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WALDORF SCIENCE NEWSLETTER

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Waldorf Science

Explorations in Phenomenology as Practiced in Waldorf Schools

A Science News Roundletter

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VOL. 16, #26

Spring 2010

FROM THE EDITOR

Indications and quantifiable results¹ suggest that the subject of Waldorf science has both improved and strengthened in the past decade. More Waldorf graduates report that they selected a science major in college and that they felt better prepared than past graduates reported. We consider this a positive sign and applaud the teachers who have made this a reality.

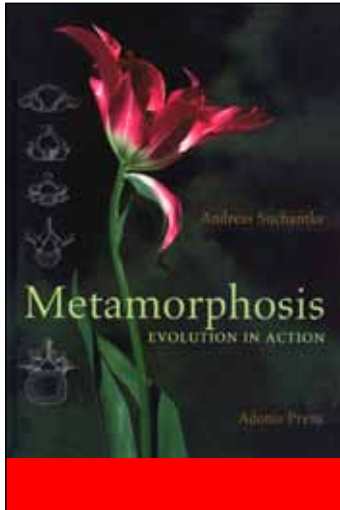
Our capable co-editor for the past several years, Bob Amos, has left his teaching position and had to pull back as co-editor from the *Waldorf Science Newsletter*. Bob is a valued friend and was a trusted support in the production of this effort and I will miss him. A replacement for Bob is sought and interested individuals should contact me with a résumé at the above address. The tasks include gathering material, proofreading, and having an interest in science and phenomenology.

This edition features the following: “Going through, Taking in, Considering: A Three-Phase Process of Learning as a Method of Teaching in Main Lesson Blocks” by Manfred von Mackensen; “The Geometry of Life” Toward a Science of Form” by Arthur Zajonc; “Phenomenology: Husserl’s Philosophy and Goethe’s Approach to Science” by Michael Holdrege; and the “First Approach to Mineralogy” by Frederick Hiebel. Also included are instructions for growing salt crystals, as well as articles on the beauty of slime molds and symbiotic mutualism. An interview with Daniel Pink gives an outside perspective on Waldorf education and caps off this edition.

The editor would be overjoyed to receive contributions from all teachers. It is hoped that this edition will be helpful and informative for teachers, parents, and individuals training to be Waldorf teachers.

¹. *Survey of Waldorf Graduates, Phase II*, Research Institute for Waldorf Education, 2007.

Books of Interest



Metamorphosis: Evolution in Action by Andreas Suchantke

Suchantke is a teacher and biological researcher who has spent his life observing phenomena and the formative principles which shape them. Following in Goethe's footsteps he shows how the development and evolution of plants and animals can be understood in terms of metamorphosis.

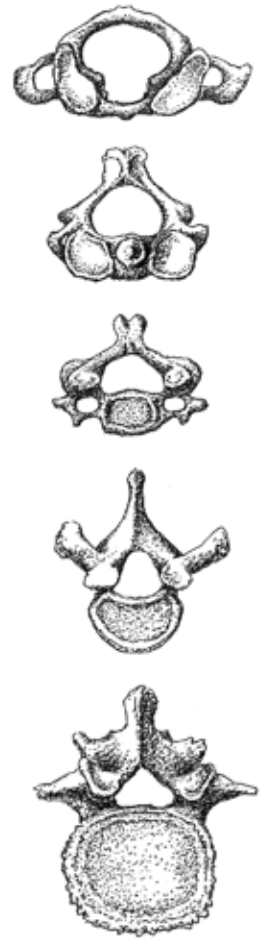


Metamorphic sequence in a peony (cultivated double form)— leaf sequence from the upper leaves via calyx to petals, continuing with intermediate forms, part petal and part stamen, and finishing up with a normal stamen.

Suchantke urges us to observe and then think about nature with fresh eyes. The book covers a wide range of topics including: plants, mammals, birds, butterflies, insects, molluscs and the human being. Each is examined from the perspective of metamorphosis, which Suchantke refers to as “the key to understanding the nature of life.”

The book contains many interesting facts that will delight the reader such as:

- The orchid, whose blossoms are the most ornate of any flowering plant, has the smallest seed of any such plant, just 1/50 of an inch long, a seed that does not germinate unless an invasive fungus provides it with nutrition.
- The sooty albatross can glide for hours without a single wing beat, but is unable to stand or walk on flat ground because of its turned-in feet.
- The marauding columns of the African army ant, which consume everything in their path, can include 20 million individual ants.
- Members of different species of butterfly in the same forest environment develop similar coloration based on the prevailing patterns of color and light and shadow in the forest.
- One species of squid, *Onychoteutis banksi*, is able to leap out of the water and to glide several hundred yards through the air, carried by sail-like fins.



This book will find a place on your bookshelf along with your other prized volumes, that is, if you can stop reading it and resist from leaving it on your table top where all your friends can admire it.

ISBN 978-0-932776-39-6

Pages 324 8.5 x 11.25 inches

Adonis Press \$50.00

Available from AWSNA Publications

Richly illustrated
Hardcover



Waldorf Journal Project #14

DARWIN (AND MORE)

Edited by David Mitchell

CONTENTS

- *What Makes Human Beings Human?* by Wolfgang Schad
- *Darwin's Incomplete Knowledge of Death* by Wolfgang Schad
- *Darwin Suffered from Darwinism* by Wolfgang Schad
- *Body Movements Are Invisible Thinking, Mathematical Thinking Is Inner Movements* by Erik Marstrander
- *What Is Goetheanism?* by Trond Skaftnesmo
- *The Hippopotamus and the Eagle* by Trond Skaftnesmo
- *Close Contact with the Earth: Necessary Experiences that Provide a Basis for Lessons in Natural Sciences*
An Interview with Linda Jolly by Eli Tronsmo
- *Physics Lessons that Start with the Human Being* by Geir Øyen
- *The Power of Observation in Literature Lessons* by Tom Horn
- *Insight into Human Nature as a Basis for Waldorf Education: Anthroposophy and Modern Brain Research* by Helge Godager
- *Think Globally and Act Locally: The Ecology Practicum in the 11th Grade* by Holger Bauman
- *Music: An Endangered "Species"?* by Magne Skrede
- *Performing Arts versus Degraded Speech* by Magne Skrede
- *From Crisis to Cooperation* by Sylvia Fuehrer
- *Productivity and Receptiveness: How Do We Work Together on the School Organism?* by Karl-Martin Dietz

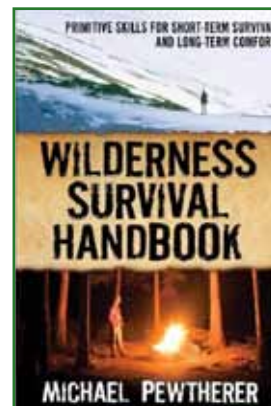
Pages 114

8.5 x 11 inches

Spiralbound

Illustrated

Available as a spiralbound copy at cost through
AWSNA Publications and gratis Online at ><http://www.waldorflibrary.org/pg/journalFocus/journalFocus.asp?journalID=15><.



Wilderness Survival Handbook

by Michael Pewtherer

What a joy it was to find this excellent resource written by a Waldorf graduate and part time teacher at the Hawthorne Valley School in Harlemville, New York. Our Waldorf students crave the knowledge of how to gain mastery in the wilderness. They seek to learn how to accurately observe the secrets in nature and survive in the wild. The subject of wilderness survival should be an adjunct course in every school. Pewtherer covers such topics as:

- Preparing to survive and making a proper survival kit
- Observing the terrain and building a proper shelter
- Locating water, sap gathering and building a solar still
- Building a proper fire
- How to navigate and deal with medical emergencies
- Trapping, making hunting weapons, tanning hides, making cordage, building crude containers like bark canteens, sealing with pitch for waterproofing and so forth.

Modern youth in North America increase their self-esteem, connect with the fabled pioneers of our continent, and gain confidence as they learn these "real" skills. The activities can be a turning point for challenged youth and both a boost and balance for capable students caught in the confines of the classroom and a one-sided intellectualism.

ISBN 978-0-07-148467-1

Pages 266 7.25 x 9 inches

Price: \$19.95

McGraw Hill Publication

Softcover

Illustrated



Waldorf Journal Project #15

MICHAELMAS

Edited by David Mitchell

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Teacher Study:

Michaelmas and the Soul Forces of the Human Being
 The Activity of Michael and the Future of Humanity
 The Michael-Christ-Experience of Humankind
 The Work of Michael
 Why Do Waldorf Schools Celebrate Michaelmas?
 Working with the Festivals through the Twelve Senses

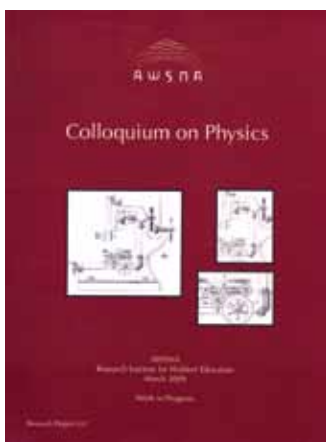
Stories and Legends for Teachers to Tell:

Feast of St. Michael (From *The Golden Legend*)
 Michael Legends (by Pico Della Mirandola)
 Gothic Hymn unto the Archangel Michael (Greek)
 Michael (Greek Hymn from the Middle Ages)
 Michael as Indra (*Rigveda*)
 The *Bhagavad-Gita* as a Reflection of Michael's Battle in Heaven
 Michael as Mithras (From the *Avesta*)
 Mithras, Revealing the Sacred Names (Mithras Liturgy)
 Michael as Marduk (After the Babylonian Song of World)
 Creation of Adam
 Michael as Guardian of the Word
 Michael Tests Moses' Willingness to Sacrifice
 Michael as Savior of Isaac
 Moses' Death
 The Four Winds
 The Rainbow
 The Bowl of the World
 The Book of the Seventy-Two Signs
 Michael as Guardian of Paradise (Medieval Tale)
 Golgotha (Russian Legend)
 Michael and the Risen One (Easter Play, 15th century)
 Michael and Evil (Ancient Bulgarian Legend)
 Michael and the Doubter (German Legend)

Michael's Sanctuary in Chonae (From the Greek)
 The Sanctuary of Michael on Mount Gargano (Latin)
 Mont Saint-Michel (French Legend)
 Mont Saint-Michel (Chronicle of the City of Speyer)
 The Leper Jew
 The Unfulfilled Vow
 The Blind Man
 The Possessed
 Sequence on St. Michael Dedicated to Emperor
 Charlemagne (Hymn from the Middle Ages)
 The Dragon of Ireland (French Legend)
 Michael as Friend of Mankind (Icelandic Legend)
 Michael Leads the Army of Barbarossa (German)
 To St. Michael (Latin Hymn, 11th century)
 How Henry II Beheld Michael on Monte Gargano and
 How He Was Touched and Lamed by Him (German)
 Prayer (From Old Norway, circa 1300)
 The Death of St. Elizabeth of Thuringa (German)
 Lucifer's Crown (From the "Singers' Contest on the
 Wartburg," 13th century)
 The Vision of Jeanne d'Arc
 Michael, the Angel, Speaketh
 St. Michael on the Crescent Moon (Polish Legend)
 Of Michael, the Archangel (From the Russian)
 Why the Sole of Man's Foot Is not Even
 Miner's Song (From Bohemia)
 The Devil's Scythe (French Legend)
 What the Peasants of Normandy Tell about Michael
 The Twelfth Chapter of the Revelation of St. John
 Concerning the Iron in the Kalewala and the Spiritual
 Forge in the North
 Michael Legend from the Philippines
 The Legend of Mont Saint-Michel by Guy de
 Maupassant

148 pages 8.5 x 11 inches Spiralbound
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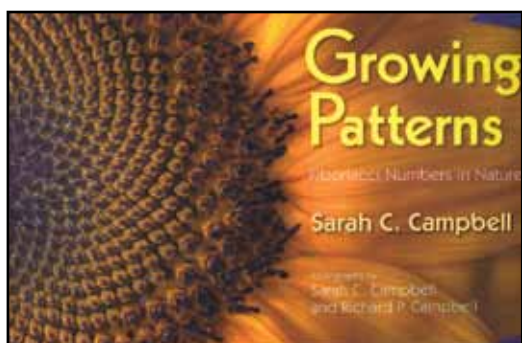


Colloquium on High School Physics

Organized by the Waldorf High School Research Group through the Research Institute

A group of experienced teachers discuss and explore the Waldorf physics curriculum and suggest new ideas while solving some of the riddles found in the current curriculum.

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Pages 98 Spiralbound Illustrated

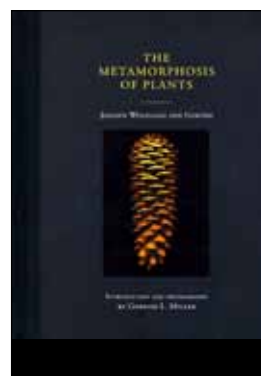


Growing Patterns Fibonacci Numbers in Nature

by Sarah C. Campbell

This title holds a lot of promise but the book was a let-down. The illustrations are lovely but the text is overly simplistic. Recommended only for those who know absolutely nothing about the Fibonacci sequence.

ISBN 978-1-59078-752-6
Pages: 32 12.25 x 7.5 Hardcover
Price: \$17.97 Illustrated
Boyd Mills Press

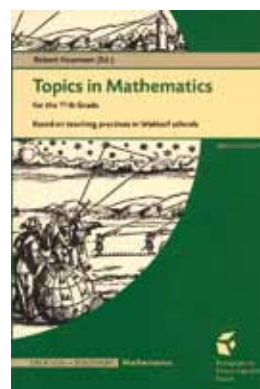


The Metamorphosis of Plants

by J.W. von Goethe

This book is a wonderful validation of the scientific worth of Goethe's pioneering researches on morphology. Here Goethe "coupled rigorous empiricism with precise imagination to see particular natural phenomena as concrete symbols of the universal principles, organizing ideas [to perceive] the inner laws of nature," says the editor Gordon Miller. Published by the MIT Press in hardcover with high quality paper and stunning colored illustrations, this book is an absolute treasure.

ISBN 978-0-262-01309-3
Pages 123 6.25 x 8.25 inches Hardcover
Price: \$30.00 Illustrated
The MIT Press Available through AWSNA Publications



Coming in the autumn of 2010

Mathematics in the Eleventh Class

AWSNA Publications is currently translating this resource book for Waldorf high schools in North America. An announcement will be made when the book is available. The edition for the 10th grade mathematics is available and can be ordered Online through Books & More at the AWSNA website.



Research Bulletin Autumn/Winter 2009
Volume XIV, Number 2

Editor: Stephen Keith Sagarin, PhD

Dedicated to furthering research in education, the *Research Bulletin* provides schools with studies and data that place Waldorf education at the forefront of the educational scene in North America. Key topics in this issue are:

- The Social Mission of Waldorf School Communities
- Identity and Governance
- Changing Old Habits: Exploring New Models for Professional Development
- Developing Coherence: Meditative Practice in Waldorf School Colleges of Teachers
- Teacher's Self-Development as a Mirror of Children's Incarnation: Part II
- Social Emotional Education and Waldorf Education
- Television in, and the Worlds of, Today's Children: A Mounting Cultural Controversy
- Russia's History, Culture, and the Thrust Toward High-Stakes Testing: Reflections on a Recent Visit
- *Da, Vadorvskii!* Finding an Educational Approach for Children with Disabilities in a Siberian Village

as well as the writings of our Research Fellows. If you have not seen the latest edition, you are encouraged to obtain a subscription available from:

researchinstitute@earthlink.net

80 pages 7.5 x 11 inches Price \$12.00
 Available from AWSNA Publications



Research Bulletin Spring/Summer 2010
Volume XV, Number 1

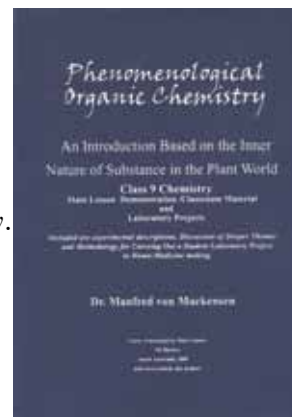
Editor: Stephen Keith Sagarin, PhD

- What Can Rudolf Steiner's Words to the First Waldorf Teachers Tell Us Today?
- Social Emotional Intelligence: The Basis for a New Vision of Education in the United States
- Rudolf Steiner's Research Methods for Teachers
- Combined Grades in Waldorf Schools: Creating Classrooms Teachers Can Feel Good About
- Educating Gifted Students in Waldorf Schools
- How Do Teachers Learn with Teachers?
- Does Our Educational System Contribute to Attentional and Learning Difficulties in Our Children?
- Survey on Waldorf School Trustee Education

Pages: 72 7.5 x 11 inches Price: \$12.00
 Available from AWSNA Publications

Phenomenological Organic Chemistry
For the Ninth Grade
 by Manfred von Mackensen

Through the stellar efforts of Peter Glasby from Australia, we now have an English version of Manfred von Mackensen's *Phenomenological Organic Chemistry*. Included are experiment descriptions, discussion of deeper themes and methodology for carrying out student laboratory projects. Contents include: deeper thoughts on the intent of the curriculum; Stages of Refinement; Combustion; Fragrances; Petroleum; Essential Oils; Anesthetics; and much more.



ISBN # 978-1-888365-79-5
 Pages 134 8.5 x 11 Softbound
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 Available from AWSNA Publications

GOING THROUGH, TAKING IN, CONSIDERING

A Three-Phase Process of Learning as a Method of “Teaching Main Lesson Blocks”¹

by

Manfred von Mackensen

Curtain Raiser

We would like to elaborate certain phases of teaching by, deliberately, taking an example from our everyday life. Occurrences which usually take place in school may, for the time being, be projected onto a private situation. So let us have a try on three phases and imagine the following:

- Phase I A couple is going to a birthday party. Good luck!
 - A lot of guests, a lot of confusion.
- Phase II On their way home, they exchange their impressions: a highpoint, a striking character.
- Phase III The next morning they debate:
 - (a) in what way were the guests related to each other and to the host?
 - (b) which news about the world did one learn from them?
 - (c) how would oneself wish to celebrate a coming birthday; what do birthdays really demand, anyway?

Are these really three phases? Let us have a look again at what exactly happens here.

At the beginning, one just throws oneself into the crowd (Phase I). One makes acquaintances without thinking much about it and enjoys meeting with the people who turn up. Any form of investigation or classifying would be distracting.—Afterwards, all that is resounding in both of them (Phase II); both are still preoccupied with what they experienced² and, while talking it over, their emotions unite the details automatically. The ups and downs of the party now appear more as a related “whole,” and less as a mere series of events. Something that was frightening changes into a deep impression, rejoicing into true interest, a muddle into a sequence of related scenes. Later on, one dissects that “whole” again into fragments and discusses their interrelations (Phase III). One examines

1. This paper was written during the work on the project *Phenomenological Natural Science and Human Didactics*. In conferences and courses it has served as a text for introduction, reflection, and fixation. At the same time it can be regarded as an example for how to organize teaching lessons (Pädagogische Forschungsstelle beim Bund der Freien Waldorfschulen Stuttgart, Abt. Kassel, Brabanterstrasse 30, 34131 Kassel).

2. Perhaps humming softly the refrain of a song, such as “Going through, Singing about,”

how this related to that, who has secretly wanted what or who has suffered, and so on (a). One is digging for insights, for knowledge (b). Finally, one ponders, asks what consequences will follow, and also, how oneself could achieve something (c).

In this story, not a word about school lessons appeared. It demonstrates how the three elements of the elaborated method work in real life.

An Example

1. Understanding on Your Own (enterprising, joining in, experiencing) = Phase I

We imagine teaching physics, perhaps in Grade 8, and we are experimenting. (a.) The pupils stream out of the school building. Soon they are gathered around a flexible tube of which the end is immediately lifted up the wall of the house until it reaches a window. There it is held 12 meters above the ground. The tube, about 3 cm diameter and made of transparent plastic, has a plug at each end and is completely filled with boiled and slightly colored water; there is no air in it. Air is surrounding everything. Every two meters it is marked with a line.

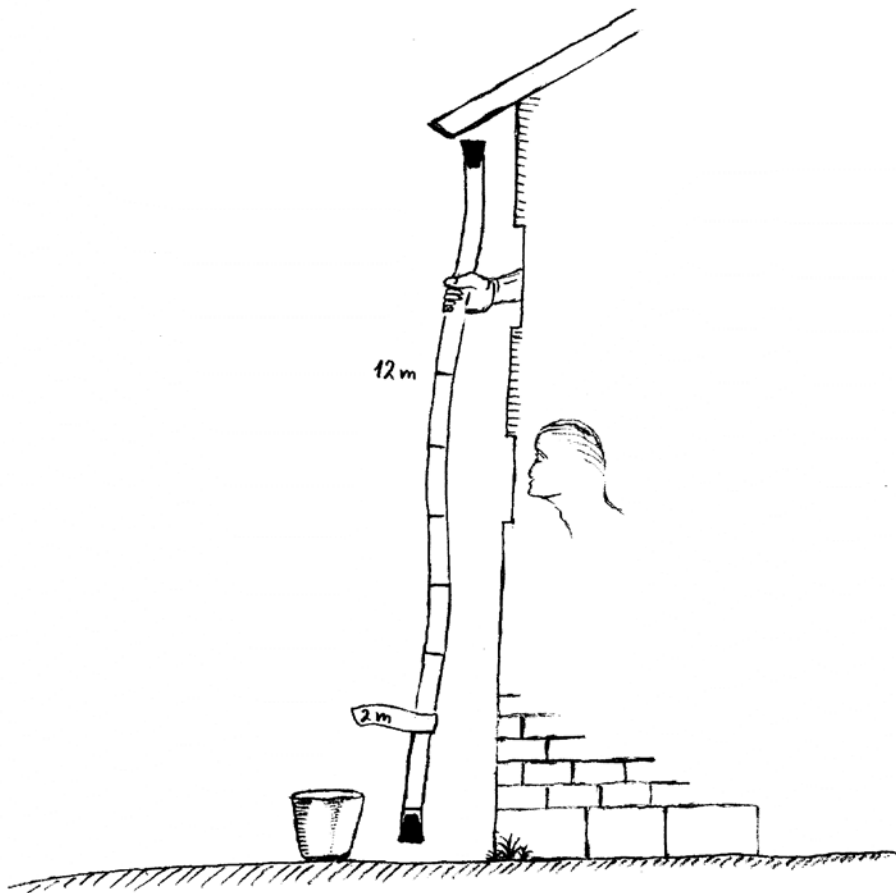


Figure 1: A flexible tube, with marks every two meters, is hanging down a wall. The second mark at the lower end bears a little flag with “2m” written on it. The bucket is filled to the brim with water.

(b.) The lower end is now dunked into the bucket provided which is filled to the brim with water, causing an overflow, and another student puts his hand into it and after counting “1,2,3!” the plug under water is pulled out. Immediately, several meters of the water in the tube runs into the bucket. But surprisingly, most of the water remains in the tube. The water level settles down around the 10-meter mark. Now, from the top down to approximately 8 meters high, the tube is “squeezed” in the middle:



Figure 2: Cross-section of the squeezed tube at approximately 9-meter height, after the water level has fallen to 10 meters.

After the bucket has been refilled, an assistant in the window draws the attention to the water level in the tube. The pupils count the meter marks down to the surface of the water in the filled-up bucket. The number remains the same, even when the upper end of the tube is moved downwards or when the bucket is lifted upwards.

(c.) When, just for a short moment, the lower end of the tube is taken out of the bucket, approximately 1 meter of water runs out. Its space is replaced by air. This air rises in the tube as a stretched bubble, and, afterwards, the water level is several meters lower than before.

(d.) If the upper plug is pulled out, the remaining water column shoots into the bucket, causing again an overflow. The tube is thrown to the ground. Now it is straight again, that means, no longer squeezed like in Fig. 2.

2. Common Recollection in Class = Phase II

Back in the classroom, the teacher characterizes the experience, accompanied by various observations or answers of the pupils, however, without explaining a thing! He does that by using more personally colored words, like following the motto: “Gosh! What are we going through here!” E.g., when recalling the tube lying on the ground, he evokes a feeling of how everything was at rest, the water being closed in. Looking back at the tube, hanging in the air, he then creates the impression that the situation was somehow full of tension, as if the water would come running out at any moment. Who would have been the first to get wet? Did the situation seem to be suspicious for somebody, perhaps, when we built a sort of barrier in the bucket—a barrier for the tube, water out of water?

After all, it came to stop somehow. Isn’t it amazing what our teacher is able to achieve? Maybe the air, surrounding everything, was helping? Later on, what a relief! With just one grip this spooky phenomenon was gone.

A recollection like this, led by the teacher, should be carried out with sympathy and benevolence—towards the objects, the occurrences and also towards the participating humans; no harsh questions, no forced

explanations. Everything that gets mentioned is accepted, as you would do during a good meal in the hut after a tiring alpine tour. A cheerful common feeling runs through all and everything and should be kept light. Perhaps somebody writes some key words on the blackboard, so that the collective experience can be recalled later. The beginning of a sketch similar to Fig. 1 may also be drawn on the blackboard.

This recollection is not at all a purely subjectively roaming; however objective judgments of facts, such as cause and effect for example, are avoided or simply ignored. What arise are collective images, clear enough for all to remember: this was first and that followed. Through the teacher calling the attention of the pupils to the closed-in water, the air and the way the water runs out, as well as to the air surrounding, the beginning of explanations could be anticipated. It is this anticipation that should be worked towards.

3. Questioning and Considering the Facts = Phase III

On the next morning, the pupils bring along their completed drawings, similar to Fig. 1, as well as their personal review of the experiment—which in no way must resemble an impersonal technical description. (How to create both, see below.) The ideas and imaginations concerning the course of the experiment that were called up the day before (see the above paragraph), have now “settled down.” Particular turning points are recalled into common awareness (consciousness) with a few repetitive questions. And now follows the elaboration of the case as such. It begins with questions about interconnections as well as with explanations and widening reflections:

- Could the upper plug hold the water column from above—without any threads between the bottom of the plug and the surface of the water? If not:
- Could the water in the bucket from downwards up carry the water column above it; does the size of the bucket play a part here?
- Could the water in the bucket at least slow down the running out?
- What is it that squeezes the tube; and why isn't the lower end squeezed too?
- What is contained in the tube above the water level?
- How strong was the carrying force of the air pressure shown to us, expressed in meters of water column? How many meters would it be if we used other fluids (salt water, oil)? Would the water column have the same height everywhere on earth and at all times?
- Does the air temperature play a role? Yes, through the pressure of the steam, at 20° C it is 23 millibar which equals to 23 cm of water column. But those finer details don't have to be explained in Grade 8 yet, nor any of the other questions before.

It is of great importance that individual opinions come up in the class, as engaged and diverse as possible. The more original and even more fantastic they are, the more they stimulate. Thus, they will be impressed if it is revealed that neither the water in the bucket nor the plug above brings about a force that could hold up the water level, or even draw it

back when it swings downwards. Rather there is something invisible at work here, namely the “endless ocean of air.” And moreover it is important that the standard aero-mechanical explanation with the help of the pressure of the outer air upon the water surface in the bucket, should not be ruling alone here,³ but should be expanded through ‘vaguely’ qualitative elements, like “endless,” “ocean of air” or “horror vacui.”⁴ These elements direct the attention less to the mechanical facts but rather lead the pupils to feel, to understand, even to immerse themselves in a subject. This is the only way to motivate a pupil towards a lasting striving for knowledge and learning. In addition to the logical subjects and the pure qualitative aspects, there might arise more widening questions, like changes of the air pressure, the influence of the weather, breathing in relation to the flying heights of airplanes, and so on.

Discussing the Method

A. Making Use of the Night

The advantages of a teaching in two-day loops, partly already evident in the above example, will be obvious especially if the subjects are taught in blocks, i.e., the teaching of technical subjects occurs in main lesson blocks, so that the ripening process of the night can be included. What can we do to activate this process? A part of it was already shown above (see Chapter 2), where, for a long time that work was done non-informative but nevertheless systematically theme-oriented, let us say with the aim: “Getting an impulse to move on instead of receiving information.” Such an effort pays off immediately causing sympathy and, in the end, leading to a successful level of education (a well-known experience in practice). The well prepared process of ripening during the night is even generally known and nowadays scientifically observed, but, since cognitive-psychological, never simply deductible. With the above exemplified model of the three steps in two days, perhaps called “two-days-three-steps-model of learning in blocks,” we have a practical method at hand that is proven and certainly an ingenious invention, no matter by whom. It should just be presented in a form that is ready for use.

Its core derives from the question: How can it be achieved that the student not only gains a profit for his mind and behavior, but that he, with every subject, takes a step forward in his entire existence and his individual development? A single subject in school has to be more than a sum of communicable notions and definitions. That means, closer to life, to reality, and, therefore, also dark. At first the subject has to be introduced to the class in open and sensitive terms, that warmly flow

3. It is well known that the actual air pressure drives the water against a vacuum up to a height of about 10 m above the surface of the water upon which the air presses, no matter whether the tube is sloping or lying in waves. These measures can be only approximate because the air pressure changes with the weather, often hours until days in advance; i.e. about +5 or –10%, and also because it generally decreases along with the height above sea level (in 5.500 m by 50 %).

4. It is the term for an experience; built on the discovery that the world is lacking the natural, continual vacuum spaces. The “horror vacui” was, during thousands of years, an important, fundamental force of earth and heaven and was attributed to the universe, as also was philosophically given its place. Today we see it more in terms of some continuous pictorial gesture.

around the pupil and will become seeds for him to sprout, so that he won't get emotionally petrified by being exposed to mere definitions and final statements. And still, these open terms should provide a basis for a deeper elaboration of the matter, since everything has to end in professional knowledge.—How could this, generally, be achieved?

B. The Various Activities of the Teachers

1. Concerning Phase I

First of all, our experiment was intended to provide more than mere information. It should not convey teachings subjects but, structured by the teacher, the dark reality of the world (this concept of reality may, for the time being, remain unexplained). In any case, the pupil should, at first, save his perceptions as inner pictures (“ . . . now he takes that, there, that is dangling . . . ”), without understanding them technically. For that, he naturally combines all his recollections with his observations, in order to identify them somehow as objects. This is a really demanding, an exhausting process, since all the impressions will hit him shapeless and hard. Basically, the teacher and the pupils, since they are completely immersed in the matter, enjoy all that is developing here.

The teacher provides the students with objects and facts as well as with impulses for his soul by an elaborated experiment (in other school subjects rather with pictures, narratives, music, sightseeing-tours, and so forth). He creates a configuration. The students adapt to that. Therefore, this first step regarding the mental activity of the pupils could be called deliberate or determined (volitional), for they were fully dependent on all their physical sense organs. They adapted the situation in an interactive way—which, indeed, provides a basis for any decisive will to act.

2. Concerning Phase II

Looking merely at information, it is just a repetition of Phase I. In reality however, everything is different. Nothing at all gets repeated. Completely different mental powers are devoted to a problem when the person moves from one inner activity to the next: at the beginning, he used his will, now his feeling. In Phase I, the pupil struggled to sort out his own recollected imaginations. Now these imaginations are picked up in class and the group process helps him to harmonize and confirm them. The emotions of all group members are flowing together, so that a cheerful sense of community replaces the preceding silent feeling of helplessness and captivation. Through this, the unconnected facts of the initial confrontation are brought on a way towards being embedded in something greater. In Phase I, the inner pictures of the pupil are pushed back and forth by the outer occurrences. In Phase II, they will be mentally refreshed in such a way that they can serve as a seedbed for something new, mentally as well as intellectually, which ought to grow during Phase III; even if, superficially, the experimental noises are, at first, only followed by nice word noises. In any case the students will begin to look out for the context of it all. Connecting links seem to emerge. The pupil even gets the impression that he achieved something. At this stage of Phase II, the teaching may pause.

3. Concerning Phase III

In Phase II, the consolidation of the swirling impressions of Phase I formed a solid basis for anchoring the questioning now as well as for

a new construct of ideas. This was caused, on the one hand, by writing down a review of the experiments, quite possibly in the style of Phase II, and by the natural settling-down and the ripening process during the night.

On the next morning, the gelled imaginations will call for evaluation, expansion, and categorizing through a joint exchange of ideas in class! Only thereafter, the time will come to start the necessary general survey, and for the teacher to deliver broader contemplations, e.g., Why is this topic so important? What else belongs to it? The history of discoveries in this field, special tools and measuring devices, technical applications and/or accidents may come into play, and ecological problems are to be regarded.⁵ At the end, during the final lecture of the teacher, the group process is carried by a sense of community and sympathy. Before that, however, during the process of questioning and searching, uncompromising and distance have been prevailing, i.e., antipathy contracted into mere facts.

4. To all three phases

Only within the third Phase, the first part of the double period on the second day, a general realization (cognition) arises. It arises out of the change of experiences, practical knowledge and actions, which took place in the individual. So, the conventional “aim of the lesson” is first to come on the second day, but then, larger and deeper than would have been possible on the day before—provided everything went well. The aim of knowing the subject is completed with an educational aim, for, in such a way, its light shines into the world outside as into the personal power and abilities.⁶

* * * *

Other scientists, too, are striving for such a way in three phases. Klaus Schmidt, one of the most famous and successful archaeologists of the present time, talks about strategies like this when he tries to comprehend “the oldest monuments of mankind,”⁷ in this case the context of a complex structure of an entire excavated temple city.⁸ This early metropolis was founded with all its buildings, murals and other objects of art at the end of the glacier epoch. It is not yet known why, after several thousands of years, the whole town became completely filled up again, buried up to the wall copings in the hidden seclusion of Anatolia up to our time—a phenomenon that seems to be from another world.

5. How to include such aspects within the period on physics of class 8, and also more about the pressure of the air and so on, one will find in: M. v. Mackensen: *A Phenomena-Based Physics, Vol. 3 for Grade 8*, AWSNA Publications. The problems that airplanes have by the pressure of the air are described in Hofberger/Mackensen : *Flug, Landung, Absturz*; Publ.:Verlag Bildungswerk Kassel, 2009 (in preparation).

6. The author describes how the different judging forces of the soul are active and at work in all three stages, also how then the logic of the subject opens up to “over-logical” extensions, in “Urteilstätigkeiten . . . ,” Kassel, 2009.

7. The title of the accompanying book; edited; Badisches Landesmuseum Karlsruhe 2007, published; K. Theiss Verlag, Stuttgart.

8. Klaus Schmidt; *Sie bauten einen Tempel*; dtv München, 2008, p 1909.

And yet, here lies the origin of our culture, upon which followed the ancient empires and, finally, Europe. “To look at, to describe, to understand,” that is now the general working plan of the research team at Göbekli Tepe. Three separate steps! Otherwise, the unexpected would be overwhelming. We, immediately, see that these steps basically correspond to our three phases, provided the aim is not only to categorize the structures of the excavated objects but also to sort out the mental state of the humans involved.

And indeed, where anyhow would we end up, if teaching would not be life itself?

Seeing the above as a whole, we elaborate the following

Phase I	An attentive observation, active in all our senses—suffering from the world physically	The impact of single objects and impressions from outside The WILL is challenged.
Phase II	Feeling the characteristics of one’s own experiences—a taking and giving	Interaction of opinions and stirring of the mental state FEELINGS, and EMOTIONS surge up.
Phase III	A fierce dividing into pieces, reconnecting them—expanding them— Moving the thoughts around	An approach to the spiritual powers of the world The THINKING becomes creative.

Phase II works for the short term memory, the efforts in thinking of Phase III for the long-term one. And if the latter also open up to the mind to make out the intrinsic character of man and world, the striving for knowledge becomes education. Then, a stepping through the three phases will encourage the student to want to remain committed to his world. This would be an initial exercise for his subsequent freedom, which would then be not to let oneself be washed over arbitrarily by pleasure, but to find fulfillment in one’s own awareness and conscious actions so that his freedom, later in life, exceeds the influence of school.

These three steps should grasp the entire adolescent person: body, soul and mind. And in his soul: his thinking, his feeling and his will (Steiner).⁹ And always all the three simultaneously, just different combined. That should needs to be elaborated more deeply. Not only concepts and logic should be troubled. We did point out in the above paragraph (Section A of this Chapter): a progression from a mere transfer of information to a step forward in life, i.e. from abstract learning towards a real development, transformation instead of information.

9. Rudolf Steiner, 1919 and 1921, GA 293 and 302, especially lecture III.

THE GEOMETRY OF LIFE

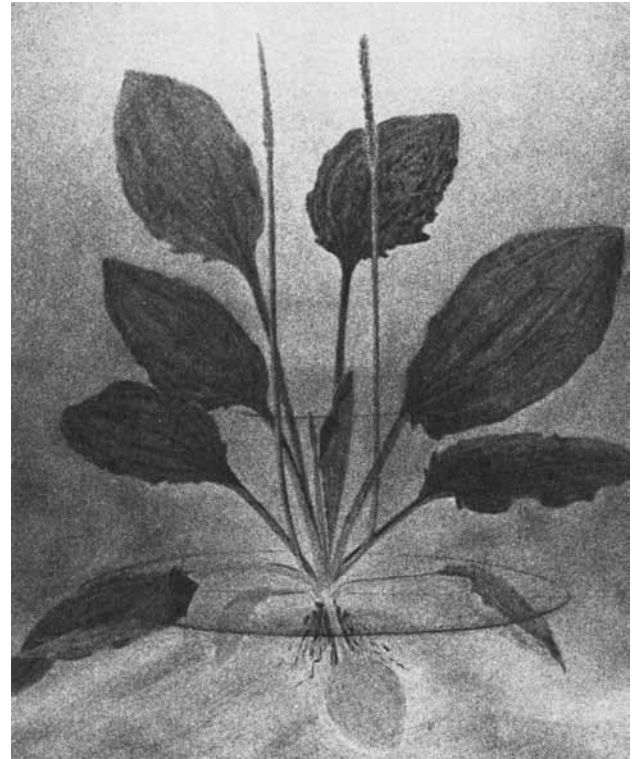
Toward a Science of Form

by Arthur Zajonc

Amidst nature's ever changing raiment, we descry what may be her greatest miracle—her constancy. Each year, fresh, new soil, water, and light weave to form the familiar shapes of leaf and flower. The memory of last year's forms silently lives through a wintry night to unfold under warmer skies into the foliage of spring. Nature remembers the maple's leaf just as we do. The miracle deepens as we turn from the kingdom of plants to that of animals. For while leaf and stem die each fall into the earth, the life of beast and bird is not so completely bound to the seasons. They—and we—persist from season to season, year to year, even though every cell of our bodies is changing: perishing, to be recreated. Every seven years we are filled out anew. The familiar countenance is familiar not for its substance but for its lineaments, its shape or gesture. In it we recognize a form that passes through all change. As Heraclitus put it two thousand years ago, "It is in changing that things find repose." The world, in constant flux, rests.

Such considerations as these have stirred philosophic and scientific reflections since at least the time of ancient Greece. Plato raised form to the realm of incorruptible, eternal *eidos*. His pupil Aristotle paired form with matter and named them the twin principles that underlie all being and becoming. Throughout the history of science, the mystery of form's origins has been the central question. Why are things formed as they are? Why does the pyrite crystal show itself as cube and dodecahedron only? Why do leaves spiral around the stem? Why is the heart shaped and structured as it is? Again and again one encounters among biologists the judgment expressed by Joseph Needham that "the central problem of biology is the form problem."

It is this aspect of nature, the aspect of form, that we shall explore here, in a brief introduction to a man whose discoveries open new avenues of inquiry, not only into the forms of nature, but into the very nature of form itself. His particular study, and ours for the purposes of this article, is that of mathematics, which is concerned with pure form, form winnowed completely from the corporeality that always accompanies it in the sense world.



Greater Plantain (Plantago major)

Since ancient times, arithmetic and geometry divided the universe of mathematics between them. The queen, however, was geometry, who reigned unchallenged from the time of Euclid until the eighteenth century. Only during the Enlightenment, at the hands of men such as Lagrange and Laplace, was geometry dethroned and purely algebraic, abstract analysis put in her place. Lagrange informs us with evident satisfaction in his *Mécanique analytique* that "no diagrams will be found in this work. The methods which I expound in it demand neither constructions nor geometrical or mechanical reasonings."

By contrast, we shall be drawn into that realm of mathematics that speaks directly and visually of form, namely geometry, for our ultimate goal will be to describe a visible and highly ordered domain of natural phenomena.

To date, the geometry of the living world has essentially defied our attempts to imitate it. Perhaps our

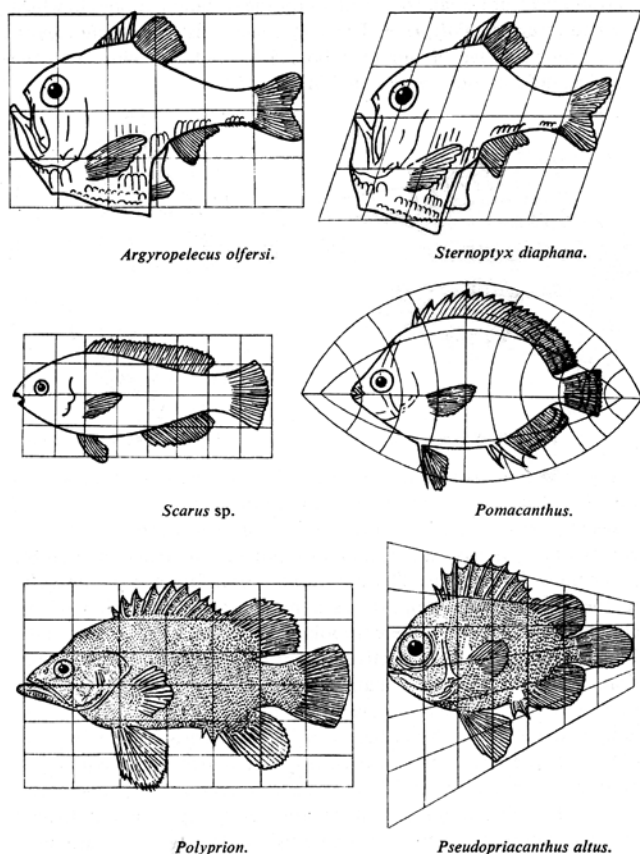


Figure 1.

approach has been too limited in scope or too inflexible. The concepts we bring to bear are often bound by our very conception of space and the movements we think possible within that space. To comprehend the geometry of forms in the living world, new concepts may be needed, ones intimately wedded to organic phenomena. The task of finding such concepts is not a simple one, but there are paths that beckon and individuals who have begun to explore them. The path we are going to pursue here is that of projective geometry. It embraces a vision of space far more dynamic, far more general, than the one implicit in Euclidean geometry. By giving up the rigid, restricted movements of Euclidean geometry, we gradually rise to a wonderful, fluid form of geometry, one with which we may hope to capture at least a small portion of those forms the living world displays before us. This is, after all, a world characterized by becoming, by development, by growth and decay. It seems somehow appropriate to approach the living world with a geometry of becoming.

The study of geometry and pattern in the inorganic world is an old and honorable pursuit. From the hexagonal forms of the snowflake to the intricate dance of the planets, both the static and dynamic patterns of the physical universe have been systematically described.

The forms of plants and animals have been more resistant to precise mathematical description. True, individuals such as the Scottish biologist D'Arcy Thompson have in their treatment of organic forms drawn upon geometry to establish connections between a great variety of plants and animals. The apparatus of geometry, however, is introduced only toward the end of D'Arcy Thompson's classic *On Growth and Form*, and only in an elementary way. In the famous last chapter, "On the Theory of Transformation or the Comparison of Related Forms," he lays systems of coordinate nets over various animals or skeletal members. By imagining these nets as subject to particular systematic distortions, the form of one species can be geometrically transformed into that of another with remarkable fidelity. The adjoining drawing shows what I mean (figure 1). As an example, he takes the fish *Polyprion* and places over it a rectangular coordinate system and then transforms it to an alternate coordinate system to yield the species *Pseudopriacanthus altus*. The original form, that of the *Polyprion*, is given rather than constructed, and thereafter is transformed point by point via his "method of transformed coordinates."

D'Arcy Thompson's work is only a hint at a more general and powerful use of geometry in the study of form in nature. As I hope to show, if we consciously develop geometry with the principles of transformation foremost, we gradually move from the most elementary to more and more complex transformations. In so doing we are following the program put forward in 1872 by the brilliant mathematician and pedagogue Felix Klein. His work, and especially that of his Norwegian collaborator, Sophus Lie, provides the basis for a geometry that can be used to study certain of nature's forms. This study has been pursued by several geometers, of whom Lawrence Edwards is the most recent and most successful. Much of this article concerns the discoveries he has made and continues to make. But before we enter into Edwards's study of organic forms, I would like to try to give the reader some sense for the mobility and beauty of the mathematical thought with which he works.

When asked by King Archelaos for an easier way into geometry, Euclid is said to have replied, "There is no royal road to geometry." The nineteenth-century German mathematician Hankel was certainly thinking of Euclid when he called projective geometry the royal road to all mathematics. Once one travels a way along that road, Morris Kline's more recent sentiment quickly becomes one's own: "In the house of mathematics there are many mansions, and the most elegant is projective geometry." Yet for all that it is a mostly forgotten mansion today, and so we must spend a moment or two retracing its elements.



*Pyrite crystals—cubic and dodecahedral.
From the editor's collection, found in Austria*

It is to the Renaissance artists of the fifteenth and sixteenth centuries that we must turn for projective geometry's beginnings. The discovery of perspective brought about the extraordinary transition in painting from two to three dimensions. We need only compare the spatial arrangement and composition of medieval paintings by such artists as Giotto, Duccio, and Simone Martini to those of works by Dürer and Leonardo to realize that before 1500 space, size, and composition obeyed spiritual or symbolic laws, not the physical laws of perspective.

With the discovery of perspective is born the basis for projective geometry. Dürer's 1525 woodcut, "The Designer of the Lute," shows clearly the fundamental operation of projection and section so central to projective geometry (figure 2). To assist us in understanding this construction, let us imagine that "visual rays" are emitted from the eye. The object before us, in this case the lute,

is touched by each visual ray and the object is thereby perceived. Now between the eye and the lute place a screen. The rays from the eye to the lute are intercepted by the screen, forming a "perspective" view of the lute on the screen, as Dürer shows us. Here we have the key construction of projective geometry: projection from a center (the eye) and section by a plane (the screen). In the process we have "transformed" the object, that is, created an image by identifying each point on the screen with each point on the lute. This is the mathematical definition of a "point transformation." By tipping the screen or moving the center of projection, an enormous range of transformations becomes possible. We can also take the screen as a new object and transform it in the same way by a second transformation, placing a second screen between the first one and the center of projection. The business of projective geometry is to investigate the laws of the patterns that arise in space through a series of such transformations.

When confronted by the whirl of movement that projective transformations entail, it may seem difficult to imagine any stable ground or lawfulness. However, by making the transition slowly from the simple transformations associated with ordinary Euclidean geometry to the far more general ones of projective geometry, we can be led to experience an element of order that persists throughout.

As the following discussion will show, a triangle projected onto a surface can assume many different triangular forms, depending on the angle of its projection. Yet certain properties will remain unchanged. The straight lines that compass the triangle, for instance, will always reappear as straight lines. Thus is "straightness" one of the invariants, or unchanging elements, of projective

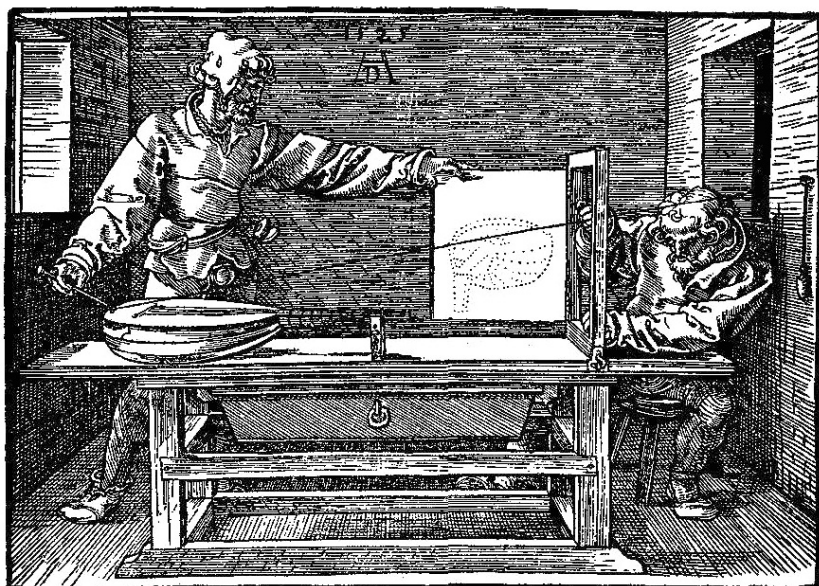


Figure 2. Woodcut by Albrecht Dürer illustrates the principle of projection and section. In the woodcut the artist marks the points at which the rays from the eye to the lute intersect the screen.

geometry. What other elements exist such that “in changing they find repose”? By pursuing this question we come not only to the stable ground of geometry, the laws of space that govern projective transformations, but also to a special set of forms, some of which will be startlingly familiar.

To learn how these special forms arise, we must first bring geometry into motion, for only against the backdrop of incessant change does the concept of repose, or “invariance,” gain meaning. Imagine you have before you a triangular piece of paper. It can be slid easily about the tabletop to assume any number of positions. The accompanying figure shows three such positions (figure 3). To move from one to the other I can push the triangle up and to the right, and then rotate it. If I take my ruler, I find the corresponding sides of the triangles are still of the same lengths. My protractor likewise shows that the corresponding angles are of unchanged magnitudes. The triangles are, as Euclid would say, congruent. Neither length nor angle has changed in the process I have just described. Formally, one would say that lengths and angles are “invariant” under translations and rotations. Here we discover one kind of motion, by noticing that lengths and angles remain unchanged.

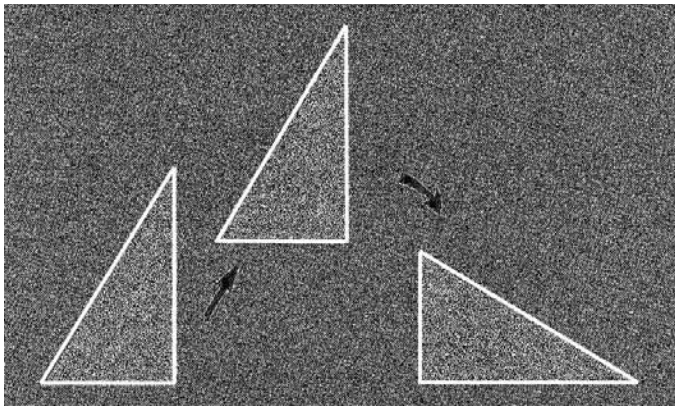


Figure 3. A triangle can be moved from one position to another by translation (left arrow) and by rotation (right arrow). Such simple transformations fall within the bounds of elementary Euclidean geometry.

Yet clearly there are other kinds of motions or changes possible. The cubic form of a pyrite crystal is forever the same, yet it may grow in size. That is, the lengths of its sides will change, but without an associated change in the angles. Here we encounter a new kind of transformation, one that involves a change in size but not in shape. Thus to translation and rotation we add dilation as a possible transformation.

We may proceed stepwise to ever freer types of transformations, ones that will take us beyond Euclidean geometry. With each step, what was before an invariant enters the realm of change. In the case of our original

triangle, not only lengths, but angles too were invariant. We then allowed the lengths of the sides to vary, yet only in such a way that all the angles remain the same. In other words, the sides all grew simultaneously. Now we will change angles as well as size, thus entering the realm of “affine geometry.” We can do this by replacing our original triangle with one of rubber. Such deformations occur constantly in nature. Consider a stream of water. If you could enclose a portion of a brook in an imaginary flexible cube, then the cube, through which the brook flows, would tip and stretch because the water nearer the brook bed moves more slowly. D’Arcy Thompson often uses such transformations as these in his *On Growth and Form*.

And so we may continue our pursuit of ever more flexible transformations. Though not obvious, certain invariants remain, even in this last class of transformations. It is rather remarkable, for instance, that under these transformations a set of parallel lines is transformed into another set of parallel lines—all the more astonishing when we remember that the angles between intersecting lines may change in general. One may state the invariance in another way. In plane geometry, two lines intersect at one point, unless the lines are parallel. We may overcome the exceptional character of parallel lines by defining a new “ideal” point, namely the point at infinity. Since under affine transformations, a set of parallel lines remains parallel, then the point at infinity remains a point at infinity. In projective geometry, even this invariant disappears. Infinitely distant elements can be brought into the finite by a projective transformation. We can easily see how this occurs in the next set of figures.

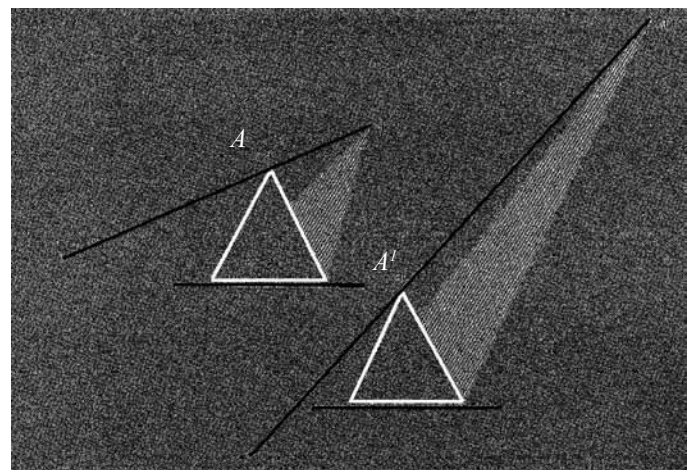


Figure 4. A triangle, illuminated by a small bulb (the center of projection), casts a shadow onto a plane. The shadow represents a “projection of the triangle; point A' in the shadow corresponds to A in the original triangle. As the center of projection is gradually lowered, the apex of the shadow (A') recedes and passes to infinity, and even returns from infinity in the opposite direction (not shown).

Imagine our ever-ready triangle as standing upright on a plane surface (figure 4). A small light bulb illuminates the triangle, casting a shadow onto the plane. The shadow we call a “projection” of the triangle onto the plane. The apex A of the triangle is projected to A^1 . But notice what happens if the light is lowered. The apex of the shadow triangle recedes farther and farther, until it vanishes into the infinite horizon. The finite has become infinite. In projective geometry, we replace the light bulb with its mathematical analog, a center of projection. By lowering the center of projection, the apex can be made not only to recede to infinity, but even to return again from the other side! It is as if passing to infinity in one direction brought one back from the opposite. Such is the nature of a projective transformation. With it we attain a very high order of freedom, yet even here there are properties and forms that remain unchanged. “Straightness” is one of them. Another is the property of “incidence.” That is, if two lines intersect in a point before transformation, they will intersect in a corresponding point after transformation. There are still other invariants, but for our purposes we can limit our treatment and turn now to Sophus Lie, in whose work the idea of invariance meets with that of form in space, the heart of our considerations.

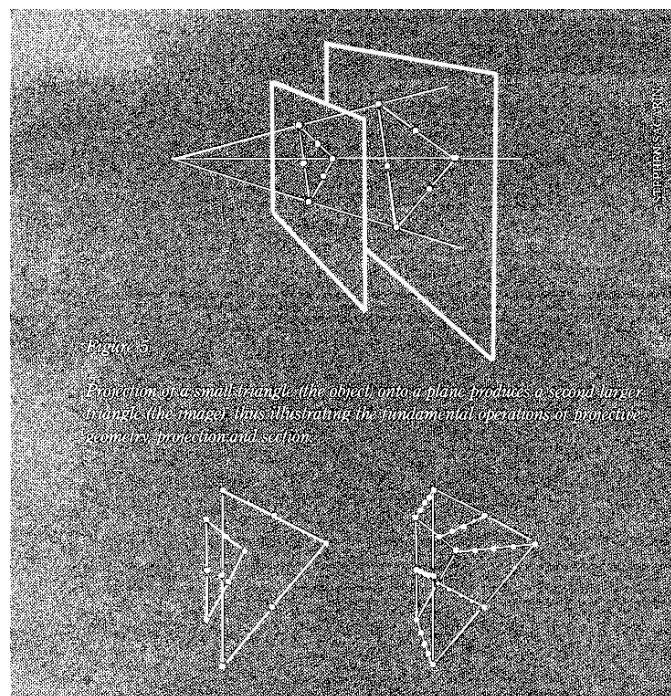


Figure 5.

Nearly one hundred years ago Lie presented a systematic discussion of a special set of curves in two dimensions, which he termed *Bahncurven* or “path curves.” These curves, and the analogous surfaces in three dimensions, possess the remarkable property of remaining unchanged when acted upon by repeated application of a projective transformation.

Path curves can be seen as arising in the following way. Recall our discussion of Dürer’s drawing of the lute. I commented there that we could take the screen as a new object and project it onto another plane or screen by means of a second projective transformation. Clearly there is no end to the number of times such an operation could be repeated, the new screen now becoming the object.

Now imagine three lines forming a triangle drawn onto a thin glass plate; several points around the perimeter of the triangle are carefully marked with blue dots (figure 5). Some distance above the glass plate is a small lamp, our center of projection. We imagine the shadow to fall on a second, cleverly fabricated glass plate, which turns black exactly where the shadow falls and produces blue dots at the proper corresponding points. We have just performed the fundamental transformation of projective geometry, projection and section. (Whereas in the Dürer drawing, the plane is between the object and the center of projection, in this instance the object is between the plane and the center of projection.) Placing the two plates together and looking through them, we see two triangles, one slightly different from the other, the degree of difference depending on the particulars of the projection and section. If the second plate was very close to the first, then the difference can be small indeed. Thus one has two triangles in one plane. Mathematicians formalize the process by saying that the first plane and the second are united after the transformation.

The process can be repeated with the object plate, image plate, and projecting lamp all situated exactly as before. The image plate is now projected. After the planes are united, three triangles appear, each with its set of blue dots. By repeating the process over and over, many triangles appear, all with blue dots. The mathematician would say that we have transformed the plane onto itself many times via a series of identical projective transformations. Now forget the triangles and attend only to the blue dots. They will form a set of curves. Following the trajectory of one of the dots, a point in a plane, we have been led to a path curve. Although we have chosen to watch only a few blue dots, clearly all the points of the plane are brought into movement by the series of projective transformations. Transforming the plane onto itself has produced path curves. They are forms of the plane, structures that remain unchanged throughout the movement. By changing the angle of projection, we could arrive at a different series of projective transformations and a different set of path curves.

If we considered the entire plane, we would find that three and only three points never move at all. They are

completely invariant.² All other points move along path curves that cross only at the three invariant points of the plane. We can watch the points of a path curve march dutifully along behind one another, never deviating from their designated path, as if moving through the veins of some organism. The whole plane is in movement. Yet within the flux, there abides form: The pattern of path curves does not evolve, although every aspect and point of the plane (save three) are in motion! One cannot help noticing the kinship between such form within movement in geometry and the similar biological phenomenon. Every human cell is replaced within a seven-year span, yet our countenance remains, in all essentials, unchanged. The beauty apparent in the contemplation of these concepts and forms quickly wins the heart of anyone with the least affection for the elegance of pure mathematics.

While far more difficult to imagine, an entirely analogous procedure can be followed in three dimensions. In this case, surfaces as well as curves fill out space with forms. These are the invariant forms of space, invariant, that is, under repeated applications of an identical projective transformation. It is just these dynamic yet invariant path curve forms that we shall discover around us in the plant and animal kingdoms.

Path curves present a rich variety of spatial forms. These include egg shapes, cones, and vortices (figure 6). Using a particular mathematical procedure, one can assign a number, called lambda, the Greek letter λ , to each shape that appears. For instance, positive values between zero and infinity are associated with various egg-shaped path curves. Negative values give all the vortex forms. The forms so created on the geometer's drawing table bear a striking resemblance to certain forms in nature. Lawrence Edwards starts with the question: Is this resemblance merely superficial, or does a genuine correspondence exist?

During twenty years of research, Edwards has explored the kinship between path curves and natural forms as diverse as pine cones, plant buds, eggs, the human heart, and developing embryos. The results of his research and his reflection on their meaning are summed up in his recent book, *The Field of Form*. In it he tells of the blind alleys into which he wandered but also of the moments of excitement when he saw clearly how transformations of projective geometry touch the earth and gather up substance to clothe their forms. We will inquire into only two of his findings, those concerning plant buds and the human heart. With them the beauty of his work will become apparent.

2. The basis of this statement can be shown mathematically but is too complex to present within the confines of this article.

Let us begin with the bud of the wood sorrel (*Oxaliacetosella*), which gives forth its small white flower during midsummer. By carefully collecting several samples, mounting them for photography, and enlarging the prints, we can make very exact measurements of the bud shape in profile. In constructing the corresponding path curve, we find that by placing two of the invariant points at the upper and lower poles of the bud and following an exact mathematical procedure, we can determine the path curve that best fits the wood sorrel bud. This can be done for many wood sorrel buds at the same stage of development, regardless of size. The agreement between the pure mathematical form and the living one is striking. Perhaps the most immediately convincing evidence is found in the simple visual comparison of an ideal path curve with the actual form of the bud. Often the difference is little more than the width of a pencil line—well within the precision with which one can make reliable measurements on these frail little buds. Not all species follow path curve forms so perfectly, but in over eighty percent of the cases studied, the plant buds are found to reflect path curve geometry with remarkable fidelity.

Correspondences can be found elsewhere in the living world. The spiral tendency of leaves on a stem has long engaged botanical and mathematical researchers. Similar spiral configurations are to be seen in pine cones and in bud formations, in the way petals arrange themselves around the bud center. It turns out that the path curve surfaces of the bud are themselves covered with a spiral pattern, each spiral being a path curve. Very often one can capture the gesture of these spiral patterns by suitable path curve analysis. Such agreement seems unlikely to occur by chance, for it can be found in many

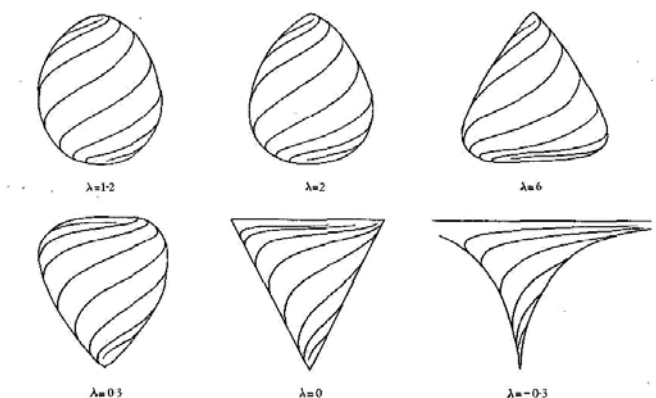


Figure 6. Path curve forms in three dimensions resemble egglike/vortexlike figures, depending on the manner of their construction. The examples shown here represent path curve forms differing only in the important mathematical parameter, lambda (λ). If $\lambda = 1.2$, the form is round and egglike. As λ increases, the form becomes sharper and blunter at its ends. Negative values of λ produce vortex forms.

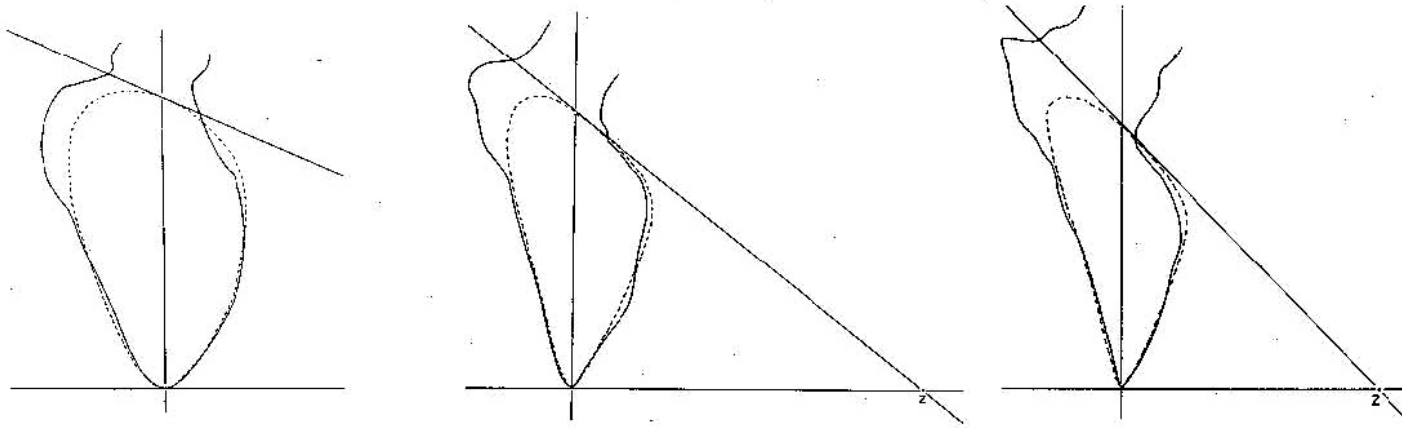


Figure 7. The solid lines represent tracings of the actual living form of the ventricle as detected by an X-ray procedure. The broken lines illustrate the path curve forms calculated to fit the actual forms. During one full heart cycle (of about 0.8 seconds' duration), the path curve forms change dramatically and reveal a rhythmic sevenfold process.

The left ventricle of the human heart at the moment of full diastole or relaxation (left).

The same ventricle 0.14 seconds before systole or contraction (middle).

The ventricle 0.04 seconds before full systole (right).

other biological forms, including that of the heart.

The heart in animal or man can be thought of as the perfect or archetypal muscle. Other muscles may be seen as variations of this central organ, whose whole existence is ceaseless rhythmic activity. Beginning with the detailed studies of the heart made by Scottish anatomist J. Bell Pettigrew in his book *Design in Nature*, Lawrence Edwards worked to uncover the path curve form of the heart. In this instance, not only was the outer form of the heart significant, but so were the particular circling patterns made by the several layers of muscle that together comprise the heart. Pettigrew distinguished seven layers. Moving from the outermost inward, the muscle patterns change from a left-handed to a right-handed spiral at the fourth layer. In addition, the left ventricle, which Pettigrew terms the "heart of the heart," changes its form as one moves from layer to layer. Would it prove possible to follow these changing forms as one moved inward? Indeed, by changing the positions of the invariant points, the slightly asymmetric form of the heart can be geometrically reproduced. The form of the left ventricle also proved possible of capture in a path curve. Even the spiral gesture of the muscle layers, like the spiral of the wood sorrel bud, finds its expression in path curves, as a second set of curves that cover the surface.

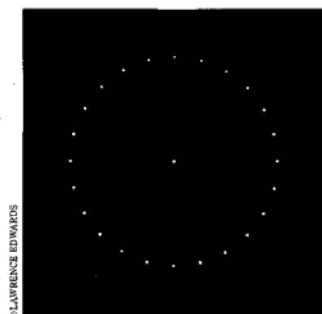


Figure 8. Pointwise Circle

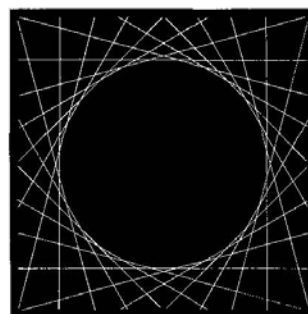


Figure 9. Linewise Circle

One of Edwards's most dramatic accomplishments must surely be his study of the living human heart, made possible through a kind of X-ray moving picture. Every fiftieth of a second an X-ray image was taken of the beating heart. The technique provided a picture of the inside surface of the heart, the innermost of Pettigrew's seven layers (figure 7). Edwards followed the changing form of the heart throughout the duration of a pulse and found that the movement from full expansion to full contraction is in itself a rhythmic sevenfold process, one beautifully revealed through his path curve analysis.

So far we have seen a remarkable congruence between those forms inwardly created by the human mind, that is, path curves, and the tangible forms of plant bud and heart. Lawrence Edwards has made preliminary studies in several other directions, but we must leave these aside for want of space. Of much greater importance is his discovery of what he terms the "pivot transformation," which relates forms in space to those of a complementary realm, one that is sometimes called counterspace.

I shall conclude by spending a few moments considering the general character and significance of these ideas for the understanding of plant forms.

When visualizing a circle, we tend to see it as a continuous curve formed of

points all equally distant from the circle's center. The circle is formed from the center out, point by point (figure 8). It is initially surprising to learn that there is a second means of forming a circle. We must free ourselves from the habit of thinking of points as somehow more primary than the line. For in this other view, it is just the line, and not the point, that is used to generate a circle. The construction can easily be understood by visualizing one line after the next as touching a circle. The set of lines has thereby created a tangent envelope that also completely defines the circle (figure 9). If we generalize still further to three dimensions, the infinitely extensive, unitary, and undivided plane becomes the generative entity of space. Thus is the sphere formed no longer of points equidistant from a given point. Rather, planes shape the sphere, just as the sculptor shapes his clay with the flat of his hand. So may the infinitely many planes of space fashion geometric forms from the periphery inward. It becomes possible to imagine a new kind of space, a "counterspace," wherein point becomes plane.



Wild rose bud with immature seed capsule.

Working from indications for projective geometry given by the Austrian philosopher and scientist Rudolf Steiner, George Adams and Louis Locher Ernst sought to develop a geometry of counterspace and to connect it with the botanical kingdom. (Adams's work is to be found in his books *The Plant between Sun and Earth* and *Physical and Ethereal Spaces*, both coauthored with Olive Whicher.) Lawrence Edwards, who worked with Adams, has continued these efforts. In particular, he has explored a novel class of projective transformations that involves a change in space element. That is, instead of transforming

one point to another, or a line to a line, Edwards uses those projective transformations that transform a point to a line, or a point to a plane.

Such transformations immediately call to mind what the quantum physicist David Bohm termed "the implicate order," wherein the entirety of a line can be "enfolded" into a point. In such instances the relationship between the whole and the part is clearly unusual, for the whole is in the part, the line is in the point!

We cannot delve here into the complexities of counterspatial geometry. Suffice it to say that once we have explored its properties mathematically, we are free to move between space and counterspace, between point and line, by means of Edwards's pivot transformation. Can this possibility be exploited in the study of organic forms? Lawrence Edwards saw the means for doing so. Working with the hip of the wild rose, he was able to discover the beautiful "plane-wise" vortex that stands in counterspace behind it. Moreover, the character of the pivot transformation is such that the bud of the wild rose (itself a path curve) mediates the transformation from vortex to hip (figure 10). Thus are all three elements—bud, hip, and vortex—brought into a harmonious interrelationship. Other plant species show similar fidelity to the geometric forms generated from his counterspatial vortex.

The discovery of the counterspatial vortex as he describes it in his book, is a grand moment to rehearse with Mr. Edwards. Through it he seems to approach the nature of life itself. And now the full strength of projective geometry becomes clear. In addition to providing transformations that are highly mobile, it establishes, through the development of counterspace, a new relationship between the whole and the part.

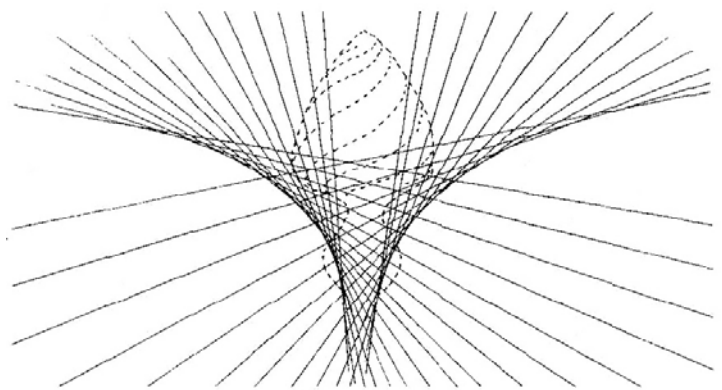


Figure 10. Through use of the pivot transformation, it can be shown that a path-curve vortex form mediates between the form of the bud and the form of the seed capsule, in this instance, a rose hip. The seed-bearing organ of the plant is usually not a path curve, but its form can be delineated with great accuracy by the pivot transformation.

In his work, Edwards is not only concerned with describing mathematically the natural forms he studies, but also tries to find the origins of these forms. He has not, as do most contemporary researchers, sought to find them through molecular biology, but instead by developing a science of form. When reading about what he terms “fields of form,” one is reminded of the great English physicist Michael Faraday, developer of the field concept. The fields in Edwards’s work, however, are conceived not as physical forces but as insensible, ideal forms that are nevertheless imaged in the tangible shapes of the living world. He is convinced, as was Goethe, that nature creates her infinite forms according to a plan, according to an Idea. Goethe wrote: “The Idea is eternal and unitary All that of which we become aware and of which we can speak are only manifestations of the Idea.” The Idea is not to be identified with a purely material or molecular basis—the building blocks of life. Rather, we should attend to the forms themselves. In writing of biology, Aristotle made use of an analogy, that of a house:

The object of architecture is not bricks, mortar, or timber, but the house; and so the principal object of natural philosophy is not the material elements, but their composition, and the totality of form, independently of which they have no existence.

Lawrence Edwards has attended to the composition and form of organic nature as few before him and has shown that through careful observation of nature and the free activity of human thinking, the Ideas that seem to touch nature may also unfold in the human mind. When Kepler brought forth the great laws of planetary motion, he said he had stolen the golden vessels of Egypt. Kepler heard through these geometric laws the harmony of the spheres, and his decades of labor were requited. Lawrence Edwards shares Kepler’s vision of the world as created and formed according to an image, fashioned not simply by a field of forces, but rather in accord with a “field of form.”

Suggested reading:

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PHENOMENOLOGY: HUSSERL'S PHILOSOPHY AND GOETHE'S APPROACH TO SCIENCE

by
Michael Holdrege

Introduction

It may seem surprising that Goethe's scientific method and the philosophy of Edmund Husserl, which was developed half a century after Goethe's death, would be grouped under the same heading: *phenomenology*. To show the justification for this and to outline the nature of the profound project that Goethe and Husserl shared will be the task of this article.

Husserl's Phenomenology and the Cartesian Split

Husserl saw his phenomenology as addressing a crisis that faced the western sciences. In his last great work, *The Crisis of European Sciences and Transcendental Phenomenology*, Husserl spoke of how positivistic science—blinded by the prosperity it produced—had reduced the idea of science to a focus on purely factual data. This form of scientific endeavor, he maintained, turns away in indifference from the questions that are decisive for a genuine humanity. All valuative questions, questions of the meaning or meaninglessness of human existence, were banned from the realm of scientific endeavor. According to Husserl, this form of science “strives for and achieves nothing but ‘*theoria*’.” In other words, man becomes a nonparticipating spectator, surveyor of the world” (Husserl 1970, p 285).

Husserl's efforts to return science to “the things themselves” were held by many to be so significant that the historian of philosophy Hans Stoeig—speaking in the late 1970s—called Husserl one of the two most influential philosophers of the 20th century (Stoeig 1978). After all, Husserl's work had a fundamental impact on such prominent philosophers as Heidegger, Sartre, Ricoeur, Scheler, Gadamer and Merleau-Ponty. Central to Husserl's project was the overcoming of the split erected by Descartes between our inner life of mind (*res cogitans*) and the outer world of extended things (*res*

extensa).

Husserl saw clearly that once a distinction between mind and nature is posited, the question must inevitably arise as to how the two are related. He considered the shift in focus that this question brought with it had led modern philosophy—beginning with Descartes—down an unproductive path of inquiry. In his quest to establish a firm, irrefutable foundation for knowledge, Descartes (1968) had employed the “method of doubt,” which involved rejecting all previous opinions that allowed for even the slightest incertitude. Through this process of methodologically doubting, Descartes was led to question even the apparent reality of the physical world and his own body. The only certainty that remained for him was that he, the doubter, existed: *Cogito, ergo sum* (I think, therefore I am). From this point of certainty, Descartes then deduced the necessary existence of a perfect God, who—because perfect—would not deceive him. Therefore, the reality of the eternal world as it appeared to him must be guaranteed.¹ Nonetheless, two distinct worlds still presented themselves to Descartes. First, there is the *res cogitans*: the thinking dimension that one perceives within and which can be known with inner certainty. Entirely separate and fundamentally different from this is the *res extensa*—the extended substance: the outer “objective” world of the physical universe (Descartes 1968; Husserl 1970, 1982; Tarnas 1991; Brady 1998).

Using Galileo's distinction between primary and secondary qualities, Descartes concluded that the scientist should not rely on the qualitative secondary qualities (color, sound, taste, etc.) that are merely manifestations

1. It should be noted that with the deduction of a perfect God who would not deceive him, Descartes fell back into the same medieval practice of deductive reasoning that he was attempting to overcome.

of the “subjective” organization of our senses (as part of the *res cogitans*), but should address only those primary qualities (duration, shape, number, extension) that can be analyzed quantitatively and “objectively” because they belong to the outer world of the *res extensa*. This assertion of the essential dichotomy between thinking substance and extended substance (between secondary and primary qualities, respectively) led to the ordaining of mechanics—a form of inquiry permeated with mathematics and based on the “eternal” testing through experiment of the “internally developed” hypothesis—as the primary form of scientific endeavor by which the physical universe could be understood (Descartes 1968; Husserl 1970, 1982; Tarnas 1991; Brady 1998).

Husserl (1970) considered this dualistic basis for modern science to be naïve, particularly if one took into account Kant’s analysis of sense perception as developed in his *Kritik der reinen Vernunft* (1781). In this work, Kant argued that our experience of the sense world is not actually based on direct sense perception alone. The objects of experience point to a hidden mental accomplishment of which we are normally not aware. According to Kant’s analysis, we do not passively receive sensory input, but actively integrate and structure it. Once this is realized, Galileo’s so-called primary qualities no longer appear to be so “objective”; they cannot be abstracted from the formulaic activity of the mind and thus do not “stand alone” (Kant 1781, 1783; Kemp 1968; Husserl 1970; Tarnas 1991; Brady 1998).

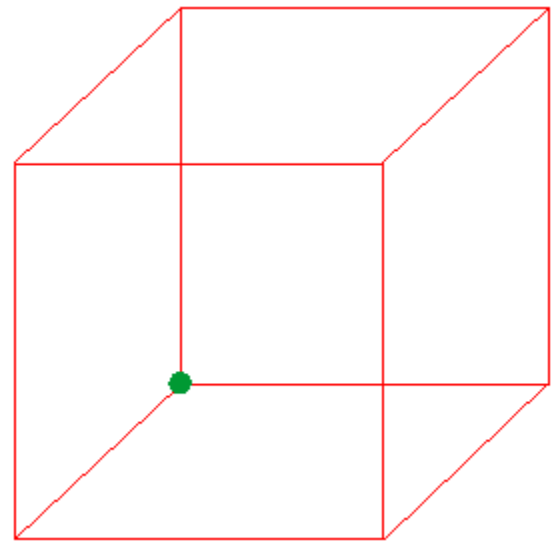
This insight did not escape modern philosophers of science (Brown 1977), even if they addressed the question of the theory-laden nature of perception quite differently from Kant. Before considering Husserl’s fundamental concept of *intentionality*—which provides a way of avoiding the Cartesian/Galilean conundrum—a brief look at one of the key contributors to the “new view” of science will be helpful.

N. R. Hanson and the New View of Science

Science in the first half of the 20th century was dominated by logical empiricists, who saw the system of postulates that made up a theory as hovering freely above the plane of empirical facts, whereas these facts—since they could be known independently of any theory—guaranteed the objectivity of science (Brown 1977). Beginning in the 1950s, this view came under sustained attack by a diverse group of philosophical thinkers.²

2. N. R. Hanson, Michael Polanyi, Stephen Toulmin, Paul Feyerabend and Thomas Kuhn wrote pivotal works that founded this new approach (Brown 1977).

Although it was Thomas Kuhn’s now famous book on *The Structure of Scientific Revolutions* that brought the decisive paradigm shift in the philosophy of science to general awareness,³ the approach of Yale philosophy professor N. R. Hanson⁴ relates more directly to the context of this article. Hanson’s often quoted words that “there is more to seeing than meets the eye” encapsulate a central theme in his analysis of the nature of perception. In *Patterns of Discovery* (1958), for example, Hanson discusses the familiar Perspe cube (Figure 1).



Hanson asks if all individuals who see this figure—and who, if they are requested to, are able to produce essentially identical drawings of this figure—actually see the same thing. Although the tiny inverted images on each viewer’s retina will be virtually the same, some will see it viewed from above, others from below, and still others as a kind of polygon-like gem. A fourth group might see only lines criss-crossing in a plane, and so on. Using many examples of this sort (such as Koehler’s famous “Goblet and Faces” drawing, Toulouse-Lautrec’s old and young woman picture, etc.), Hanson makes clear that—although nothing essential changes at the level of optics or physiology—people see different things! What changes is not the sensory data as such, but *the organization of what one sees*. Organization is not an element in the visual field, however; it itself is not seen as are lines or colors. In a related sense, Hanson points out, the plot

3. Amrine (1998) remarks that the influence of Kuhn’s book was so profound that one is tempted to divide the history of the philosophy of science in B.K. and A.K.—“before Kuhn” and “after Kuhn.”

4. Hanson—in the words of Amrine (1998)—“fired the opening shot” in this revolution with his classic work *Patterns of Discovery*, 1958.

is not another detail in a story, nor is the melody merely one more note in a song. Yet in the absence of plots and melodies, the elements of a story and the notes of a song would not hang together. In a similar manner, the organizing activity that lets the cube become a cube cannot to be seen. The following words of Charles Babbage (1830, cited in Hanson 1958, p 184) illustrate vividly how this influences the process of scientific research:

An object is frequently not seen from not knowing how to see it, rather than from any defect in the organ of vision...[Herschel said] I will prepare the apparatus, and put you in such a position that [Fraunhofer's dark lines] shall be visible, and yet you shall look for them and not find them: after which, while you remain in the same position, I will instruct you how to see them, and you shall see them, and not merely wonder you did not see them before, but you shall find it impossible to look at the spectrum without seeing them.

Different ways of seeing lead to different scientific results. In Hanson's understanding, then, we must recognize that all observation undertaken in the name of science is "theory-laden." This was the fundamental insight that led to a revolution in the philosophy of science (Hanson 1958; Brown 1977; Brady 1998; Amrine 1998). This insight that eternal reality can no longer be understood as divorced from the mind also provided Husserl (decades before) with a starting point free from the Cartesian split.⁵

Husserl and Intentionality

Although Husserl emphasized the role that consciousness plays in "constituting" the world, he did not conclude with Kant that beyond the—from consciousness co-shaped—phenomenal world, there exists a deeper level of reality—the thing-in-itself (the *Ding-an-sich*)—which is unknown and unknowable to us. Husserl was able to avoid such dualism, as well as the Cartesian version, with the help of one central concept: *intentionality*. Consciousness, as Husserl had learned from his teacher, Franz Brentano, is always directed toward an object—it is *consciousness of*.... For Husserl, this consciousness was inseparable from its object and hence not solely "a thinking thing" (*res cogita*) as it was for Descartes. Since consciousness always has an object, is always

conscious of something, it can no more doubt *of what* it is conscious than it can doubt *that* it is conscious. The indivisible unity between the conscious mind and that of which it is conscious overcame for Husserl the Cartesian bifurcation. The dualist dilemma that had faced western philosophy ever since Descartes was thus not to be overcome by eliminating one of the two categories—subject or object, mind or body—but by recognizing that that distinction itself—even if it informs every individual's daily experience—is problematical. Husserl recognized that every *cogito* intends a *cogitatum*.⁷ Consciousness itself is unified, although within this unity two poles can be identified, the *cogito* and its content (Stewart and Mickunas 1974; Brady 1998; Husserl 1999).

Even though experiences can be of very different kinds, Husserl demanded that each experience be taken in its own right as it presents itself to consciousness (as it shows itself). Husserl's phenomenological method expanded the meaning of "experience" beyond sense experience alone to include anything of which one is conscious. We can be aware of many different things, such as mathematical entities, natural objects, moods, feelings, values, desires and much else. Husserl called such experiences *phenomena* and saw phenomenology as the systematic investigation of the content of consciousness. This project required an awareness, however, that different kinds of content—such as mathematics and values, for example—have different kinds of reality, none of which are reducible to the others. Husserl considered anything of which one is conscious to represent a legitimate field of inquiry, and that each phenomenon must be taken as it is, without imposing upon it a methodology taken from elsewhere that is inappropriate to that particular subject matter. It would be nonsense, for example, to investigate mathematical questions by the same means that one investigates creatures such as birds and bees, or feelings such as affection. The acts of consciousness and their objects are very different in all these cases⁸

6. In everyday life, we do not notice the organizing activity of our intentionality. We bring to consciousness only the results of that activity—"I see the Perspe cube from below"—rather than the act of composition itself. Although my internal act does not create the perception of the cube—I cannot see it as a sphere, for example—it shapes it from a particular point of view.

7. "[T]he word intentionality signifies nothing else than this universal fundamental property of consciousness: to be conscious of something; as a *cogito*, to bear within itself its *cogitatum*" (Husserl 1999, p 33).

8. It would go beyond the scope of this paper to explore the method of "phenomenological reduction," or "bracketing," that Husserl applied to the pre-philosophical "natural

5. It is also fundamental for an understanding of Goethe and the way in which he attempted to "organize" his perceptual activity so that it harmonized with (corresponded to) the kind of phenomena he was studying.

(Husserl 1962; Stewart and Mickunas 1974). A rigorous science in Husserl's sense would, then, pay close attention to the kind of thinking (organizing activity) that it applies to various realms of phenomena. Its goal would be to find a close fit (correspondence) between the phenomena under examination and the intentional activity that beholds and investigates them.

Goethe's Phenomenological Approach

Husserl's double perspective that a) takes the phenomena seriously as they appear to us—as they show themselves—and that b) finds for each field of inquiry a methodology—a way of thinking—appropriate to it, brings us back to Goethe, for whom these two tenets were fundamental. Goethe's approach to the natural world was characterized by Rudolf Steiner, the first editor of Goethe's natural scientific writings, in the following way:

Goethe's view of the world is the most many-sided imaginable. It proceeds from a central point, which rests in the unified nature of the poet, and it always brings to the fore that side which corresponds to the nature of the object. The unity of the activity of intellectual forces lies in the nature of Goethe; the temporary form of that activity is determined by the object concerned. Goethe borrowed his manner of observation from the eternal world instead of obtruding his own upon the world. Now, the thinking of many men is effectual only in one definite way; it serves only for a certain type of object; it is not unified, as was Goethe's, but only uniform... All sorts of errors arise from the fact that such a way of thinking, entirely appropriate to one type of object, is declared to be universal. (Steiner 1968, p 7)

Rather than summarizing how Goethe's many-sided approach expressed itself in a wide range of phenomena—for Goethe's pioneering work includes studies in the realms of geology, meteorology, anatomy, zoology, and optics, among others—this paper will briefly consider

attitude" that accepts the natural world in an unquestioned way. The reduction involves calling into question all of one's presuppositions about the world. It is reminiscent of Descartes' method of doubt—and is undertaken in a similar spirit—but it leads, in contrast to Descartes' approach, to a non-dualistic phenomena-based relationship to the world (Stewart and Mickunas 1974; Husserl 1982).

his views on morphology,⁹ as well as one way that his scientific approach can be applied to the study of plant life.

Goethe recognized the value of a detailed analysis of the anatomy and chemical make-up of living organisms, but was convinced that a one-sided emphasis in this direction (an exclusive application of this form of intentionality) made one blind to that which distinguishes the living from the nonliving—in particular the fact that within an organism the totality is active in every organ. This is evident at death, when this all-parts-permeating principle disappears and "dis-integration" sets in. Goethe characterized the one-sided reductionistic approach in *Faust* (1971, verses 1936–1939):

Who wants the living to know and describe,
Seeks first the spirit from it to drive.
Now has he—indeed—the parts in hand,
Lacks merely—alas—the spiritual band.

In Goethe's view, the overall coherence-creating principle within the organism cannot be comprehended by detail-analysis alone. Morphology in his sense involved shifting one's intentionality from a predominantly analytical (reductionistic) mode to a more synthetic or holistic one¹⁰ that attempts to grasp the overriding unity of an object as it develops both spatially and temporally. For Goethe, the analytic-synthetic contrast was also reflected in the German expressions *Gestalt*, which intends the more fixed and finished final forms of an organism, and *Bildung*, which refers more to the dynamic, formative processes that lead to the fixed *Gestalt* (Steiner 1968; Naydler 2000).

Goethe's efforts were strongly directed toward developing the capacity to apprehend the plant not only in the spatial juxtaposition of its organs, but in the way those forms constantly transform—"changing ever, the same forever." He, himself, put it best:

In observing objects of Nature, especially those that are alive, we often think the best way of gain-

9. Goethe coined the term *morphology* and is recognized as the founder of modern comparative morphology (Naydler 2000).

10. This distinction can also be found in the German philosophy of Goethe's day, which followed Kant in distinguishing the intellect (*Verstand*), or normal analytical forms of thought, from the capacity of reason (*Vernunft*), which referred to higher intuitive or synthesizing insight (Steiner 1968; Naydler 2000).

ing insight into the relationship between their inner nature and the effects they produce is to divide them into their constituent parts. Such an approach may, in fact, bring us a long way toward our goal. In a word, those familiar with science can recall what chemistry and anatomy have contributed toward an understanding and overview of Nature. But these attempts at division also produce many adverse effects when carried to an extreme. To be sure, what is alive can be dissected into its component parts, but from these parts it will be impossible to restore it and bring it back to life....

The Germans have a word for the complex of existence presented by a physical organism: *Gestalt* (structured form). With this expression they exclude what is changeable and assume that an interrelated whole is identified, defined, and fixed in character. But if we look at all these Gestalten, especially the organic ones, we will discover that nothing in them is permanent, nothing is at rest or defined—everything is in a flux of continual motion. This is why German frequently and fittingly makes use of the word *Bildung* (formation) to describe the end product and what is in process of production as well. Thus in setting forth a morphology we should not speak of Gestalt, or if we use the term we should at least do so only in reference to the idea, the concept, or to an empirical element held fast for a mere moment of time. When something has acquired a form, it metamorphoses immediately to a new one. If we wish to arrive at some living perception of Nature we ourselves must remain as quick and flexible as Nature and follow the example she gives (Miller 1988, pp 63–64).

Since the plant world presents itself to us as a realm of ongoing transformation and change, Goethe attempted to meet it with an understanding that is “as quick and flexible as Nature.” Cassirer (1950, pp 138–139) characterized Goethe’s unique approach to the organic world as follows:

[Goethe] did not think geometrically or statically, but dynamically throughout. He did not reject permanence, but he recognized no other kind than that which displays itself in the midst of change.... Form itself belongs not only to space but to time as well, and it must assert itself in the temporal.

How does such an emphasis on *Bildung* and dynamic play itself out when faced with the concrete *Gestalt* of the plant? Instead of demonstrating this using Goethe’s own writings, this paper will employ an example of leaf metamorphosis typical of the approach developed by Gerhard Grohmann and Jochen Bockemuehl,¹¹ two pioneer practitioners of Goethe’s phenomenological method in the latter half of the 20th century.¹²



Figure 2. Leaves taken from the common buttercup (*Ranunculus acris*).

Ordered from bottom of stem (lowest left) to top (bottom right).

Downloaded from

www.hyattcarter.com/goethe's_way_of_seeing.htm

When one observes a series of foliage leaves such as those in Figure 2, it is striking that—despite considerable differences between individual leaves—the transformation from one to the next is gradual enough to give the impression of overall unity. What Nature presents to us are individual leaf forms (*Gestalt*). If we focus our attention (intentionality) on those individual forms themselves, we have difficulty identifying a single form—or

11. Grohmann’s two-volume work, *The Plant* (1974), and Bockemuehl’s numerous publications—see, for example, Bockemuehl 1998—have stimulated a great deal of research over the past 40 years into the nature of plant metamorphosis.

12. In this section I follow Ron Brady’s (1987) illuminating analysis of leaf metamorphosis in light of the concepts *Bildung* and *Gestalt*. His paper was first read at a symposium sponsored jointly by the departments of Germanic Languages and the History of Science at Harvard University and the Boston Colloquium for the Philosophy of Science.

schema—that reveals much about the entire series. Even the simplest schema—such as one based on the three-part leaf at the lower right—tells us little about the more complex forms. If we intend, on the other hand, a continuous movement from one to the next, then an impression of gradual modification arises. By intending a dynamic context for the individual forms, a lawful relation between them becomes apparent. Although the empirical forms appear separately, we can dissolve that condition in our minds by shifting our intentional focus from static particulars to movement, which allows us to detect a relationship that unites the individual forms. Brady (1987, p 278) puts an even finer point on this insight by inviting the observer to compare two leaves from different zones of the series—for example the second and the second to last leaves—in isolation. Seen side-by-side they appear quite dissimilar. On the other hand, if one moves through the series “backward and forward” until it becomes a continuous movement—as Goethe (1949, p 35) would have done—then a relationship becomes apparent despite significant differences between the individual leaves. The separate leaves now appear to us as different phases of one dynamic series (Brady 1987).¹³

Further reflection reveals that although the individual forms provide the basis for intending the movement between them, they themselves cannot produce the movement—for no individual *Gestalt* as such is able to generate the transformation to the next form. On the other hand, the intended movement is able to reveal a unity within the individual forms that is not apparent when they are viewed statically. One grasps the individual *Gestalt* as something like a frozen moment (in *space*) of a process of becoming (*Bildung*) that unfolds over *time*. When forms are intended in this dynamic way, they are no longer independent and complete in themselves. Every form calls for a preceding form and for one that follows—a before from which it arises and an after into which it develops. Each individual leaf (*Gestalt*) finds its full expression only through the continuous transformation of the series. Each image is thus representative of all the others and yet incomplete without them.

Viewing the plant in this dynamic manner is appropriate because individual leaves are, in fact, parts of a living whole that—in contrast to the nonliving—possesses an internal potency for growth and change. What exists in the seed as mere potential unfolds in space and time when suitable conditions present themselves (light, water, etc.). Furthermore, the parts of this living whole unfold in a specific sequence. The plant as such is not a finished entity, but a transition of states, one into another. Its “way of being” is one of constant becoming. Just as

cutting off an individual leaf from the plant as a whole results in its withering and death, so does considering the leaf merely as *Gestalt*—statically, in isolation—cut it off from its true context: the unfolding sequence out of which it arises. Attending to the parts of the plant as *Bildung*, by contrast, allows the form to be grasped dynamically, as a moment in the process of becoming (Steiner 1968; Brady 1998).

Conclusion

Why does this view of organic nature appear so inaccessible to mainstream scientific thinking? One reason is certainly that the prevailing mode of scientific observation arose historically in the realm of physics, which calls for a different form of intentionality than that suited to the organic world. Since the advent of modern science, the focus of most researchers has been on that which has already become (*Gestalt*), a level of existence well suited for investigation with analytic thought forms. The form of intentionality that this entails is firmly anchored in the mindset of the modern age—it signifies a deep-seated habit in our way of engaging Nature. A way of thinking that is better suited to grasping transformation and change in a holistic manner is still—almost 160 years after Goethe’s passing—quite new and unusual to us. Moreover, it requires significantly more intentional effort. The willingness to make this effort will first arise, I believe, when the role that our own consciousness plays in the coming into being of perceptual experience is more widely seen and appreciated.¹³ For that reason, Husserl and Goethe belong together. What Goethe developed through the concrete study of Nature—in the field, so to speak—received a significant foundation through Husserl’s efforts to overcome Cartesian/Galilean dualism.¹⁴ Husserl’s insights into the nature of intentionality provide the foundation for a differentiated phenomenological understanding of the world as it “shows itself” to human consciousness. It provides the groundwork for understanding the significance of Goethe’s “Bildung-oriented” approach to the plant world,¹⁵ an approach

13. Even though Hanson (1958) and others shed a bright light on this relationship over a half century ago, it still appears to be largely ignored in the day to day practice of the biological sciences.

14. Albeit those investigations were undertaken without any direct consideration of Goethe’s approach to natural science.

15. To reiterate what was said earlier, Goethe’s scientific method is very differentiated in the sense that it attempts to approach different realms of phenomena with a form of intentionality fitting to each. This essay has limited its focus, however, to the plant alone.

that attempts to activate our thinking in a way that is “as quick and flexible” as the plant that it beholds.

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FIRST APPROACH TO MINERALOGY

by

Frederick Hiebel



*Rhodochrysite specimen
from the editor's collection.
Found in Colorado.*

In one of his lectures, at the opening of the Waldorf School, Rudolf Steiner told his teachers that the age of twelve is an important turning point in a child's development. We have all noticed that just before and at about the age of puberty children gradually lose their grace of movement. They can become clumsy and spasmodic in the use of their limbs, their manners and, even their facial expressions. Their long arms hang awkwardly in sleeves which are always too short. In fact, at this phase of life, we can say a child is actually under the domination of his bony structure, his skeleton. Parallel with this physical phenomenon, there awakens within the child a more independent attitude toward his environment. His judgment of parents and teachers becomes more critical.

This is the age at which a child should learn the fundamentals of physics and approach, for the first time, abstract arithmetic in algebra. It is also at this time, while under the influence of his own bony structure, that a child can best learn about the "bony" structure of the earth.

Nature Study in a Waldorf/Steiner school begins in the fourth grade with "Man and Animal," and continues in the fifth with botany. During these two years the natural science classes, which always keep the human being in the center of his natural surroundings, work their way closer and closer to the earth until, in the sixth grade, we reach the study of geology and mineralogy.

Steiner advised the widest sort of approach toward the study and understanding of nature as a whole and of minerals in particular. Following his valuable indications we start with geography, and in close connection with geographical teaching the children learn to discriminate between a primitive mountain range (granite) and a

limestone range. For a class in New York City it seems natural to start with a study of the geological formation of Manhattan's own granite foundation. The countless subterranean 'tunnels' of the subways and the iron foundations of the highest buildings on earth are possible only because of the foundation provided by this solid ground. Even the inner vigor of this city's inhabitants appears to depend upon these layers of granite.

It is important that children should learn and actually grasp the fact that granite originated from the oldest era of our earth's development and is for that reason the firmest and strongest of stone formations. Countless ages ago granite was a vast mass of fiery-fluid substance which cooled slowly while other rocks formed a covering over it. During later ages these overlying rocks were destroyed by water and glaciers until granite appeared as the axis of the highest mountains.

In telling of these slow, majestic changes the teacher should try to arouse a feeling of "devotion towards the oldest altar of the world's creation." Let the children dwell upon these words from Goethe.

The children draw and paint the stages of the earth's development with pleasure and a sense of discovery. Through poetry, too, a feeling for the earth's wonders and hidden beauties can be brought forward.

From placid mountain brow, so solemn, old,
the mysteries of days long fled unfold.
There in time's far-distant dawning morn
the word of worlds in trinity was born.
Its first faint echo, rising from this hour,
bespeaks primeval harmony of power
and strives in white of quartz and dark-hued gneiss
and golden mica like rosin bound in ice
to spread forth pure the altar-table here,
presented long ago to that first year.

The granite mountains are the products of fiery eruption. The opposite of the granite mountains are the limestone ranges which were created by sediment, uplift, and erosion. Fire and water as the primeval forces in the development of our earth's surface are understood by children without giving them theories. They seem able to grasp how creative and divine forces were at work much as in olden times Vulcan and Neptune were understood when spoken of in connection with the earth's development.

Here is the place for a sketch or diagram of a volcano and the children draw the different layers of the earth's surface descending from sandstone, limestone, coal, devon, gneiss, to granite and the magma—the fiery original foundation of earth.

We soon find out that our whole subject can be divided into four parts: rocks, minerals, metals, and gems. Rocks contain many minerals and they in turn are composed of numerous chemical substances which often contain metals. Minerals and metals can appear on a higher level of development under the special condition of crystallization. Crystals and gems are the rarest and noblest forms of the solid element. And so we lead the children from the description of the rocks and minerals to that of metals and crystals, stressing the point that within these minerals the architectural plan of the earth has become far more spiritual and refined than it is in the crude forms of rocks and minerals.

As we always try to proceed from the whole to the details, from the original to the descendants, quartz appears as the primeval phenomenon of all mineral substances.

As honey held within the white-brown wax
Was gathered gladly in the day-long task,
So one day with a hundred thousand suns
Saw quartz, now hid in mountain-deeps, outspun.
Beside sun-radiance of quartz appear
The many other stones but dark and drear.
For this outshines in age and naturewise
What in the other stones imprisoned lies.
It is the oldest child of light, first-born.
Reminding us how blinded we are grown.

Metals are purified ores. The obvious place to begin this study is with gold, for gold is the archetype of all metals. In teaching about gold we should never neglect to speak of the important part gold has played in all legends, fairy stories, and myths, delved from an age of mankind which we call the Golden Age. Then we speak of the unique qualities of gold in regard to its malleability, ductility, flexibility, its quality of being insoluble. We can beat gold as thin as 1/250,000 of an inch. A piece of gold less than the size of a pinhead can be drawn out into a wire 500 feet long. That is its high ductility. Finally, it never loses its color and splendor: It does not tarnish.

We must always find the threads which lead from the human being to the natural world. When we describe these five qualities of gold which make it the “king” of all metals, we can draw parallel lines with the five most important qualities inherent in everyone who wants to become a spiritual “king”—that is, a person who knows first of all how to lead himself. Can we not apply these five qualities to our inner and moral self-education in relation to guidance of thoughts, strengthening of will, calmness of emotions, positiveness in judgment and impartiality towards life? (See the fundamental writings of Rudolf Steiner.) In the Middle Ages there lived people who ‘searched’ for gold in this way—the true students of Spiritual Science. They did not want to “make gold” in the superficial sense of the word, but to develop these five “golden” abilities for attaining their “spiritual kingdom.” This is the underlying significance of gold in all fairy stories and legends. To the children, of course, the teacher never mentions these facts or comparisons in literal form, but this connection must live as an inner impulse of conviction and enthusiasm within his own mind.

Such a presentation of the subject, including as it does a moral and uplifting undercurrent, prevents a one-sided, materialistic idea about gold and, by indirection, becomes a living force in the child’s mind. It reaches the child through the wisdom of a trusted teacher, leaving an impression more lasting than would the mere restatement of fact out of a textbook.

It is clear that after this the study of silver, copper, and iron is easier. We point out that historically gold was the first discovered metal. Silver and copper were used later, and iron does not come into use until the first millennium BC. Iron is the true Roman metal. Lead was discovered still later than iron (about 500 BC). We may conclude the study of metals by speaking of one of the very latest, such as radium in connection with the tremendously mysterious X-rays.

In the final chapter of our mineralogy, we touch upon crystals and gems. Here we look at the greatest works of art which the kingdom of the minerals can produce. Crystals and gems consist of the same products as the rocks and minerals, but in them the art of building up the earthly element has reached its highest perfection. Crystals have the most amazing geometrical forms, frozen into stone after an eternal law of the world. The ancient Greeks said that “God is a geometrician,” and surely crystals and gems are products of this divine geometry. Does it not seem, in precious stones, as though the splendor of the stars had been brought down into the earth itself?

Familiar to most of us is the snowflake—the simplest crystal in the making. The shape of the ice crystal is the hexagonal prism. The Greeks called ice *kristallos*, and from this our word *crystal* is derived. Starting with the crystals of the quartz family (rock crystal, amethyst, rose quartz), we go on to the garnets and to the corundum family (pointing to sapphires and rubies, emeralds, and topaz) and finally come to the diamond—truest archetype of all crystals and gems.

Diamond is the strongest of all minerals. It cannot be cut by another mineral for it is 140 times harder than corundum which stands next in hardness. All other gems consist of two or more chemical substances. The diamond alone contains but one. When pure carbon, or graphite, crystallizes in the form of an octahedron, the



African diamond in matrix

greatest miracle of transformation takes place—from the blackest opaque substance to the whitest most transparent one—the diamond. The diamond, then, can symbolize the discrimination between good and evil. We conclude our study of mineralogy by developing moral and idealistic thoughts on this phenomenon. We can see in diamonds the pure splendor of sunlight—as though, in them, the whole earth had begun to turn toward a future in which its darkness will be overcome by the power of light.

Mineralogy brings to a close the study of Natural Science as given in a Waldorf/Steiner school. It is important that we should not terminate such a period of teaching unless we have given to the children a feeling of true veneration for the greatness of nature.



Herkimer diamond from Fonda, NY, in matrix—from the editor's collection



“In the Crystals We Recognize the Presence of the Gods.”

As we look at the salt crystal, we realize that a spiritual principle is active in the universe. The salt crystal is the manifestation of that spirituality which permeates the whole universe; it is a world unto itself. Then, from an examination of a dodecahedron, we discover that there exists in the universe something that permeates the world of space; the crystal is the impress, the manifestation of a whole world. We are gazing on countless beings, each of which is a world unto itself. As human beings here on Earth, we conclude that the Earth-sphere is the focal point of the activities of many worlds. In all that we think and do here on Earth are reflected the thoughts and deeds of a wide diversity of beings. The infinite variety of crystal forms reveals the multitude of beings whose activities find consummation in the mathematical-spatial forms of the crystals. In the crystals we recognize the presence of the gods. “As an expression of reverence, of adoration even towards the universe, it is far more important to allow the sublime secrets of this universe to possess our souls than to gather theoretical knowledge on a purely intellectual basis. Anthroposophy should lead to this feeling of at-one-ment with the universe . . . able to perceive in every crystal the weaving and working of a divine being. Then cosmic knowledge and understanding begins to flood man’s whole soul. The task of anthroposophy is ... to enlighten the whole man and show his total involvement in the universe and to inspire him with reverence and devotion towards it. Every object and every event in the world shall be invested with a spirit of selfless service proceeding from the heart and the soul of man. And this selfless service will be rewarded by knowledge and understanding.” (pp. 61–62)

— From *True and False Paths of Spiritual Investigation*,
Lecture 3, August 12, 1924, Devon, England

SALT CRYSTALS



Evaporated salt around the Dead Sea, the lowest point on the earth's landmass



Growing Salt Crystals

Table salt or sodium chloride crystals are simple crystals to form if you've never grown crystals before.¹ The ingredients needed are salt and water, the crystals are non-toxic, and no special equipment is required.

Procedure:

Obtain a clean, sterile container like a glass Mason jar. Heat water to just before it boils and add the water carefully to the container until it is 1 to 2 inches from the top. Next pour salt into the hot water and stir until no more salt will dissolve. (A white scale will appear at the bottom of the container. These are minute crystals upon close observation.)

If you want crystals quickly, you can dip a piece of cardboard into this supersaturated salt solution and allow it to soak. Once it is soggy, place it on a plate or pan and set it in a warm and sunny location to evaporate. Numerous small salt crystals will form.

If you wish to form a larger, perfect cubic crystal, you will want to make a seed crystal. To grow a big crystal from a seed crystal, carefully pour the supersaturated

salt solution into a clean container (so no undissolved salt gets in), allow the solution to cool, then hang the seed crystal in the solution on a pure cotton thread attached to a pencil, popsicle stick, or twig balanced across the top of the container. You could cover the container with a coffee filter if you like.

Set the container in a location where it can remain undisturbed. You are more likely to get a perfect crystal instead of a mass of crystals if you allow the crystal to grow slowly (cooler temperature, shaded location) in a place free of vibrations.

Tips: Experiment with different types of table salt. Try iodized salt, uniodized salt, sea salt, or even Epsom salt. Try using different types of water, such as tap water compared to distilled water. See if there is any difference in the appearance of the crystals.

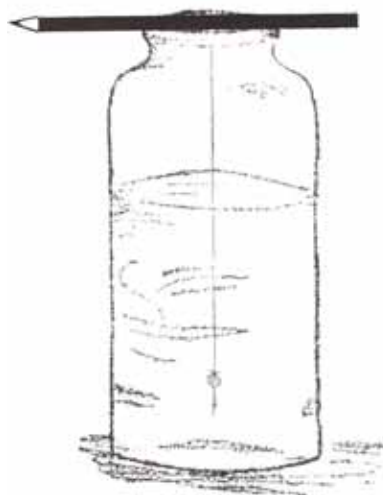
If you are trying for the 'perfect crystal,' use uniodized salt and distilled water. Impurities in either the salt, the container or the water can cause dislocation, a condition in which new crystals will not stack perfectly on top of previous crystals.

DSM

1. For many more examples see *The Wonders of Waldorf Chemistry*, AWSNA Publications by David Mitchell.



Cubic salt crystal



*Salt crystal generator
with supersaturated
solution*

THE BEAUTY OF SLIME MOLDS

Slime molds is a term describing fungus-like organisms that use spores to reproduce. The term conjures up in most of us a gelatinous, viscous fluid that is to be avoided. It is, in fact, only one stage of the slime mold's life cycle and is seen mostly with the myxomycetes which exist as a macroscopic mold.

Slime molds have been found all over the world and feed on microorganisms that live in any type of dead plant material. For this reason, these organisms are usually found in soil, lawns, and on the forest floor, commonly on deciduous logs. However, in tropical areas they are also common on inflorescences, fruits and in aerial situations (e.g., in the canopy of trees). In urban areas, they are found on mulch or even in the leaf mold in gutters.

Most slime molds are smaller than a few centimeters, but some species may reach sizes of up to several square meters and masses of up to 30 grams. Many have striking colors such as yellow, brown and white.

I first encountered the form while reading Ernst Haeckel's *Kunstformen der Natur* (*Art Forms in Nature*), written in 1904. This fantastic study is profusely illustrated with forms he observed, and I was overwhelmed by the geometric symmetry and profound beauty in these simple organisms.

For example, a plasmodial slime mold involves numerous individual cells attached to each other, forming one large membrane. This "supercell" (a syncytium) is essentially a bag of cytoplasm containing thousands of individual nuclei.



When they exist scattered about in single cell organisms and a chemical signal is secreted into their environment, they are able to respond to the chemical stimulant, find one another, and assemble together into a cluster that then acts as one organism.

There exist many myths about slime molds. For example, traditional Finnish lore describes how malicious witches used yellow *Fuligo* (in Finland called "paranvoi," or butter of the familiar) to spoil milk. Also, the giant amoeba-like alien that terrorizes the small community of Downingtown, Pennsylvania, in the 1958 American horror/science-fiction film *The Blob* might be based on slime molds.

Slime molds have almost no fossil record. Not only do slime molds produce few resistant structures (except for spores, which are often overlooked or unidentifiable), but they live in moist terrestrial habitats, such as on decaying wood and fresh cow dung, where their potential for preservation is low. A few fossil slime molds have been found in amber (Poinar and Waggoner, 1992).

There are more than 500 species of slime molds. They creep on decaying wood and in moist soil, ingesting bacteria and decaying vegetation. They help give the forest soil the strong, unique, "earthy," smell with which we are all familiar.

The photographs on the next two pages illustrate how beautiful and colorful slime molds are—those organisms, which are responsible for breaking down forest substances into brown rich mass that feeds new growth and renewal.

DSM







MUTUALISM BETWEEN ELK AND MAGPIES

by Jeff Mitton



Elk love magpies, which gently remove their ticks. Elk dislike and distrust ravens, which rip out their fur for nesting materials.

A large herd of elk had settled into Moraine Park at Rocky Mountain National Park to bask in the sun of an early-spring afternoon. They sat motionless except for their ears, which they flicked constantly. Something was bothering their ears. Probably ticks. A magpie glided over the herd and landed among the elk. In a determined manner, it approached a sitting elk, hopped onto its flank and continued up onto its back, where it paused to survey its surroundings. The elk did not move. The magpie climbed onto the head, and the elk remained unperturbed and motionless. The magpie probed an ear with its bill and then stuck its head inside the ear to probe deeper. The elk did not move. Then the magpie withdrew, turned its attention to the other ear and groomed it slowly

and deliberately. The elk looked more silly than majestic with a magpie on its head, but the elk was probably more concerned with its ticks than with my opinion of its appearance. Two more magpies arrived and began foraging on elk. One magpie started at the head, walked down the elk's neck and along the back to stand on the rump, when the elk obligingly lifted its tail. The magpie probed the edge of the tail and beneath the tail. No doubt about it, elk and magpies were cooperating to transfer ticks from the skin of elk to the bellies of magpies. A cleaning mutualism is a mutually beneficial relationship between two species in which one removes ectoparasites, most commonly ticks, from the other. One individual is relieved of bothersome,

usually blood-sucking hitchhikers and the other gains an easy meal in a safe interaction. Several cleaning mutualisms involve birds and large mammals. The textbook example is red-billed and yellow-billed African oxpeckers cleaning rhinos, cape buffalo, zebras and giraffes. Several lesser-known mutualisms have been described in North America. Scrub jays remove ticks and insects from Columbian blacktail deer, and both scrub jays and crows groom wild boars. Magpies forage on feral horses in Nevada. Jays, crows, ravens and magpies are all members of the family *Corvidae*, meaning they are closely related. Many corvids engage in cleaning mutualisms, but not all; Steller's jays and ravens are not known to groom large mammals.

Two ravens dropped into the herd and I wondered whether they would also groom elk, but they had a surprise for me and for the young elk. One of them walked up to a young elk, grabbed a bill full of fur and yanked. The elk glared at the raven, but the bold raven grabbed more fur and

yanked again. The elk quickly stood up and walked away. The other raven also approached a young elk and yanked out a tuft of hair. One raven took five yankfuls from several elk before it could hold no more in its bill. Both ravens flew off to line their nests with elk fur.

Elk responded differently to magpies and ravens. When a magpie approached them, they sat or stood still, even when the bird probed deep into their ears. Ravens approached only young elk. Perhaps the ravens knew that the older elk had already learned to avoid ravens collecting nesting material. Each young and presumably naïve elk responded to being plucked with alarm if not indignation and moved away from the aggressive raven.

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The Red-billed Opecker feed on ticks off the impala's coat. Mutualism is any relationship between two species of organisms that benefits both species. This is the relationship most people think of when they use the word "symbiosis."



Nurse shark with remora removing parasites



Giraffe licking salt and minerals from a ground squirrel. Parasites and lice are also removed in the process.

SYMBIOTIC RELATIONSHIPS

Many organisms live together in beneficial relationships toward each other within an ecosystem. *Symbiosis* is the term used for this type of relationship. These liaisons play an important part of the community structure in ecosystems. Similar interactions within a species are known as co-operation.

Generally, only lifelong interactions involving close physical and biochemical contact can properly be considered symbiotic. There are three distinctly different types of symbiotic relationships, depending on the nature of the benefits and yields to those organisms involved.

- Mutualism—describes any relationship between individuals of different species in which both individuals derive a benefit.
- Commensalism—concerns an interaction that benefits one organism but does not harm the other.

- Parasitism—one organism is dependent on another for its energy supply and usually harms its host or exists at its expense to some extent.

The complex interplay of these relationships demonstrates the intricate nature of the interdependence of organisms within any environment. For example, mutualistic interactions are vital for terrestrial ecosystem function, as more than 70% of land plants rely on mycorrhizal relationships with fungi to provide them with inorganic compounds and trace elements.

In addition, mutualism is thought to have driven the evolution of much of the biological diversity we see, such as flower forms (important for pollination mutualisms) and co-evolution between groups of species.

A few plants, animals, insects, and fish that have symbiotic relationships are listed below. There are many more.

Biological Pairs				Type of Symbiosis
Human	↔	All plants	➔	Mutualism (gas exchange)
Human	↔	Intestinal bacteria	➔	Mutualism
Human	↔	Tapeworm	➔	Parasitism
Rhinoceros	↔	Oxpecker Bird	➔	Mutualism
Deer	↔	Tick	➔	Parasitism
Barnacle	↔	Whale	➔	Commensalism
Algae	↔	Aquatic Turtle	➔	Commensalism
Flowering plants	↔	Pollinators such as bees	➔	Mutualism
Remora	↔	Shark	➔	Mutualism
Eel	↔	Coral	➔	Mutualism
Nomeous Fish	↔	Man o' War	➔	Mutualism

Hermit Crab	↔	Sea Anemone	→	Mutualism
Bass	↔	Wrasse Fish	→	Mutualism
Clownfish	↔	Sea Anemone	→	Mutualism
Blood Fluke	↔	Snail	→	Parasitism
Flea	↔	Mouse	→	Parasitism
Honeybee	↔	Flowers	→	Mutualism
Monarch Butterfly	↔	Milkweed	→	Mutualism
Lice	↔	Horses	→	Parasitism
Nematodes	↔	Sheep	→	Parasitism
Honey Guide Bird	↔	Badger	→	Mutualism
Cowbird	↔	Bison	→	Commensalism
Crocodile Bird	↔	Crocodile	→	Commensalism
Wren	↔	Osprey	→	Commensalism
Red-billed Oxpecker	↔	Impala	→	Mutualism
Magpie	↔	Elk	→	Mutualism
Plants	↔	Aphids	→	Mutualism
Mycorrhizal Fungus	↔	Corn	→	Mutualism
Lichen Algae	↔	Lichen Fungus	→	Mutualism
Shelf Fungus	↔	Hickory Tree	→	Parasitism
Moss	↔	Maple Tree	→	Commensalism
Woodpecker	↔	Pine Tree	→	Parasitism
White Rot Fungus	↔	Oak Tree	→	Parasitism
Spanish Moss	↔	Oak Tree	→	Commensalism
Spruce	↔	Mistletoe	→	Parasitism
Saguaro Cactus	↔	Gila Woodpeckers	→	Commensalism
Rhizobium Bacteria	↔	Legumes	→	Mutualism
Algae	↔	Sloth	→	Mutualism

AN INTERVIEW WITH DANIEL PINK

Why Waldorf?

by

Tracy Stevens



Daniel Pink is a horizontal thinker. He has had his hand in business, government, law, and writing among other things. He worked with U.S. Labor Secretary Robert Reich and was formerly chief speechwriter for Vice President Al Gore. He is a contributing editor of Wired magazine and an independent business consultant as well as a best-selling author

who chronicles the changing of the work world. Pink postulates that in the future right-brained thinking will dominate and drive the new economy. It will no longer be enough to rely on left-brained thinking alone. He describes the Conceptual Age as the newest phase of the modern economy in which we will need to develop and incorporate the six senses of design, story, symphony, empathy, play, and meaning for success.

Pink, the author of A Whole New Mind: Why Right Brainers Will Rule the Future sees Waldorf education as not only addressing the 21st century's need for right brain skill development, but doing it in a manner that creates lifelong motivation by de-emphasizing the reward-and-punishment, high-stakes test environment characteristic of the No Child Left Behind legislation. Following are excerpts from Tracy Stevens's interview.

How can schools improve performance through the arts?

It starts with realizing that arts education is fundamental, not ornamental. We urgently need people to think like artists. This is especially important in the work place, where everything is abundant, automated, or made in Asia more cheaply than it is here. Creativity, design and

the arts will be the way to prosper and succeed in the new economy. The arts are also a way to help people reach their potential and find their element.

How can teachers use the arts as a tool to teach?

The arts in education enable teachers to explore subjects in ways that can be better understood and inter-related. History, math, science and any other subject can be taught through the arts in ways that brings them to life. The arts provide a way to connect subjects, as they are in the real world.

How do Waldorf schools fit with the dawning of the Conceptual Age?

Waldorf schools get the idea that the arts are fundamental, not ornamental. They focus on the unit of the child, not the school as an institution. They customize education for each child. Waldorf promotes autonomy and self-direction, whereas most schools actively squelch those qualities in favor of compliance, which seems to be the most important value. The irony is that compliance is much harder to achieve and it is less important in the work world. I think Waldorf schools are very much in synch with the notion of the Conceptual Age and the ideas of *A Whole New Mind*. They foster internal motivation in students, as well as mastery and persistence. They teach the habits of the heart that children need to do well in life after school.

Can you identify any education system specifically that integrates daily art into its curriculum?

Waldorf does it. Montessori does it. There are some arts and design charter schools that do it well. There is an art-centered elementary school in Maryland near where I live that does a good job of it. The teachers and principals in these schools understand the necessity of the arts in

education. We are not talking about replacing math with art! We are talking about bringing out math more strongly through art. The arts train people to become horizontal thinkers who can make connections. We need to rethink this whole notion of frog-marching kids from one isolated subject to another. The world does not work that way, and we are doing kids a disservice to train them that subjects are separate and unrelated before they get out into the work world. The world has very porous borders and is a tangle of interconnections. Schools should be preparing them for that.

What kinds of programs or features should parents be looking for when exploring school options for their children, be it pre-school or secondary grades?

It really depends on the kid. There isn't a formula for this, but it is not the one-size-fits-all approach that we have. Figure out what is engaging for your child, what he likes and is good at and pursue that. I think the schools have a tremendous burden on them. They can't do everything that is expected of them from parents and the government. They can't be all things to all people. Schools are expected to teach academics, provide healthcare, nutrition, and sex education. They are supposed to build character and morals and even participate in community service. The burdens on our schools are outrageous. Parents have to share some of the load or it will collapse.

How can parents help to improve a child's opportunities for success in the Conceptual Age?

Pay attention to what your child likes to do and is good at and give him plenty of opportunities to follow his interests toward mastery. We want them to be intrinsically motivated and to be persistent. There is a process of discovery in trying out new things: sports.

music, theater, etc., and parents are great coaches and facilitators in this self-discovery. Through any of these activities, kids learn valuable skills of collaboration, teamwork, persistence, and mastery. We should not be forcing them to learn a musical instrument or play a team sport if they are not interested.

If a school devotes only thirty minutes a day to creativity, what would be the most beneficial activities they could engage in with their students?

The students should sit down and write letters to their principal asking why they have *only* thirty minutes a day for creativity! That is not useful! We shouldn't be having separate, isolated time for creativity and then tell them, "Stop thinking creatively because now it is time for the real learning. Time for math." The idea is to master skills and content, become curious and engaged. Compartmentalizing is not going to help them achieve this. It is contrary to it.

For more on Daniel Pink, go to www.danielpink.com. To learn more about Waldorf education, go to www.whywaldorffworks.org.

To read more by and about Tracy Stevens, please visit her website: www.abettereducation.blogspot.com.

All Waldorf Science Kits Currently in Stock

Purchase your kits for next year now!

These AWSNA kits, with the instructions included, have been developed to assist the teaching of science blocks in a Waldorf school. It is hoped that the guidance provided will help the teacher develop other phenomenological experiments. Some of the kits are for demonstration purposes while others can be obtained in bulk to provide the students with hands-on learning experiences. We have found new, less expensive suppliers and pass the low prices on to you, while they last.

Kit #1 – Static Electricity, Grade 6

This is a complete kit with fur, rods, and other materials, a bag of shredded tissue paper, balloons, a bag of crinkle confetti, and pith balls. Included are instructions and a sample lesson plan. Sold as a single item. – \$35.00



Kit #2 – Magnetism, Grade 6

This kit contains two Alnico bar magnets, a sample of lodestone, a base for observing magnetic fields, 8 small Alnico magnets, and a bottle of iron filings. Included are instructions, sample lesson plans, and several experiments. Sold as a single item. – \$45.00



Kit #3 – Acoustics, Grades 6/7

This kit contains a Chladni plate. Included are instructions and sample lesson plans. Sold as a single item. – \$114.00



Kit #4 – Heat, Grades 6/7

This kit contains three experiments, a five-metal star, a bimetallic strip, and a brass ball and ring. Included are instructions for experiments and sample lesson plans. Sold as a single item. – \$42.00



Kit #5 – Optics, Grades 6/7

This kit contains a set of optic cards, five polished glass prisms, and a set of falling gray-scale cards. Included are instructions for several experiments and sample lesson plans. Sold in kits for 10 students. – \$55.00



Kit #6 – Hydraulics, Grade 8

This kit contains an apparatus for observing the advantage of hydraulic force. Included are instructions and sample lesson plans. Sold as a single item. – \$32.00



Kit #7 – Botany, Grades 5-11

This root plant observation kit contains a vessel for growing plants and observing root growth and instructions. Sold as a single item. – \$35.00



Kit #8 – Optics, Grades 6-12

This kit contains a large, sealed, clear prism for holding water and throwing a rainbow image on the classroom wall. Sold as a single item. – \$27.00



Kit #9 – Optics, Grades 6-12

This kit contains a bent lucite rod used to show how light follows a bent path by multiple internal reflections. Sold as a single item. – \$25.00



Kit #10 – Optics, Grades 7/8

This kit contains material for an optics bench, allowing your class to study the properties and laws of lenses. Sold as a single item. – \$45.00



Kit #11 – Optics, Grades 7/8

This kit contains four mirrors with stands and experiments for reflection, shadows, and refraction. Sold as a single item. – \$34.00



Kit #12 – Electricity, Grades 7/8

This kit contains all the components and instructions for children to build an electric motor.
Sold as a single item: suggest one kit for 2-4 students – \$26.00



Kit #13 – Acoustics, Grades 7/8

With this monochord, the teacher can create experiments on the mathematical relationship of sound. Sold as a single item. – \$90.00



Kit #14 – Chemistry, Grades 8/9

This kit contains different materials for fiber experimentation. Included are instructions and student lab sheets. Sold as a set for 10 students – \$15.00



The following three kits were developed to be used in conjunction with Michael D'Aleo's and Stephen Edelglass's book *Sensible Physics Teaching* – AWSNA Publications – \$18.00

Kit #15 – Physics, Grade 6 – 334.00

Kit #16 – Physics, Grade 7 – 120.00

Kit #17 – Physics, Grade 8 – \$625.00

Please check Online at

<http://www.awsna.org/catalog/index.php?cPath=28>

or contact Robin at publications@awsna.org 518/634-2222 for pricing and ordering.

New Lower Prices!

Teaching Sensible Science Course to Begin in October, 2010

The next Teaching Sensible Science Course will begin at the Chicago Waldorf School in October 2010. This is an excellent training course for class teachers who want to prepare themselves for teaching the science curriculum in Grades 6 through 8. The course is comprised of three, one-week sessions, each focusing on the Physics and Chemistry curriculum of a specific grade. Led by Michael D'Aleo, participants will enrich their understanding of the philosophical underpinnings of the phenomenological approach to teaching science and benefit from lots of practical advice and experience in presenting the demonstrations and experiments. This course is highly recommended. The tentative dates for the three sessions are:

- Session One: Wednesday 6 October to Monday 11 October, 2010
- Session Two: Friday 18 February to Thursday 24 February, 2011
- Session Three: Mid-June, 2011 (specific dates tbd).

For more information or to register, contact the director of the program, Michael D'Aleo, at: spalight@verizon.net.

Sponsored by AWSNA and the Research Institute for Waldorf Education

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Waldorf Science Newsletter
edited by David Mitchell
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This newsletter is published once a year and is dedicated to developing science teaching in the Waldorf schools. Teachers are invited to pose questions, seek resource material, discuss experiments, write about their classes (successful and not very successful), and investigate phenomena. The editor also translates relevant science articles from Waldorf periodicals from around the world. The following past editions are available from:

AWSNA Publications
E-mail: publications@awsna.org
458 Harold Meyers Road
Earlton, NY 12058
fax: 518/ 634-2597
phone: 518/ 634-2222

available on-line at: http://www.whywaldorfworks.org/books_sciencenews.htm

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Partial contents—Acoustics in Grade 6; Teaching about Alcohol in Grade 8 Chemistry; The Chemistry Curriculum: The Debate over Teacher Demonstration vs. Student Experimentation; Spiritual Aspects of 20th Century Science; Overview of the Waldorf Science Curriculum; Water; Characteristics of the Major Sugars; Goethe's Meditation on Granite; Book Reviews; Humor; Poetry; Conferences; and Sample Experiments

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