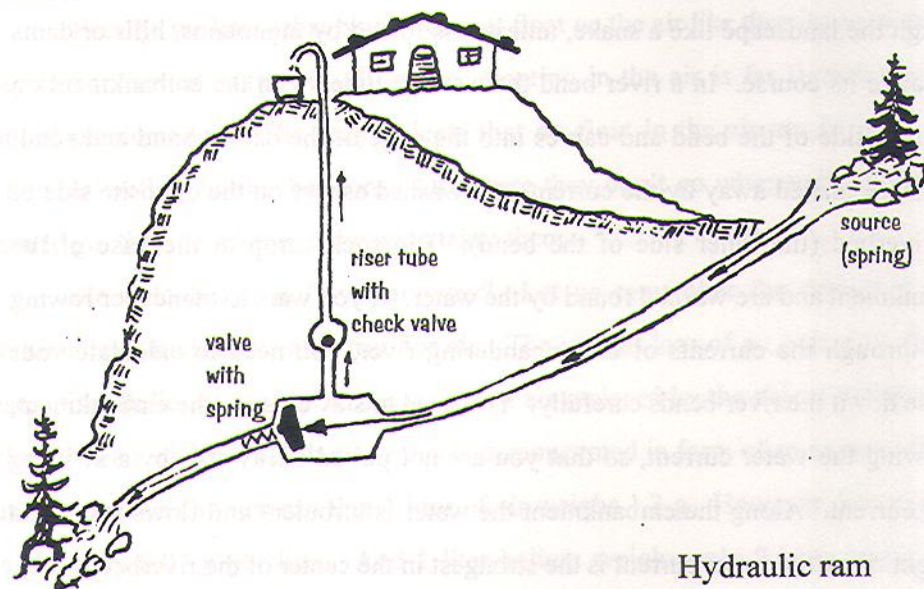


Cross-section of a meandering river.

However, water currents are more complex than discussed because within each river there are two juxtaposed water currents (see figure). The vortex near the steep river embankment, is smaller than the vortex at the shallow side. And,

although hardly noticeable to the eye, the water level is higher on the edges of the river than in the center. This comes in handy for rafters, because they follow the water current as long as they keep in the middle of the river.

When we broaden our perspective, looking at rivers entering the ocean, it almost appears that the rivers come to rest once they enter the sea. However, currents still exist. The major maritime currents are marked on maps. They are like rivers in the sea. The warm Gulf Stream is the most famous. It distinguishes itself from the surrounding waters through its temperature and color. Other streams, like the Bengali stream and the Equatorial stream, are cold. All ocean currents change slightly with the seasons, they exist on different water levels (in layers), and can work their way through different water levels, vertically. Nevertheless maps only register and present horizontally moving surface currents. The regularities of underwater currents are still unclear. We only know that all driving forces for all water streams and currents have to do with the sun.

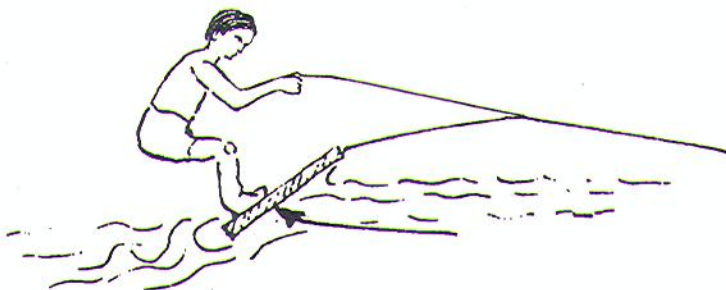


Hydraulic ram

At this point, you can start talking about pumps. Pumps lift or move water with the force of an outside power. You will find plenty of information on pumps in physics books. However, there is one installation which moves (lifts) water out of its own power; it is called a "hydraulic ram". The "hydraulic ram" makes it possible to move/ lift water with its own force and power from the bottom of a hill to the top of the hill. This works the following way: A fairly turbulent mountain stream is channeled into a large tube. This tube is out of solid material. It is wider in the middle than on both ends, where the mountain stream

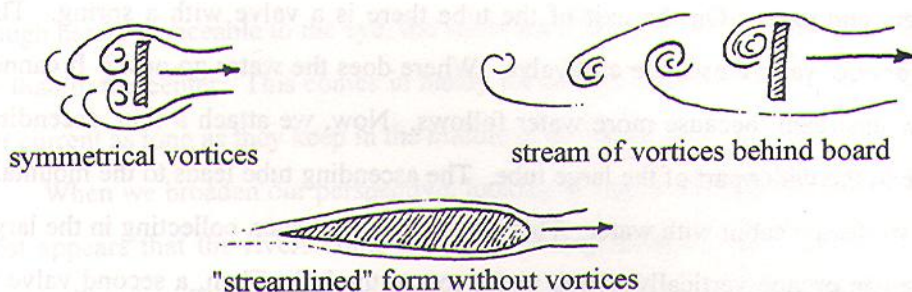
enters and exits. On the exit of the tube there is a valve with a spring. The oncoming water closes the exit valve. Where does the water go now? It cannot flow upstream, because more water follows. Now, we attach a thin, ascending tube to the wider part of the large tube. The ascending tube leads to the mountain top to feed a cabin with water. This way the stalled water, collecting in the large tube can escape vertically, rising to the top of the hill. Then, a second valve is installed in the ascending tube, to prevent the rising water from running back down to the mountain stream. The turbulent mountain stream is forced to take a new course. Inside of the tube the stream is calmed temporarily, in intervals. A strong spring allows the first valve to open, and the overflowing water will close it once more to allow the stalled water to rise in the ascending tube. With precise calculations, one can expect a constant, spasmodic flow of water at the cabin.

So far, we only have looked at moving water. However, hydrodynamics includes also phenomena of moving objects in resting water. The closest personal experience we can rely on in this case is swimming. The position of a swimmer demonstrates a moderate "dynamic buoyancy." The body is slanted, with the head higher than the feet. The oncoming water lifts the forward-moving body slightly in the water. When the swimmer stops to move, he loses his buoyancy and needs to hold onto something in order not to sink. For a water-skier, the dynamic buoyancy is even greater. The skier is moved at great speed. Therefore, the skis can support a whole person above the water. When the speed is reduced, the dynamic load that can be maintained on the skis is reduced and the skier falls back into the water. Another water sport is surfing.



Water Skier

You can let the children experience the function of a surf board by attaching a board with two ropes to both edges of a turbulent stream. Students climb on the board which is positioned perpendicular to the water current. They will be able to balance on the seemingly unstable board. (figure 8)



Flow Vortices in Water

Now, some final experiments demonstrate hydrodynamic phenomena in resting water. Take a long, rectangular container, filled with water (the water does not need to be very deep). Add some fine sawdust and pull a small board through the water. The students will see that a vortex develops behind the board. Observing closely, they can see that at the beginning *two* vortices develop, one on each side edge of the board (see figure 9a). Those are called initial vortices. Then, these vortices continue to form, only on one side at a time, alternating between both sides of the board (see figure 9b). These vortices then curl in opposite directions and develop alternately. Each vortex persists, but weakens as the board moves onward. Thus, a vortex-stream develops. However, if we pull a round log lengthwise through the water, we notice less vortices. And, an object with aerodynamic qualities practically does not leave any vortices behind – the vortex stream disappears quickly. Students need to observe closely and quickly in order to notice these formations and their changes. If you would like to extend the observation time, you can add some glycerin to the water. Photographs of vortices, vortex pools and trains of vortices can also be found in Theodor Schwenk's book: *Sensitive Chaos*, Stuttgart, 1984.

We can observe the currents in a stream as it flows around a bridge piling; the whirls are more complex than they appear to be on the surface. In addition to the surface whirls, there are whirls that go down (move vertically). The oncoming current digs into the ground in front of the post and deposits the lifted sand downstream, behind it. Another vortex form is the one we can observe watching water going down a drain. These vortices also exist in nature. In the case of a swimmer getting caught in such a water whirl pool, there is only one way to survive: following the current where it takes you, namely down to the ground. At the ground, the current weakens and the swimmer can escape it to reach calm water. In one of his stories, Edgar Ellen Poe described a giant whirlpool near the Lofol Island. Although he exaggerated, the fishermen are still careful in this area.

MOVING MONARCH BUTTERFLIES

Sun is compass for migrating butterflies

A "sun compass" lights the way for migrating monarch butterflies on their yearly 2,500-mile trip from southeastern Canada and the eastern United States to winter roosting sites in central Mexico, researchers report.

The butterflies use the sun's position in the sky to tell them which direction is south. Because the sun's position changes throughout the day, the butterflies must consider the time of day when deciding which direction to fly, said ecologist Sandra Perez of the University of Arizona in Tucson.

The butterflies must keep the sun to their left in the morning, fly toward the sun at noon, and keep the sun on the right in the afternoon, she reported in Albuquerque last week at the Ecological Society of America's annual meeting.

To test their theory about the butterflies' navigation rules, Perez and her colleagues at the University of Kansas in Lawrence shifted the biological clock of one group of butterflies six hours by keeping the animals in the dark from midnight to noon. When the clock-shifted butterflies were released at noon, they flew west - just as they would if they were using the morning rule of "keep the sun on your left."

Since no individual monarch butterfly makes the trip more than once, Perez said, the butterflies cannot navigate using learned landmarks or by following an experienced leader.

DALLAS MORNING NEWS

* * * * *

Could our planet be a waterworld?

C U researcher says water might be locked in solid form in Earth's mantle

Colorado Daily Staff Report

The Earth's interior may contain three to five oceans of water locked within billions of crystals that could help regulate the level of water on the surface of the planet, a CU geologist said.

Ten years ago, Professor Joseph Smyth discovered that a mineral called wadsleyite, located 250 miles to 350 miles below the Earth's surface could contain water. The

wadsleyite does not contain liquid water, but holds the elements needed to make water bound up in crystals in solid form.

Smyth chaired a panel of 13 presentations Friday on "Water in the Mantle at the American Geophysical Union meeting in San Francisco. As a rule, rocks on Earth are quite dry — much drier than meteorites, for example, which also contain wadsleyite. Earth rocks generally contain only a small fraction of 1 percent of water. Wadsleyite is about 3.3 percent water.

That may not seem like much, but given the amount of wadsleyite scientists think is in the Earth, it could be three to five times the amount of all the surface water on planet, Smyth said. "It's possible the Earth has this way of regulating the amount of water on the surface," Smyth said. The part of the Earth where leyite is located, the mantle. convects and occasionally breaks through to the surface in the volcanic vents of mid-ocean ridges where the continental plates are spreading.

Water may be carried down into the upper mantle through subduction zones where plates converge, and it is possible that wadsleyite could store large amounts of water in this region, he said. With rising convection currents, the wadsleyite may melt and release water vapor into the oceans as the molten rock cools.

The wadsleyite in the mantle is at a pressure of about three million pounds per square inch and a temperature of about 3,000 degrees Fahrenheit. it is located in the top half of the transition zone between the upper and lower mantle.

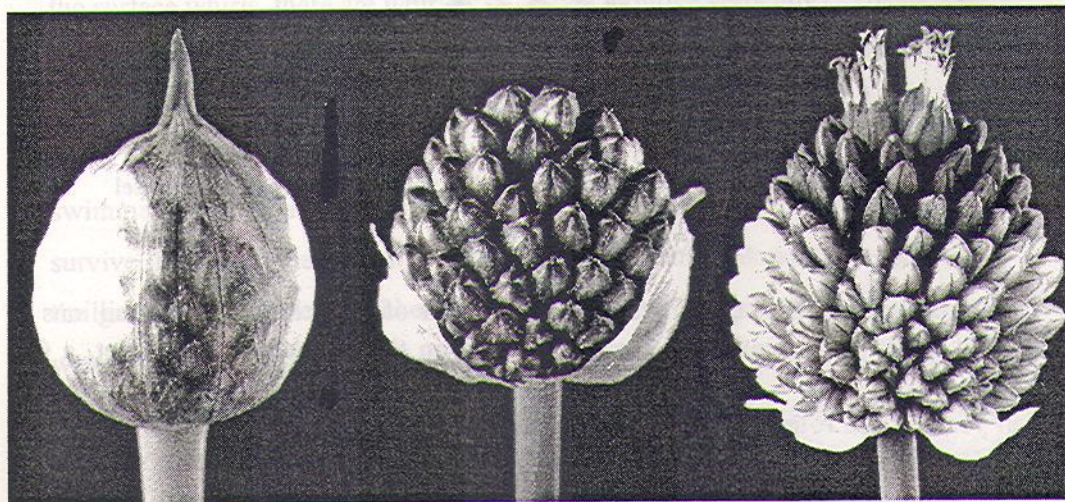
The amount of wadsleyite in the Earth has been calculated. The big question is how much water the wadsleyite contains, and Smyth is conducting laboratory tests to try to find the answer.

His tests consist of making wadsleyite in the lab by squeezing it between two diamonds in a vice, which creates three million pounds of pressure per square inch, and then analyzing the sample with X-rays to determine water content and other physical properties.

Determining the amount of water in wadsleyite would allow scientists to know the speed at which wadsleyite transmits seismic waves. If seismic waves sent through the Earth matched that speed, scientists would know how much the water is held within the Earth.

The Earth's oceans have existed for at least 4 billion years and have been fairly constant in volume over the past 500 million years. These "inner oceans" may play a role in regulating that supply, Smyth said.

In 1996, Smyth also discovered wadsleyite II that may store water under even greater pressures at a lower portion of the transition zone. Two undergraduate students and four graduate students are assisting Smyth on his research.



Introduction of Advanced Arithmetical Operations for a 7th Grade Waldorf Class

The Calculation of a Square Root, Higher Roots

(Complete text will be available from AWSNA Publications in the Spring of 1999)

"From Dividing to Extracting Roots"

by
Ernst Schuberth

When we treated powers we discussed the following example $3^4 = 3 \times 3 \times 3 \times 3 = 81$. How can we now get back from 81 to the root that it has grown out of in four steps? While calculating the power of a number, you have to *multiply*, going back, we have to *divide*. To extract the fourth root of 81 means to find just such a number, that 81 divided by it four times makes 1. Generally, on the left hand side of the root sign $\sqrt[n]{}$ we write the number that indicates which root we have to extract. Underneath the root sign we write the number from which the root is extracted. In our case, we write $\sqrt[4]{81}$ and read: "fourth root of 81." The number outside (⁴) is called the root exponent, 81 the "radicand." If we want to write an n^{th} root of the number a , we write $\sqrt[n]{a}$.

While it was certain that division carried out through multiple subtraction results in 0, here the division has to result in 1, because the number 1 is for multiplication and division, what 0 is for addition and subtraction: neither one alters the value of a number.

If we arrange the repeated divisions when extracting roots accordingly, we lay out the

template: $4 \left\{ \begin{array}{l} 81 \div \text{---} = \text{---} \\ \div \quad \quad = \text{---} \\ \div \quad \quad = \text{---} \\ \div \quad \quad = 1 \end{array} \right.$ Thus, we know the beginning (the number 81 as radicand), the

number of the division (the root exponent 4), and the result 1. Which number is it?

If at first we deliberately choose a number that is too small, for example 2, dividing

four times gives us: $4 \left\{ \begin{array}{l} 81 \div 2 = 40 \\ 40 \div 2 = 20 \\ 20 \div 2 = 10 \\ 10 \div 2 = 5 > 1 \end{array} \right.$

Since after the four divisions a number larger than 1 emerged, the divisor, that is the assumed value of the root, must have been too small. If we check the number 4, we get:

$4 \left\{ \begin{array}{l} 81 \div 4 = 20 \\ 20 \div 4 = 5 \\ 5 \div 4 = 1.25 \\ 1.25 \div 4 = 0.33 < 1 \end{array} \right.$

Because now the result after four divisions was smaller than 1, the assumed value of the root must have been too large. If we correctly choose number 3 as the divisor, we get:

$4 \left\{ \begin{array}{l} 81 \div 3 = 27 \\ 27 \div 3 = 9 \\ 9 \div 3 = 3 \\ 3 \div 3 = 1 \end{array} \right.$ Thus we get $\sqrt[4]{81} = 3$.

A number of integer roots can now be easily calculated in this way. The following examples present themselves:

$\sqrt[3]{8}$, $\sqrt[3]{64}$, , , , , , , etc.

In the next step, any root generally can be characterized as a division exercise:

If we have to extract the 2nd root out of number a, we are looking for number b that leads in two division steps from a to 1.

In the following example, we will call successive quotients that occur in divisions q_1, q_2 , etc. $2 \begin{cases} a \div b = q_1 \\ q_1 \div b = 1 \end{cases}$ By looking at the last line we see that in this case $q_1 = b$. Thus we can

also write: $2 \begin{cases} a \div b = q_1 \\ b \div b = 1 \end{cases}$ If we are looking for the third root of a we must find a b that

leads to the number in three division steps: $3 \begin{cases} a \div b = q_1 \\ q_1 \div b = q_2 \\ q_2 \div b = 1 \end{cases}$ This time $q_2 = b$, so that we can

also write: $3 \begin{cases} a \div b = q_1 \\ q_1 \div b = b \\ b \div b = 1 \end{cases}$

If we are looking for the nth root of a, we have to find a number b, that leads from a to the number 1 in n division steps: $n \begin{cases} a \div b = q_1 \\ q_1 \div b = q_2 \\ \dots \\ b \div b = 1 \end{cases}$

With this we have in general terms (in pure terms) traced extracting roots back to dividing. We have refrained from using general indices, because we were thinking in terms of a description appropriate for a 7th grade. Otherwise we would write:

$$n \begin{cases} a \div b = q_1 \\ q_1 \div b = q_2 \\ \dots \\ q_{n-2} \div b = q_{n-1} \\ q_{n-1} \div b = 1 \end{cases}$$

Tracing back extracting roots to dividing can also be helpful if we cannot determine roots exactly but want to *estimate* their value. If, for example, we are looking for the third

root of 100, we start calculating like this: $3 \begin{cases} 100 \div = \\ \div = \\ \div = 1 \end{cases}$ If we choose the number 4 as an

assumed root value, we get: $3 \begin{cases} 100 \div 4 = 25 \\ 25 \div 4 = 6.25 \\ 6.25 \div 4 = 1.55 > 1 \end{cases}$ Thus 4 is too small. Choose 5, we get:

$3 \begin{cases} 100 \div 5 = 20 \\ 20 \div 5 = 4 \\ 4 \div 5 = 0.8 < 1 \end{cases}$ Thus, the number 5 is *too large*. From these two calculations we can

draw one certain conclusion: If we *converge towards the value of the root in decimal steps, the number has to have a 4 before the comma*.

If we check decimal fractions we can always see if they are too large or too small. In our case, 4.6 leads to $3 \begin{cases} 100 \div 4.6 = 21.7 \\ 21.7 \div 4.6 = 4.7 \\ 4.7 \div 4.6 = 1.02 > 1 \end{cases}$ Thus 4.6 is *too small*. If we check 4.7 we get

$3 \begin{cases} 100 \div 4.7 = 21.3 \\ 21.3 \div 4.7 = 4.5 \\ 4.5 \div 4.7 = 0.95 < 1 \end{cases}$

Thus 4.7 is *too large*. Consequently, the approximation to the root value as a decimal fraction has to have the digit 6 after the decimal: $\sqrt[3]{100} \quad 4.6\dots$

In the next step, we can try 4.64

$$3 \begin{cases} 100 \div 4.64 = 21.55 \\ 21.55 \div 4.64 = 4.645 \\ 4.645 \div 4.64 = 1.001 > 1 \end{cases}$$

Thus, 4.64 is *too small*: but in this case we have to consider several digits after the decimal in order to be certain. If we check 4.65 we get:

$$3 \begin{cases} 100 \div 4.65 = 21.505 \\ 21.55 \div 4.65 = 4.625 \\ 4.625 \div 4.65 = 0.994 < 1 \end{cases}$$

Thus, 4.65 is *too large*. The next digit in the converging root value is 4:
 $\sqrt[3]{100} = 4.64$

If we check this result, through re-calculating a 3rd power, we get: $4.64^3 = 99.897344$

An error of approximately $1/10^{\text{th}}$ remains.

In principle, we can converge on the root value through continued division in this way. *Will we ever be able to determine it exactly?*

At this point the question of *irrational numbers* appears. We can tell the children that most root values can actually never be exactly presented through decimal fractions or even through normal fractions. Probably the easiest example is $\sqrt[3]{2}$. Which number d , leads after 2 divisions from the number 2 to the number 1?

$$2 \begin{cases} 2 \div d = d \\ d \div d = 1 \end{cases}$$

The children can try for a long time. Finally we can tell them: $\sqrt[3]{2} \quad 1.414213452$

But if you multiply this 'approximation value' with itself, you do *not* get the number 2 back again. The Greeks were deeply shocked by the discovery of such "irrational" numbers. The following sentence is recorded in the Scholien of Euclid: *"There is a Pythagorean story that the first who revealed that theory (about the irrational) to the public was shipwrecked, and maybe they wanted to suggest that everything irrational in the universe should remain hidden as something 'unspeakable and formless' and that, if someone encounters such a form of life with his soul and makes it accessible and brings it into the public, then he will be drawn into the ocean of creation and will be washed by its currents."*

What remains unsatisfactory in the previous calculation of an exact or converged root value is the fact that we have to look for it in such an unsystematic way. That is why mathematicians have again and again thought about how a root value can be determined as effectively as possible. They discovered a number of different procedures, one of which we will discuss in the following chapter. The basic arithmetical operations, a knowledge of the first square numbers and the first binomial formula $(a + b)^2 = a^2 + 2ab + b^2$ are necessary for this.

What is Lambda (λ)?

by

Martin Levin Ph.D.

One woman, having just completed a lecture course by Lawrence Edwards, said "Oh, that was so inspiring! I just have one question. 'What's λ ?' " This little pamphlet will answer that question in a fashion that can be easily understood, even by someone with very little mathematical background.

Imagine that a plane is set into motion in such fashion that each point is moved to another point in the plane, and each line is moved to another line in the plane. In other words, if several points lie on a straight line X, then after they are moved they will again lie on a straight line. Such a movement is called a "projective transformation" of the plane to itself.

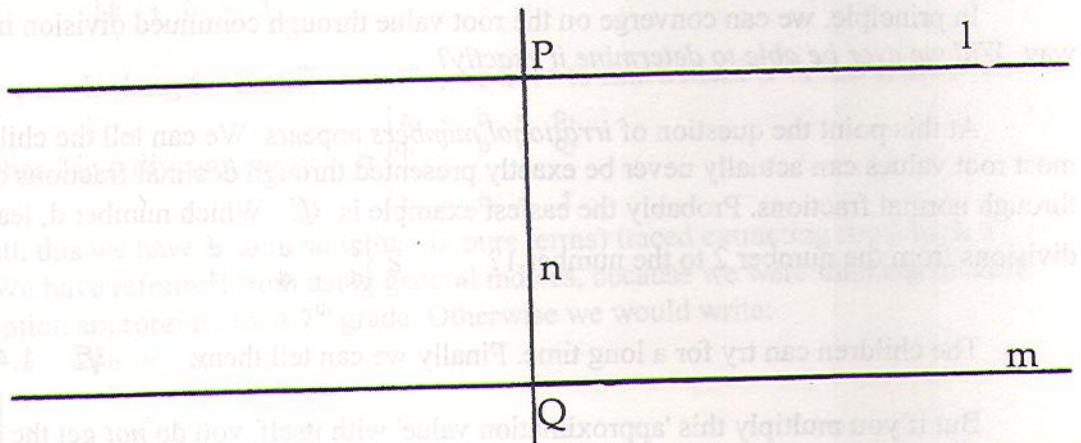


Figure 1

We are interested in the projective transformations which leave invariant the points and lines shown in figure 1. This means that the transformation will leave each of the points, P and Q, right where they are (they are therefore called "fixed points"), and the points on line l must be moved to other points on line l, so that line l as a whole is left in the same place and similarly for lines m and n.

There are many such transformations of the plane, leaving invariant the points, P, Q, and the lines l, m, n. By observing the paths that they move points along, we will arrive at the path curves. To begin with we will form the path curves that are symmetrical from top to bottom. (These have a λ -value of 1.) Then we will show how the construction can be modified to give path curves that are more pointed at the top and blunter at the bottom. (These have a λ -value greater than 1. The greater the value of λ , the more pointed on top and blunt on the bottom the curve becomes.)

Proceed with the construction as follows. Draw in helping lines, h1 and h2, and starting point W, as shown in figure 2.

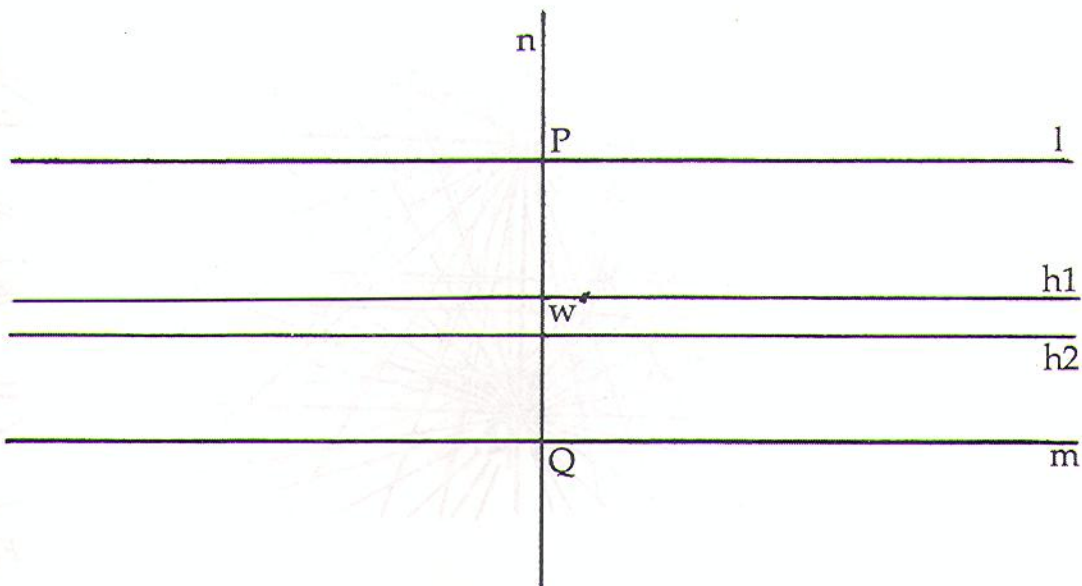


Figure 2

Next join points P and W with a line. The point where that line crosses h2 we in turn join to P. Continuing in this fashion we form the zig-zag of lines between h1 and h2 that is shown in Figure 3.

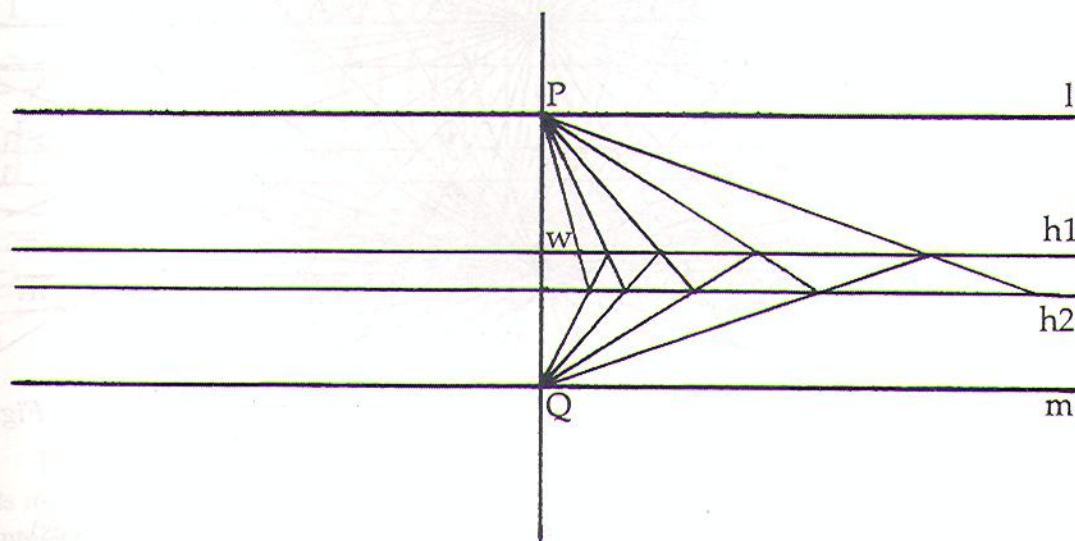


Figure 3

If in figure 3 the lines are extended and the left side is filled in, then the result is figure 4, below.

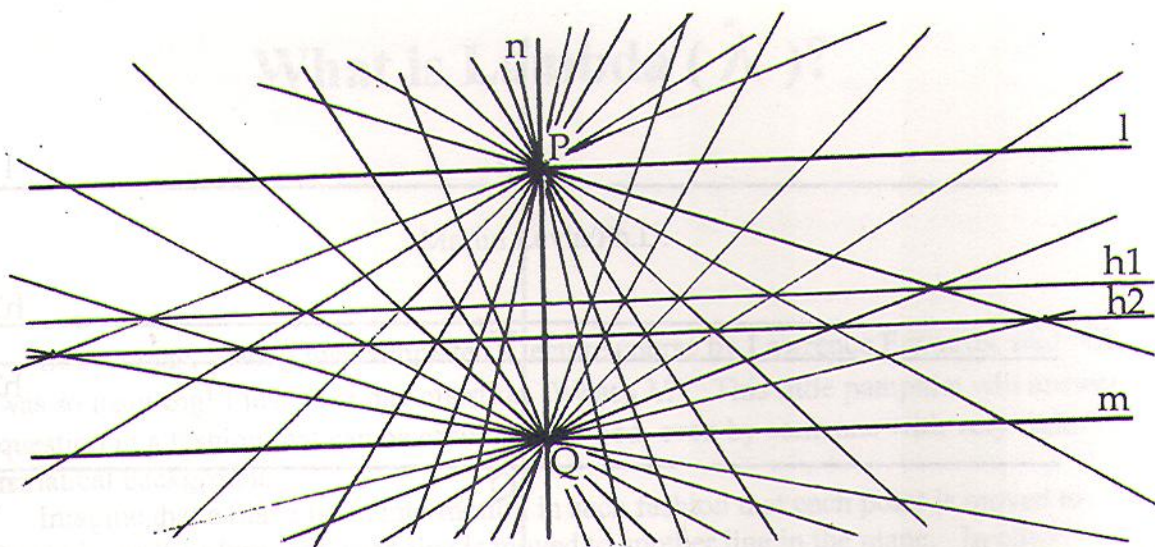


Figure 4

Unfortunately, the intersections with the helping lines, h_1 and h_2 , run off the page. By adding the further helping lines, h_3 and h_4 , we can continue the drawing further as in figure 5.

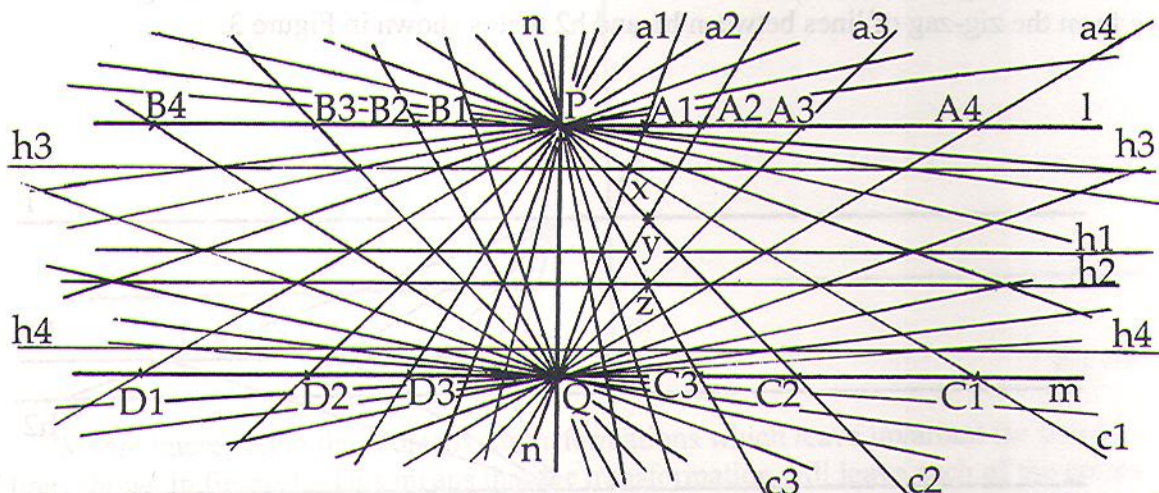


Figure 5

Now we are ready to fill in the path curves for $\lambda = 1$ (i.e. the symmetrical ones). Imagine that the whole of figure 5 is in movement. Point P remains fixed. The line l expands outward from point P with point A_1 moving to A_2 , A_2 to A_3 , etc. and B_1 to B_2 , etc. Point Q remains fixed. The line m contracts inward to point Q with point C_1 moving to C_2 , D_1 to D_2 , etc. The pencil of lines through point P is in movement; the lines through P all move away from line l toward line n with c_1 moving to c_2 , etc. Similarly the lines through point Q all move around Q, so that they are moving away from line n , towards line m with a_1 moving to a_2 , etc. It is clear from this that point X must move to point Y (since lines a_1 and c_1 which meet at X move to a_2 and c_2 which meet at Y). Similarly, point Y must move to Z, and so on. Therefore, as the transformation is repeatedly applied, point X will move along a curve which goes through points Y and Z and continues on as shown in figure 6. This curve is called a "path curve."

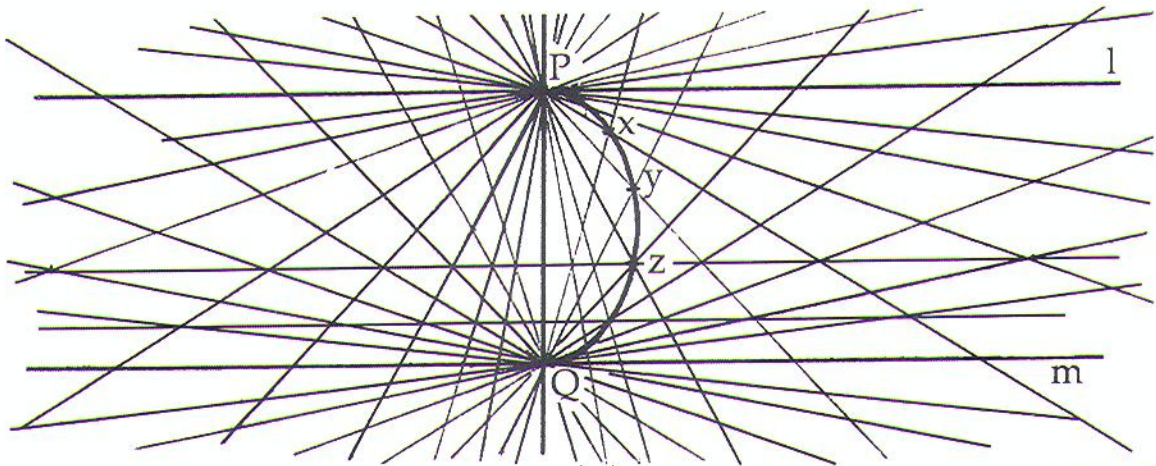


Figure 6

If we watch other points moving under the transformation, we see them trace out other path curves as shown in figure 7.

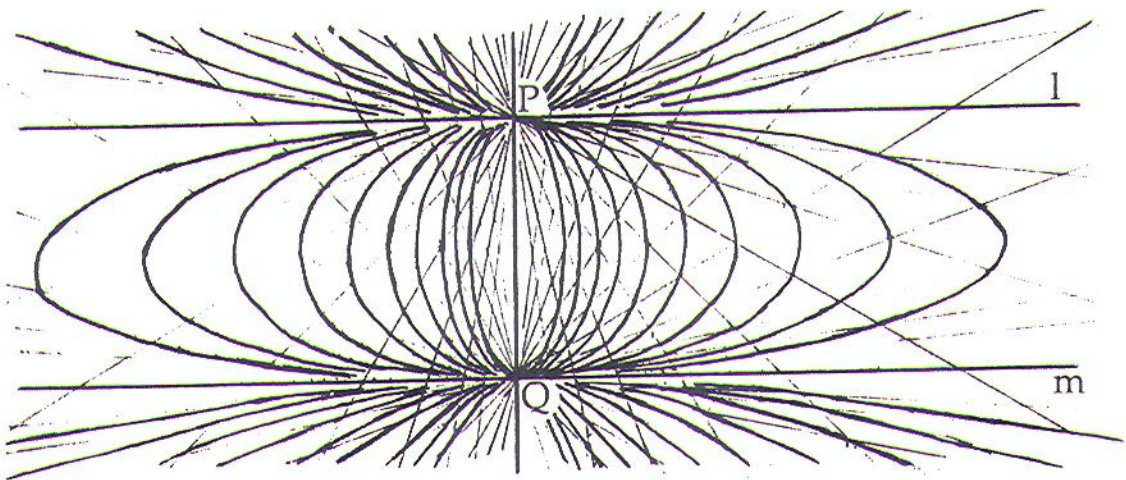


Figure 7 Path curves with $\lambda = 1$.

To appreciate figure 7, imagine the whole plane in movement in such a fashion that all points move along these path curves. All points are moving out from point P (the "source") and into point Q (the "sink"). In their movement the points trace out the path curves. In between the path curves that we have drawn there are of course others which we have not drawn in. So, we must imagine the whole plane filled with these path curves. These path curves are all symmetrical from top to bottom. We say that they have a λ -value of 1, because the points move out along line l at the same rate that they move in along line m. If we change the relative rates of movement along lines l and m, then we get a different value for λ , and differently shaped path curves. For instance, if we make exactly the same drawing as figure 5, but omit every other line through point Q (We just need to mark the points where a line to be omitted crosses the helping lines, but can omit the rest of the line.), then the result is figure 8.

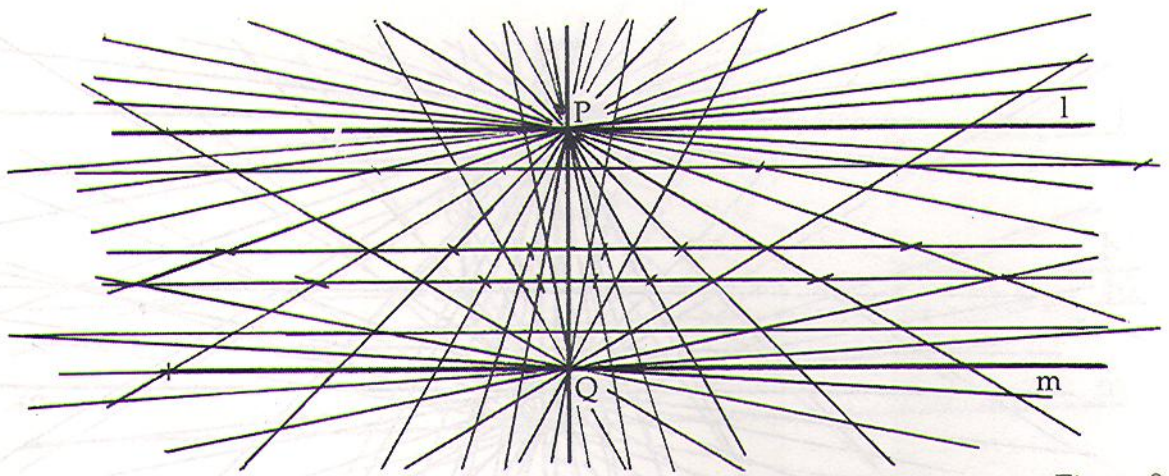


Figure 8

In figure 8 the points are moving outward along line l twice as fast as they are moving inward along line m . So we say that the resulting path curves, shown in figure 9, have a λ -value of 2. These curves are not symmetrical from top to bottom. In fact, the tops are pointed and the bottoms are blunt.

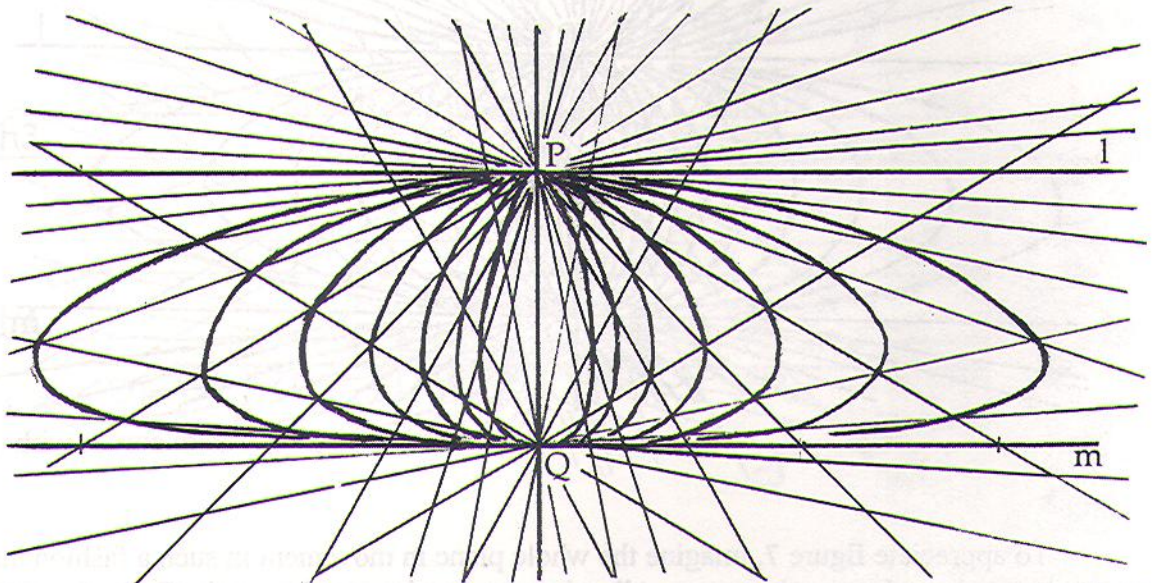


Figure 9 Path curves with $\lambda = 2$.

The larger the value of λ , the more pointed will become the top of the curve and the more blunt will become its bottom.

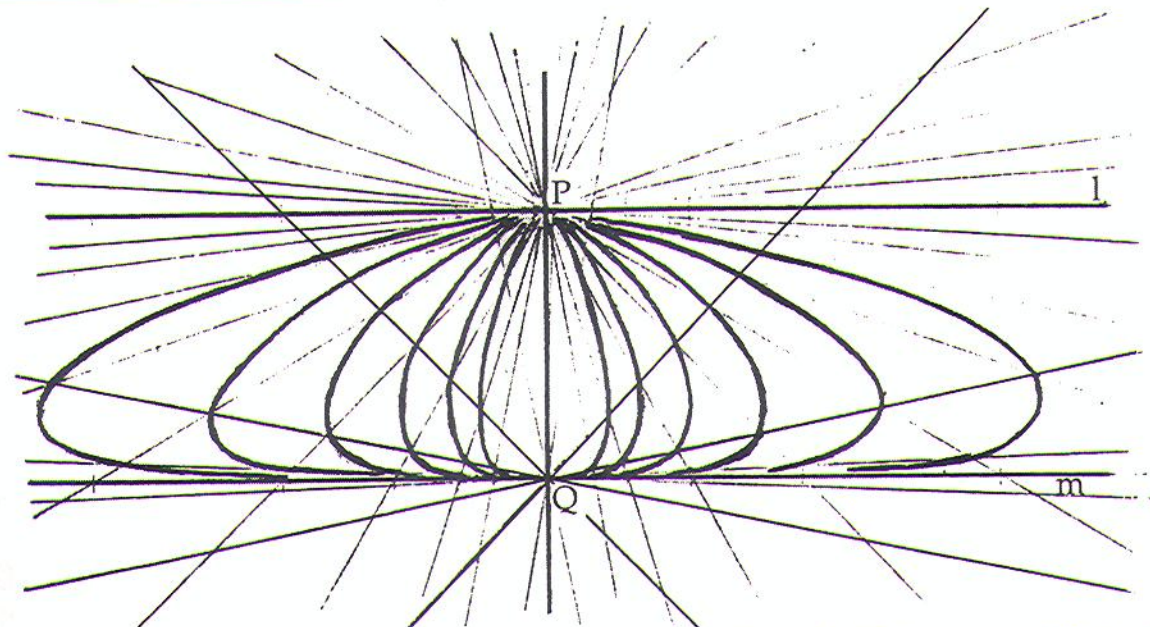


Figure 10 Path curves with $\lambda = 3$

Line l expands 3 times as quickly as line m contracts.
The construction uses every third line through Q.

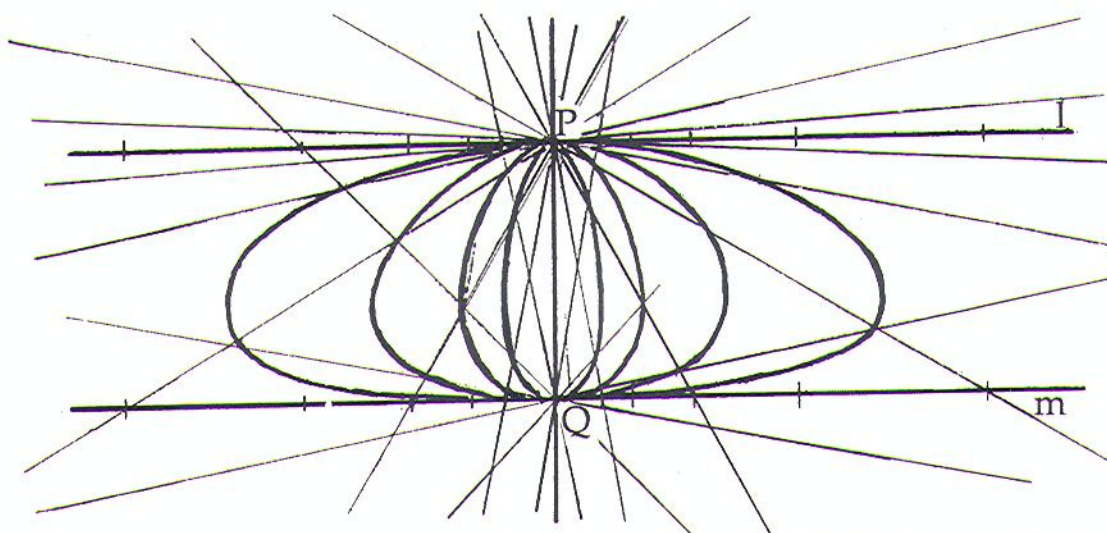


Figure 11 Path curves with $\lambda = 3/2$

Every second line through P and every third line through Q is included. So, line l expands at $3/2$ the rate at which line m contracts.

Note that turning a drawing upside down also turns the value of λ upside down. For instance figure 9, turned upside down, would have the top horizontal line moving at $1/2$ the rate of the bottom horizontal line, giving a λ -value of $1/2$. Similarly, figures 10 and 11, turned upside down, would have λ -values of $1/3$ and $2/3$ respectively.

In summary the λ -value indicates the relative rates of growth of the two horizontal invariant lines, l and m, and determines the shapes of the corresponding path curves.

Note: This article was intended as an introduction to Lawrence Edward's course entitled "The Vortex of Life" offered at the Rudolf Steiner Institute.

EXPERIMENT

Gr 10 Chem: Experiment

Decomposition of Salts by Fire

In this experiment, we will investigate the process of decomposition of a salt (lime saltpeter) as well as the decomposition products. Although our salt is chosen for its lower decomposition point, the same pattern holds for other salts, just at more intense conditions.

PROCEDURE

PART I - INITIAL HEATING

- Place about 10g of calcium nitrate ("lime saltpeter") in a 20mm Pyrex™ test tube. Using a Bunsen burner on low, begin heating this "reaction tube" gently, and observe the change in the crystalline powder, and the appearance of the sides of the test tube. *{very quickly <43°C, "water of hydration" is liberated & appears as 'mist' on the t-t walls, and the powder dissolves in its own 'crystal'-water' - it doesn't really 'melt'}*

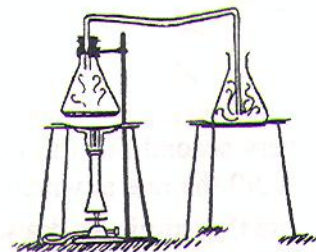
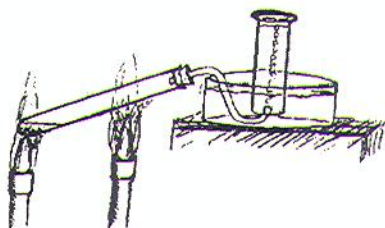
STAGE II - FURTHER HEATING

- Adjust the burner to a hotter flame, and continue heating more intensely, observing the salt in the bottom of the test tube. *{>200°C the water vapor disappears; the salt solution becomes yellowish, then foams up, and becomes dry-solid}.*

Now, insert a cork and glass tube into the test tube, to capture any gases produced in later steps (see illustration).

STAGE III - INTENSE HEATING

- Heating very intensely, observe a further change in the salt. *{the dryish residue now again becomes liquid, truly melting at its melting point 561°C, as the glass t-t starts to reach red heat; CARE that Pyrex tube is not chilled causing it to crack.}*
- Observe the colored gas produced over the salt layer at the bottom of the test tube. *{the decomposition produces NO & N₂O₄ (g) in equilibrium, which are toxic; use ventilation}*
Heat further still; observe any change(s). *{Further heating of the liquid, produces yet another whitish dry solid – CaO }*
- Allow the reaction tube to cool, setting it aside in a porcelain dish.
- Now, add distilled water to the gas collecting tube, stopper it and shake. Observe the color of the gas contents; taste a few drops of the water, now; how does it taste? Do you smell any odor from the tube? Add a few drops of indicator (red cabbage or litmus) and note the color produced.
- Once the reaction tube has cooled, now add a few drops of indicator (red cabbage or litmus) to it, and note the color produced. What does this indicate?



EXPERIMENTAL OBSERVATIONS & DATA

Your data section should include the following:

drawing of the appearance of the saltpeter and reaction tube upon gentle heating (stage 1)

Observations of stage 2: more intense heating

Observations of stage 3: very intense heating

Observations of stage 3b: after very intense heating

An anti-gravity machine!

There are real anti-gravity machines in the news – passenger trains that use magnetism to overcome gravity. Here's a small-scale demonstration.

You'll need:

- Four square magnets with holes in their centers
- Pencil, straw or thin wooden rod that fits easily through the holes
- Pen or marker

Part one

On one magnet, mark one face with an "X" and one with an "O."

Take a second magnet, and see which side wants to stick to the "X" side of the first magnet. Mark that side with an "O," and put an "X" on the other side.

Take the third magnet, and mark an "X" on the side that sticks to the "O" side of the second magnet. Mark "O" on the other side.

Test and mark magnet No. 4 the same way.

NOTE: X and O correspond to north (N) and south (S) but unless you test the magnets with a compass, you don't know which is which.

Part two

Slide the magnets onto the rod so that **UNLIKE** sides face each other. They will stick together in a block.

Now arrange the magnets with **LIKE** sides facing each other. Keep your fingers at the rod ends, or the magnets may jump off!

What happens?

The magnets **repel** each other and appear to float up and down the rod.

This is the same force – magnetism – that makes a "maglev," or magnetic levitation, train float above its tracks.



SOURCE: Weekly Reader