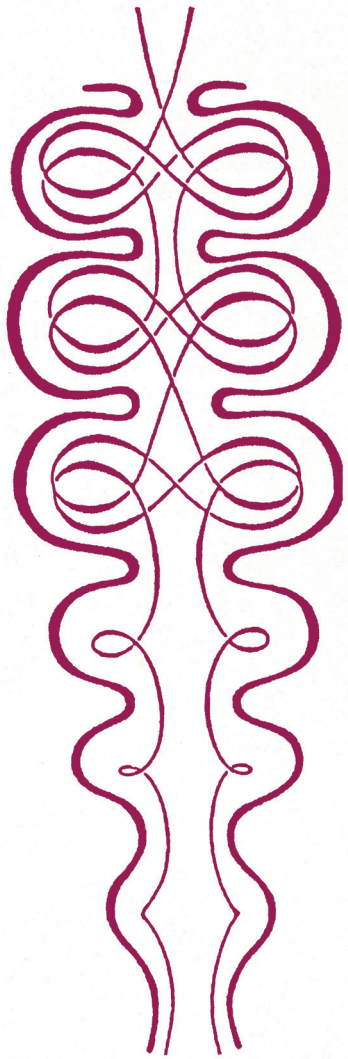


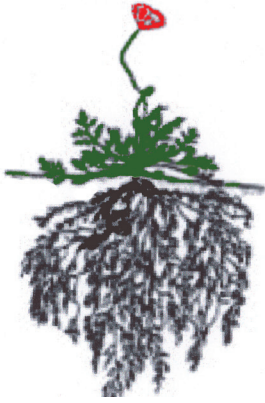
Volume 15, #25
Spring 2009



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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FROM THE EDITORS

The phenomenological teaching of science, as practiced in the Waldorf classroom, prepares students for new methods of thinking and imbues morality towards life. It enhances self confidence and promotes imagination, inventiveness, and the ability to logically question dogma and superficial reasoning. This is the thinking of the future and is evident by the social, cognitively-confused conditions currently being experienced.

Conscious, objective observation is a key to healthy science education. As I observe the world around me I see transitions in spiritual reality all about. Politically, I see a shift towards transparency where there have been walls of secrecy. I experience a mood shift from the passive voice to the active voice where responsibility is placed on everyone to engage. Emphasis on the noun is being replaced by the activity of the verb. How does this translate to education?

In order to be a contributing participant in the future, Waldorf education must be in the process of ever-renewing itself. The inner activity of Spiritual Science must replace the intellectualization of anthroposophy that is read,

discussed, and then becomes intellectual jargon. Humanity is pleading for new realities. We are in a position to provide them.

This edition of the *Waldorf Science Newsletter* includes the following articles: Doing Phenomenology in Science Education; The Western Screech Owl; Turtles use Earth's Magnetic Field; The Largest Bug in the World; Tree Talk; the Phenomenon of Colored Shadows; Analemma; Photos from Hubble; and finally a Progression through the Mechanics Curriculum of 7th Grade Physics.

The first article on phenomenology is restricted by copyright laws—the journal from which we purchased the rights does not allow it to be transmitted electronically, however, it is available from AWSNA Publications in its entirety. It is a most interesting article.

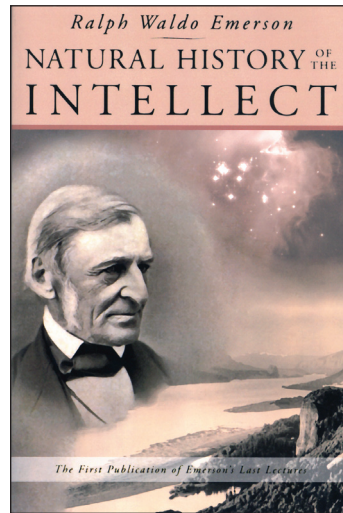
The *Waldorf Science Newsletter* is intended to be a participatory newsletter. We welcome your comments, articles, experiments and requests. We hope you will find this issue useful.

Books of Interest

Natural History of the Intellect

by Ralph Waldo Emerson

At his death in 1882, Emerson left behind a trove of unpublished material extraordinary for its quantity and depth—hundreds upon thousands of pages of journals, letters, notebooks, and lectures that dwarf his nine books in volume and scope but were never seen during his lifetime. His most important manuscripts have gradually filtered through to the public over the course of the last hundred and twenty-five years, save one: the final product of what he himself considered to be the “chief task of his life.” Here for the first time in print are the last lectures of Emerson’s career, a cycle of seventeen that he delivered at Harvard University in 1871.



Known to his contemporaries as the “Sage of Concord” and to generations since as the founder of American culture, Emerson is best known for the works of his early and middle years. The high idealism and finely crafted prose of his published works have resonated with a worldwide readership today, just as the hundreds of lectures he gave to audiences from Massachusetts to California made him one of the most famous and sought-after speakers of his time. His outspoken challenges to convention and authority, his gentle urging to value the quiet of the individual thought over the roar of the crowd, his persistent gesture towards the divine proportions of the human being revealed through nature, gave voice to an inspiration as uniquely American as the political ideals that formed the nation.

In his last lectures, Emerson set out to gather and structure the best thoughts of a project that spanned thirty-three years and ran as a constant, though largely hidden, thread throughout his active career. The result is a vibrant fabric of thought, image, and word as startling for the boldness of its pattern as for its immediacy and relevance to the modern reader. The powers of the mind and states of consciousness, the transcendence of physical into spiritual laws, the governing influence of Ideas in the history of humankind, and the ethical duty laid upon those who recognize the Good cause as their own, all serve as themes and elements of Emerson’s portrait of a practical understanding of the spiritual foundations of human experience and self-development.

CONTENTS

1. Introduction
2. Transcendence of Physics
3. Instinct and Perception
4. Memory
5. Imagination
6. Memory - Part II
7. Inspiration
8. Common Sense
9. Wit and Humor
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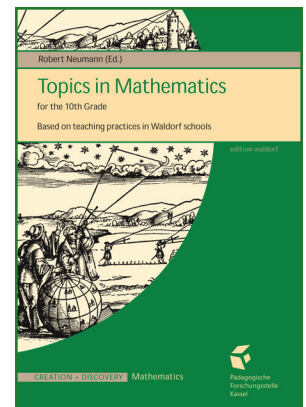
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Topics in Mathematics For the Tenth Grade

by Per Baum, et al,

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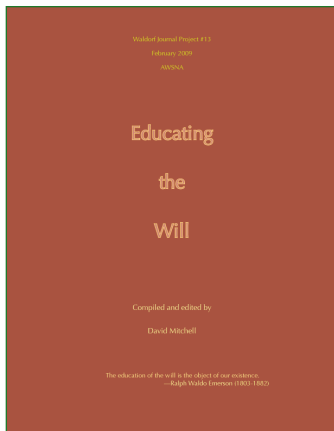


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Waldorf Journal Project #12
Research on Childhood
 Edited by David Mitchell

The Waldorf Journal Projects consist of articles translated from lectures or reprinted from Waldorf Periodicals throughout the world. Each issue has a theme (broadly). This issue draws primarily from the World Teachers Conference held last Easter in Switzerland at the Goetheanum, on Will-Education.

RESEARCH ON CHILDHOOD

CONTENTS

- *Rhythm and the Learning Process*
by Dirk Cysarz
- *Novel Methods of Researching Learning*
by Günter Haffelder
- *The Advantage and Disadvantage of Brain Research for Pedagogy*
by Christian Rittelmeyer
- *The Symphony of Life*
Importance, Interaction, and Visualizing of Biological Rhythms
by Maximillian Moser
- *Observations on Neurological Development*
Compiled by David Mitchell
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Waldorf Journal Project #13
Educating the Will
 Edited by David Mitchell

EDUCATING THE WILL

CONTENTS

- *Awakening the Spiritual Powers of the Head: Educating the Will*
by Christof Weichert
- *Wake up Your Headsprit: At Eye Level*
by Tobias Richter
- *Awaken the Spirit of the Head: Pyramids and Stars*
by James Pewtherer
- *Man’s Will Is His Kingdom of Heaven*
by Hartwig Schiller
- *Artistic Activity – Individual Resonance – New Paths*
by Claus-Peter Roh
- *Bringing the Will into Thinking in Adolescence*
by Betty Staley
- *Learning Is a Royal Path to Freedom*
by Hartwig Schiller
- *Rhythm as a Source of Regeneration*
by Dirk Cysarz
- *Art: Awakener of Consciousness, Humanizer for Society*
by Van James
- *The Push for Early Childhood Literacy: A View from Europe,*
by Christopher Clouder
- *Childhood Falls Silent*
by Dr. Rainer Patzlaff
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Research Bulletin
Autumn/Winter 2008
Volume XIII, Number 2
 Editor: Stephen Keith Sagarin, PhD

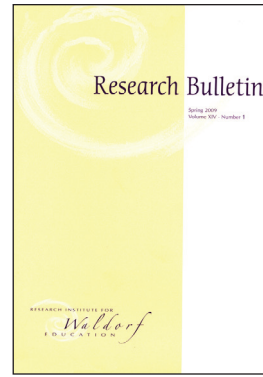
Dedicated to furthering research in education, the *Research Bulletin* provides schools with studies and data that place Waldorf education at the forefront of the educational scene in North America. Key topics in this issue are:

- Rhythm and Learning
- Thinking and the Consciousness of the Young Child
- Assessment without High-Stakes Testing
Protecting Childhood and the Purpose of School
- The Art of Education as Emergency Aid
How Waldorf Education Enables the Souls of Traumatized Children to Breathe Again
- What Have We Learned?
Comparing Studies of German, Swiss, and North American Waldorf School Graduates
- Cultivating Humanity against a “Monoculture of the Mind”
- Disturbances in the Child’s Relationship to Inner and Outer Pictures of Reality

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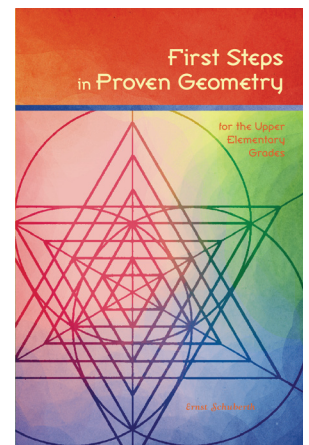
Research Bulletin
Spring/Summer 2009
Volume XIV, Number 1
 Editor: Stephen Keith Sagarin, PhD

- Sleeping on It: The Most Important Activity of a School Day
- Advantages and Disadvantages of Brain Research for Education
- What Makes Waldorf, Waldorf?
- Love and Knowledge: Recovering the Heart of Learning Through Contemplation
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This book is the latest from Ernst Schubert’s excellent series of books on mathematics in the elementary school. *First Steps in Proven Geometry* lays the first steps to develop the thinking necessary for penetrating logical proofs. Chapters include the study of angles in regular polygons, triangles, the Theorem of Thales, the Theorem of Pythagoras, the Principles of Congruence, Platonic Solids, the teaching of Projection and Shadow Drawing, the relationship between geometry and mineralogy, and much more.

DOING PHENOMENOLOGY IN SCIENCE EDUCATION

by

Edvin Østergaard, Prof. Bo Dahlin, and Askel Hugo

Introduction

In the 1975 lecture *Save the Phenomena!*, Martin Wagenschein sums up his 50 years of experience as a science educator. The lecture explicitly addresses teachers and especially teachers of physics:

Since I knew that many school children have to suffer lessons in physics that scarcely let them recognize this as the science of *nature*. Instead, the phenomena of nature are hardly touched upon as the teacher hurries on and goes further into the instrumental, the abstract, the laboratorial, the technical and the mathematical, so that the children no longer can participate with their eyes, ears and hands. Paralysed in a condition as mere spectators they cannot be physically present with their senses, and for this reason they are also unable to perform the task of abstraction (Wagenschein, 1983, pp.108–109; our translation; italics in original).

This statement can be regarded as the core of the phenomenological critique of current science education. Wagenschein points to the problem that many students in science lessons find themselves faced with an abstract and purely cognitive world, separated from their everyday life experiences. His whole professional life was dedicated to the questions of how to bridge this gap. The numerous examples he gives in all fields of elementary physics of how rich, conceptual understanding can grow step by step out of sense experience illustrate the role phenomenology might play in designing a meaningful science education.

This article presents a review of applications of phenomenology, as a philosophy of knowledge and qualitative research approach, to the field of science education. The purpose is to give an overview of work that has been done, as well as to assess it and discuss its possibilities for future development. We enter the field through three general aspects of any classroom situation: the *teacher*, the *students*, and the *subject taught*. These three aspects are interconnected, forming a triadic whole and are often considered to be a starting point for theories of curriculum and instruction, especially in the German *Didaktik*-tradition (cf Hopmann, 2007). From the point of view of each aspect, we ask: what attempts to connect phenomenology and science education do we find in the research literature and what possible effects could such connections have for teaching and learning? Since the three aspects are parts of one whole, a fourth point of entrance to the field will be through an overall integration of those three aspects.

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The Western Screech Owl



The Western Screech Owl is a small, nocturnal, woodland Owl living in western North America and is one of the west's more common Owls at lower elevations. They are squat-looking Owls that sit erect, with their plumage fluffed out, with feet and legs obscured, and distinct ear tufts raised. The iris is bright yellow and the bill is gray to black, with tufts of bristly feathers around its base. The facial disk is bordered by black. The toes are yellow. Plumage is either mainly grayish or reddish-brown, variegated dark and light, resembling a furrowed tree bark pattern. They use the variegated plumage as camouflage. When threatened, the bird stretches its body and tightens its feathers in order to look like a branch stub to avoid detection, but will take flight when it knows it has been detected. They have noticeable light spotting along the edge of the scapulars. There is much individual variation within the two color morphs. In the gray-phase, birds in the dry southwest are a paler gray, while birds in the humid northwest are darker and browner. The red-phase is very rare and found only in the Pacific Northwest.

Adult (gray) have facial disks that are dusky white with fine gray-brown mottling, overall gray-brown, with gray-brown narrow vertical stripes, bars, and spots on the underparts, and barred wings and tail. The legs have fine buff mottling. Adult (red) have similar patterns to the gray except the face is buff light cinnamon. There is rufous spotting on the breast with black anchor marks.

The juvenile of both color phases is similar to the adults, but the indistinct stripes and bars are more patterned, with many feathers tipped with white.]



Western Screech Owl

Owls Use Snakes as Domestic Help

by Jeff Mitton
Professor, University of Colorado

A male screech owl roosts 6 feet up in a blue spruce, within 5 feet of the sidewalk. People walk by without noticing him, and he serenely ignores the passers-by. Screech owls are small owls; about 10 inches long with wingspans of 2 feet, and are common in suburban environments.

This year two of my friends report that they have screech owl nests in their yards. In each case, the female tends the chicks in a hole high in a silver maple, and the male roosts in an adjacent blue spruce. The owls are a joy to the families with whom they share a yard.

Screech owls are opportunistic feeders that eat large insects and small mammals, birds, lizards, and snakes. They kill their prey immediately and carry it back to the nest. But one species of snake is often brought back to the nest alive.

Texas slender blind snakes, *Leptotyphlops dulcis*, are rare in Colorado, but are abundant in Kansas, Oklahoma, Texas, and Mexico. They are easily mistaken for earthworms, for they are pink to light brown, appear to be segmented and have no eyes. Their maximal length is about 8 inches. They spend most of their time buried in forest litter or soft soil, and they only come to the surface during drenching rains or floods. Blind snakes have tiny mouths, much too small to bite a human. Their favorite prey is the larvae of ants and termites.

Screech owls kill and eat some blind snakes, but others are brought back to the nest and released. Blind snakes remain in the nest until the chicks fledge and the adults abandon the nest, and then they slither down the tree and return to the soil.

A survey of screech owl nests in Texas revealed that about 20 percent of the nests had one or more blind snakes. Of the nests containing snakes, most had just one, but, one nest had five and another nest had 15 snakes.

Fecal matter, regurgitated bones and fur and fragments of animal carcasses attract a large number of insects to owl nests, including houseflies, greenbottle flies and bluebottle flies. These flies eat the material in the nest, but they also lay eggs. Because fly larvae and blood-sucking insects feed on the chicks, they are a source of nestling mortality. Blind snakes living in owl nests eat the insect larvae that pose a threat to the nestlings.

A comparison of nests with and without snakes revealed that chicks living with snakes grew faster and suffered lower mortality. In nests without snakes, 40 percent of the nestlings died, but in nests with snakes, mortality was reduced to 30 percent.

We know that birds are clever. Birds have learned to remove cardboard lids from milk bottles, to use spider silk as thread, and to use cactus spines and bark flakes as prying tools. But screech owls have gone a step further, establishing a mutualism with a snake. The blind snake is introduced to a protected environment with abundant food. Owl nestlings gain a resident guardian.

By sparing the life of a normal prey animal and introducing a snake to their nest, these wise little owls have established a mutualism that enhances nest hygiene, nesting growth and survival, and their own reproductive success.



Texas slender blind snake
Leptotyphlops dulcis

Sea Turtles use Earth's Magnetic Field



The mystery of the migrating sea turtle may have been solved. Scientists have shown that the marine reptile can use the earth's magnetic field as both a compass and as a map. This research shows biologists how the marine animals find their way back to their birthplace to lay their eggs, even after venturing across thousands of miles of open ocean without any visible landmarks.

At the beginning of their lives sea turtles appear to read the magnetic field of their home area and "imprint" on it, according to a new theory in the journal *Proceedings of the National Academy of Sciences*.

The Earth's magnetic field varies predictably across the globe, with every oceanic region having a slightly different magnetic signature. By noting the unique "magnetic address" of their birthplace, animals may be able to distinguish this location from all others.

Writing in *Current Biology*, an international team of scientists used satellite transmitters to remotely track turtles as they moved to and from nesting sites. They found that turtles find their way back to the same beaches, independent of ocean currents or other impediments.

"It is almost as if they were equipped with a compass pointing towards the beach in question," noted a news release from the Center for Functional and Evolutionary Ecology at Montpellier, France. "They can correct any deflection they are subject to: transport by boat, ocean currents. But, unlike human navigators, they are not able to correct for ocean drift in plotting their course. So the movements recorded by the satellite are a combination of deliberate action by the turtles and the effect of currents."

"It appears that the turtles' navigation system is relatively simple and may cause them to wander at sea for long periods during adverse ocean conditions," the release continued. "One turtle released 250 km from its egg-laying site on Europa traveled more than 3,500 km in two months before returning there!"

The researchers confirmed the role of Earth's magnetic field on turtle navigation by using a powerful magnet to disrupt the turtle's orientation. "Turtle navigation is not as good... when this field is disturbed," the researchers report. "Turtles may also use their

sense of smell like certain sea birds or homing pigeons,” stated the release, but “this hypothesis remains to be proven.”

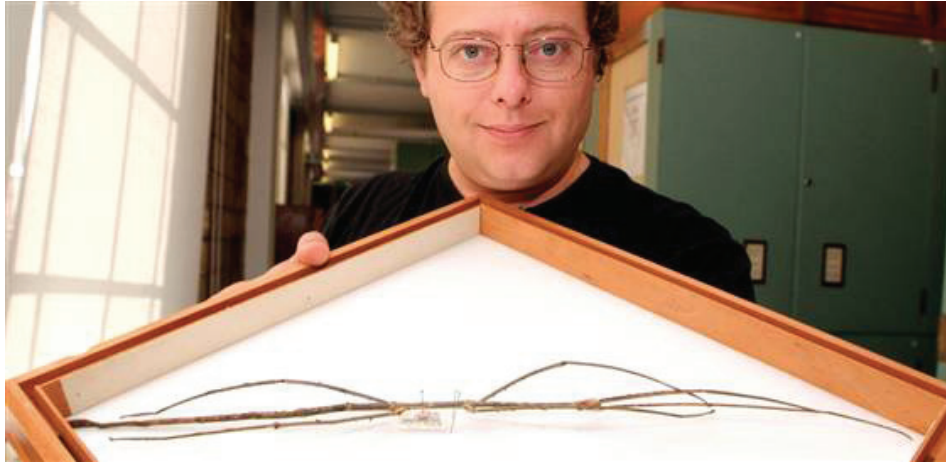
Scientists Kenneth and Catherine Lohmann, a husband and wife team at the University of North Carolina in Chapel Hill, investigated the green turtle’s homing instincts using a giant, two-storey magnetic coil they built around an aquarium in which the field could be artificially controlled. The Lohmanns and their colleagues used the coil to reproduce the magnetic fields that are known to exist at various locations along the Florida coast so they could expose captive turtles to fields from two widely different geographical locations. The results confirmed their hypothesis.

Biologists have not, at this point in time, located the sensory organ that can detect changes in a magnetic field. One idea is that it might be a general property of nerve cells that are full of electrically charged particles.

Scientists have shown that other migratory animals, notably birds, use a variety of natural cues that act as a map and compass, and those include the earth’s magnetic field.



World's Biggest Bug



A stick bug from the island of Borneo measuring well over a foot in length has been identified on October 16, 2008 by researchers as the world's longest insect stated British scientists. Looking like a pencil-thin shoot of bamboo, the dull-green insect measures about 22 inches, if its twig-like legs are counted. Its body length is 14 inches.

The specimen was found by a local villager and handed to Malaysian amateur naturalist Datuk Chan Chew Lun in 1989, according to Philip Bragg, who formally identified the insect in this month's issue of peer-reviewed journal *Zoolua*. The insect was named *Phobaeticus chani*, or "Chan's megastick," in Chan's honor.

Paul Brock, a scientific associate of the Natural History Museum in London unconnected to the insect's discovery said there was no doubt it was the longest still in existence.

About 3000 stick insects are known worldwide, and captivate humans because of their unique camouflage ability. They are often overlooked in gardens as being just sticks or twigs, however, the light from a flashlight at night reveals a hidden world as these nocturnal creatures move about feeding on plant matter. Some use noxious sprays or prickly spines to deter their predators. "Their main defense is basically hanging around, looking like a twig," Brock said. "It will even sway in the wind."

Tree Talk



Researchers have found that at least one type of tree can signal nearby plants of impending drought or other environmental stress that could affect plant well-being. Scientists at the U.S. National Center for Atmospheric Research (NCAR) in Boulder, CO, say they observed walnut trees releasing large amounts of an aspirin compound to reduce damage from adverse conditions, and to possibly warn nearby plants. “These findings show tangible proof that plant-to-plant communication occurs on the ecosystem level,” said NCAR scientist and study co-author Alex Guenther.

Writing in *Biogeosciences*, the team said the finding could lead to farmers being able to recognize early warning signs from crops that they are about to fail.

In another part of the state, physicist Ed Wagner says he has found evidence that trees talk to each other in a language he calls W-waves.

“If you chop into a tree, you can see that adjacent trees put out an electrical pulse,” said Wagner. “This indicates that they communicated directly.” Those who have read *The Secret Life of the Plants* have encountered this with house plants.

Explaining the phenomenon, Wagner pointed to a blip on a strip chart recording of the electrical pulse. “It put out a tremendous cry of alarm,” he said. “The adjacent trees put out smaller ones.”

“People have known there was communication between trees for several years, but they’ve explained it by the chemicals trees produce,” Wagner said. “But I think the real communication is much quicker and more dramatic than that,” he said. “These trees know within a few seconds what is happening. This is an automatic response.”

“Wagner has measured the speed of W-waves at about 3 feet per second through the air. “They travel much too slowly for electrical waves,” he said. “They seem to be an altogether different entity. That’s what makes them so intriguing. They don’t seem to be electromagnetic waves at all.”

A Tree Tale

Based on a passage from Gerry Spence's book: *From Freedom to Slavery*.

Mankind strikes an unholy bargain at birth. The contract reads: "Give me life and I will agree to death." We awaken in life to find ourselves trapped on a boat floating down an uncharted river with a horrible waterfall at its end. We possess no map to tell us where we shall face the falls, but we know the falls are there. We know no one ever survives the trip and we are afraid, yet we cannot get off the river. We can only, moment-by-moment, attempt to avoid its treacherous rapids, its hazardous back currents. Despite the exquisite beauty of the river and its placid bends, often we fail to enjoy the trip for we know that just ahead, perhaps around the next bend, we shall face the falls, the horrible falls.

I have lived alone for most parts of my life and have often felt lonely, even though a host of living things surround me. My loneliness, as always is born of my separation from myself, and therefore my separation from all other living things as well. I remember when the summer has gone, when the robins have gone, and when the shy slate-colored finches have gathered and gone. When the blue harebells have dried and twisted toward the earth, and when the parachute seeds of the dandelions in the meadows have long since blown away, their stems stand straight and stiff and the leaves of the elk thistle are like curled brown memories. This is when I feel the sharp teeth of loneliness gnawing at my heart, and I try to comfort myself with reason, but reason is not too often comforting.

We are all of us alone, I reasoned. Alone we struggle from the womb, and alone we float down the inescapable river of life. Alone we face the falls, the horrible falls, where alone we shall wheeze out our last mortal gasp. I looked out the window then at a slender elm tree alone in the garden, and something compelled me to walk out to it. Suddenly I wanted to talk to a tree.

To talk to a tree is strange, is it not? Yet no one thinks it odd for a man to speak to something he cannot see or touch, something he calls "God." No one thinks it bizarre that we listen, too, and are impelled into strange actions, like buying a certain soft drink because of an image on TV, something we cannot touch. Yet if we were to shake hands with a tree, something real with its roots in the ground, something that lives, grows, and rustles in the wind, something in which living birds nest and hatch their young. If we were to touch a tree and to speak to it, we might be considered very peculiar indeed. The tyranny of viewpoint, most often not our own, constricts us as surely as a horse's hobble.

The Indians thought it ordinary to communicate: "Did you know that trees talk? They talk to each other and they'll talk to you if you listen. I have learned a lot from trees, something about the weather, something about animals, and something about the Great Spirit."

I'm sure that my neighbors would have thought me quite daft had they seen me talking to this tree. But I was alone, and alone one has the right, by that reason, to do as one pleases. Alone one is free, or ought to be, and so I thought, I shall see how it is to speak to a tree. I looked around first just to make sure none of my neighbors were around, but no one were watching and no one would hear me. Yet I had a difficult time bringing myself to do this simple, harmless thing.

We are as free as the barriers we have constructed around our minds permit us to be. Indeed, as we perceive it, insanity may be simply the elimination of all of the mind's barriers. We know that trees do not talk, but how do we know? I might conclude that my neighbors also do not talk. I have never heard them speak, but that is because I have never spoken to them.

If I judged the ability of the human race to communicate based on my experience with my neighbors, I should likely conclude that the species is mute. In the same way, since I have never spoken to a tree, how could I possibly expect a tree to speak to me? Still, this was indeed strange behavior, this talking to trees, and I decided I would not mention it to my friends and family, who already thought me strange enough.

I looked around once more to make sure that no one was watching. Then suddenly I reached out and grasped the lowest limb of the tree, like one shaking hands. To my horror, I heard myself speaking out loud. "Tree," I said, "I just dropped over to say hello." It was easy. There was no parting of the clouds, no voice descended upon me saying, "Now you have finally done it! I have patiently endured your faithless pronouncements against me, and against my faithful, but talking to trees - this is finally too much!"

"Tree," I said, "I've seen you almost every day outside my window, and have often admired you, but for some reason I've never stopped over. People are like that, you know." The tree said nothing back, but I had a sense that somehow my words were being soaked up and listened to. I've been with people many times and said things that never were soaked up, things that were important to me, but when I offered them to others, my opinions just sort of lay there in a puddle, ignored.

"You're lucky to have your friends with you all the time," I said to the tree, "and you're kids and your family. You have your roots all tangled up together and your capillaries all entwined, you're cheek to cheek with those who are closest to you all summer long. And when the wind blows, your leaves caress each other. Must be quite something to have ten thousand leaves to feel with."

I looked up. The tree's leaves had already fallen. After a minute I just came out with it, "I felt lonely today, that's why I'm out here speaking to you," I said, and the tears came to my eyes. I didn't feel ashamed crying in front of a tree, although I have always felt shame in crying in front of people. "Thanks for listening to me," I said: "That's what friends are for" and gave the tree a loving pat. But the tree didn't answer.

"I don't think people understand me," I said. Still the tree didn't answer. But in the utter silence of the garden I heard a clear response. We must each find our own answers, the tree and I. That is freedom. A tree's answers would not do for me, for it moves with the wind and with the seasons. Its feet are in the soil and it's part of the earth. Its wisdom is, perhaps, too great to be imparted to the likes of me. Yet somehow I felt very wise after having listened to the tree.

The Phenomenon of Colored Shadows

by
Malin J. Starrett

The indication regarding the nature of colored shadows given by Rudolf Steiner in the *Light-Course* lectures has fascinated me for years now and soon after first reading it I was moved to experimental action. There was an initial discovery stage in early 1997 – learning how to produce the phenomenon in as pure a way as possible, along with becoming acquainted with various research techniques and the many confusing problems associated with the results obtained. In 1999 I returned to the colored shadows research with a view for it to become the central theme of my doctoral thesis. I had already seen how this phenomenon raises wonder, philosophy and debate – friends in my rented house, art students, university lecturers, members of anthroposophical groups and technicians who work with color had all been stimulated by encountering the colored shadows or even photos of the phenomenon. Many more months of experimentation followed – one experiment would point towards an uncertain area or a new question or a new possibility and the idea for the next experiment would arrive. The doctoral research involved at least one year in total of doing experiments every day and at quite a pace – no need to apply for grants, equipment, etc., and all the accompanying delays – a year of doing experiments every day and wrestling with the results obtained myself. The writing of the thesis was somewhat unusual in character – it involved me sitting with a pen and paper, but also involved running upstairs to carry out an experiment to check the words put to paper or to test the comments of other researchers in various published texts. Here is a word of advice to anyone wishing to write about color phenomena – do the experiments again and again! Remembering specific knowledge of color phenomena seems to be particularly difficult – I have personally experienced this and seen it revealed many times with others. Hence the need to re-acquaint ourselves regularly with color phenomena.

The science of color is more like an ability requiring regular practice than an activity of erecting permanent structures. The adventure with the colored shadows didn't end with writing a thesis – a whole drama ensued with the examining of the research in the university system. This resulted in experimental research regarding the nature of colored shadows being examined twice in a *viva voce* situation – once as a study in cultural life in general and once as experimental science, with a year of debate in between. I choose not to recount the details of the debate any further here – the drama was enacted within its appropriate sphere – in the university system. All of the above activity was stimulated by Goethe's *Theory of Color* and Steiner's indication about colored shadows in the *Light-Course* lectures (which can be seen as a renewal of Goethe's *Theory of Color*).

And so to summarize my work in this area from 1997 to 2000: One to two years of doing experiments, thinking about the phenomenon, studying the work of previous researchers, writing about the phenomenon, learning about the technology of color reproduction (and its relationships to Goethe's *Theory of Color*), showing the experiments to many people and stimulating much debate, teaching an introduction to Goethe's theory in the university system (probably for the first time in a long time in a UK university), presenting research to other anthroposophists, meeting with the late Hans-Georg Hetzel in Switzerland (who had been working in the same field for many years), learning about

Edwin Land's color researches and experiencing a real drama about research within a university.

To become more specific, it can be asked what role did Steiner's indication play in producing the above events. Could the same cultural activity have been stimulated by exploring Goethe's *Theory of Color* alone? The answer is, I think, no. The part of Goethe's theory entitled 'Physiological Colors' is now accepted and integrated into the modern science of color. Recent textbooks often refer to Goethe's colored shadows researches and his explanation of the phenomenon, but without fully entertaining the whole of the theory. Goethe's researches and classifications of 'subjective' phenomena have been cherry-picked by many modern color science researchers, whilst Goethe's discussions of 'objective' phenomena have been largely ignored. More important still is the theme which runs through the whole of Goethe's theory – the interrelationships between 'subjective' and 'objective' phenomena. This theme has also been largely ignored or unrecognized.¹ I realize now that entertaining the possibility that unexpected colored shadows may have a physical reality is a good way to stimulate a reappraisal of Goethe's theory as well as raise many wider issues about the 'subjective' and 'objective.'

When lay people first encounter the colored shadows, they quickly find the difficult relevant questions about themselves and their relationship to the outer events – creative debate often follows if the debate is not closed down with a simplistic 'fact' statement that the unexpected color is totally 'subjective.' The colored shadows help us to think about the relationships of our inner life to the outer world. Steiner's indication re-opened a debate regarding the nature of colored shadows which had been prematurely closed in the 19th century. I have seen that, by seriously entertaining Steiner's indication, a great deal of cultural activity has been stimulated. This includes Goethe's *Theory of Color* being re-presented to many people.

The following section is a reply to a letter posted in the March 2005 issue of the *British Science Newsletter*.

The letter begins by referring to the lecture with experiments which I presented in Cornwall in 2000. My lecture began with an historical survey of researches on the nature of colored shadows, including various versions of viewing tube experiments which produce contradictory results. The letter then makes the following statements:

Malin's light sources were very strong in comparison, so that the green shadow ... was very bright and clear. It may be that such a brilliant and technologically produced light source is the cause of the errors which Malin may have made.

Four points need to be made here:

1. Two modern slide projectors were utilized for the experiments at that lecture. They are bright and well suited to producing large colored shadows for showing the phenomenon to groups of people. More recently, I have utilized two old style 500 watt projectors because the lamps employed have better light qualities. I don't apologize for carefully finding ways to present a phenomenon in a pure form.

2. The early researches in this field often utilized candles as light sources. The contradictory results with viewing tubes can be witnessed with very simple colored shadows experiments involving a candle and daylight as light sources.

3. In the experiment Jarman refers to, the unexpectedly colored shadow was turquoise blue, not green.

4. The writer of the letter does not explicitly state the errors that he suspects when he writes: "It may be that such a brilliant and technologically produced light source is the cause of the errors which Malin may have made." This vagueness denies me the possibility of directly addressing any such implied 'error' and risks implanting doubt in the reader regarding my researches.

In the letter, the writer refers to a presentation he made regarding the colored shadows at a Science Section meeting. He selectively quotes specific comments published in the notes of the 1964 German edition of the *Light-Course* lectures to back his argument that unexpectedly colored shadows are purely 'subjective' in nature and to back his assertion that Steiner was mistaken in his original indication given during the seventh lecture.

In the September 2003 newsletter, I reminded readers that there are currently *four* published editions of the lectures in German, all with notes which relate to this indication. The notes present various recollections from various people which, when seen as a whole, present a picture of debate with opposing viewpoints. The notes do not present final definitive answer. In the March 2005 letter, the writer quoted comments which suit his own personal view; he also declines to mention the recent researches which were carried out by the late Hans-Georg Hetzel, also described in recent editions. This debate has often focused on fragmentary comments quoted out of context, utilized to argue for a specific position. This practice undermines the researches of all the individuals cited. The call is for new research, not to blind faith in acts of artistic selection. I think that other members of the Science Section may support a different view than the one agreed upon at the meeting in Stroud. Will any Science Section members step forward?

In the the letter, the writer describes an experiment at the Science Section meeting and observations by Stuart Brown. From the very brief description, it appears to be a synthesis of Count Rumford's and Gustav Fechner's viewing tube experiments,² replacing the viewing tube with a concentrated gaze upon one grey shadow. Two points may be of interest here:

1. By willing ourselves to concentrate on seeing only one small area, we avoid seeing the whole picture, if that comment isn't too obvious! Sacrificing the big picture to study only a small part is a re-capitulation of the birth of modern science. However, previous workers have done this well and we are called to see the whole again anew.

2. The reality of the gaze and the power of the gaze has been a recurring theme in the study of vision for many centuries. Many people have the experience of perceiving that someone is staring at them from behind.³ This common experience points to soul-spiritual realities.⁴ I think that Ron Jarman and Stuart Brown have proved that their willing and wishing for a certain result can be facilitated by a specific way of looking. This does not prove anything about the nature of colored shadows, it only proves the power of the gaze. While lecturing to many groups of people and showing them the phenomenon of colored shadows, I have recognized that the colors can be augmented or diminished by the individuals present, usually unconsciously. If one person has a strongly held view that the unexpected color is purely an 'illusion' or is purely 'subjective,' they can reduce the strength of color for all present – an individual can will the color away. Conversely, if, for instance, an artist with a strong inner experience of color is present, the unexpected color may be strengthened for all present. (I think this is usually without reference to the 'subjective' – 'objective' questions, it is to do with experiencing color in an inwardly rich way.) In the above polarity resides questions relating to the activities of our etheric and astral bodies in relation to this phenomenon and its study. Much more research is required in this area. Here are some hypothetical indignant exclamations which may give clues:

A strong artistic experience of color producing new physical color in the outer world – surely that's not science! A strong preference for a certain idea expressed in willing a color away – surely that's not science! Perhaps the colored shadows are prompting us to think carefully about what natural science is and of how it may evolve.

The letter refers to a question which I raised in the September 2004 newsletter. The question relates to a novel research technique which Ron Jarman described for studying the colored shadows.⁵ This involves viewing the whole image with one eye while the other eye is given an isolated view of one shadow through a tube. This practice is out of line with the whole previous history

of using viewing tubes because the idea of the viewing tube is to isolate an area from its surroundings so that any contrast effects are removed. The general technique is to close one eye and use the other eye to look through the tube at one small region of the image. The question simply stated is this: why view the whole image with one eye but restrict the view of the other eye?

In this scenario, the initial reason for utilizing a viewing tube seems to be contradicted in the research technique itself. Jarman's reply to this question of why he utilised such a technique is as follows: "The simple answer is that Steiner was called upon to use it and that Malin himself had used it." This is an answer relating to the use of viewing tubes in general. Jarman has not yet answered the question regarding his novel technique.

In the letter critiquing my paper the writer mentions previous comments I made of how the viewing tube "tends to lighten and desaturate the color of any region when we look through it."⁶ Jarman agrees that the region is lightened when we look through the tube but then states "...it is not true that the color of this area is 'desaturated.'" The writer is incorrect here. In my opinion, the attributes of *lightness* and *saturation* – as utilized in color science – are often interrelated.

Here is an example – a projector with a red piece of glass in front of it produces a saturated red on screen. If a second colorless projector is directed to the same screen, the red is likely to be considerably *desaturated* to a pale red or pink. The pale red or pink is also a *lightened* version of the red. Here is another example: a pure violet paint is highly saturated with a low lightness (or brightness). If we begin to mix white paint with it, the basic *hue* (the named color) remains the same, but the saturation decreases and the lightness increases. The three attributes of *hue*, *saturation* and *lightness* are described separately in color science but it is well known that a change in one attribute often affects another.

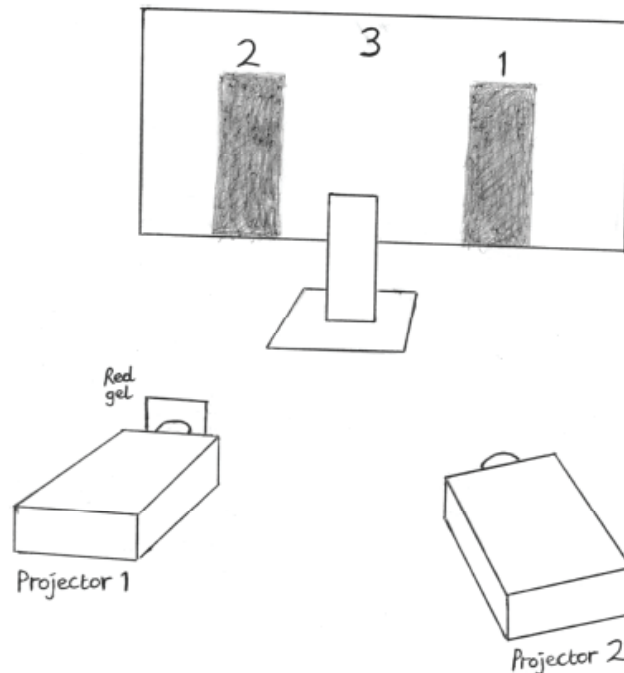
The letter states the view that Steiner was incorrect in saying that unexpectedly colored shadows do have a physical 'objective' presence.' I stand by Steiner's original indication – through extensive personal researches and from the researches of others I have seen evidence which supports the view that unexpectedly colored shadows can exhibit a physical 'objective' reality. However, I think that Steiner's indication should be viewed in the whole context of the *Light-Course* lectures where he criticizes rigid classification of phenomena into being either 'subjective' or 'objective.' From studying Steiner's lectures, Goethe's theory and doing many experiments, I have come to see that Goethe's *Theory of Color* can help us to recognise dynamic interrelationships between the 'subjective' and 'objective.'⁷ I have found that unexpectedly colored shadows exhibit a dynamic reality which ranges from mostly 'subjective' to partly 'objective,' depending on various parameters such as: physical factors, research techniques and the inner life of the researcher studying the phenomenon. I see Steiner's indication as a small correction to Goethe's theory, very much in harmony with Goethe's theory as a whole.

Today, many people are becoming more open to Goethe's *Theory of Color* in the academic world and in the scientific communities. However, as stated previously (see note 1), there is a danger of Goethe's theory being widely embraced as purely a theory of 'subjective' phenomena. This would undermine one of the central themes of Goethe's theory – the dynamic relations between 'subjective' and 'objective' – a theme which needs to be explored today to move science forward.

The development of modern natural science involved keeping 'subjective' and 'objective' completely separate, and for good reasons. However, times have changed, conditions are different and natural science needs to evolve. By seriously entertaining the possibility that unexpectedly colored shadows exhibit a physical 'objective' presence, many important questions are raised regarding natural science and the human being; eventually it becomes obvious that a Spiritual Science is required to proceed any further. To insist on unexpectedly colored shadows being neatly boxed as 'subjective' is to deny the existence of a real debate in 19th century science and to ignore the results of various experimental researches. Such a 'closure' would also play into the hands of those who will to prevent Goethe's theory and spiritual science from attaining a wider

recognition. This debate about the reality of unexpectedly colored shadows is a microcosm of many important issues.

The lecture which I presented in Cornwall in 2000 did not end with showing those present the contradictory results obtained with viewing tubes. I went on to discuss Steiner's indication and to show what can happen when this idea – that unexpectedly colored shadows exhibit a physical presence – is seriously entertained. Some experiments were presented which explore this idea and which attempt to go beyond the use of viewing tube research techniques. Please see the diagram below:



A basic colored shadows experiment is depicted. Shadow 1 is the unexpectedly colored shadow, in this case turquoise blue. Shadow 2 is red and region 3 is a pale pink. If a yellow gel is then placed in front of projector 2, the little color world on screen is transformed: shadow 1 becomes lime green, region 3 becomes yellow-orange and shadow 2 remains red. The obvious explanation for the lime green shadow 1 is that the turquoise blue shadow and the yellow of the gel have interacted to produce a new color – lime green.

This experiment is very rarely mentioned in the literature of color science, probably because the results do not correspond to simple explanations of the colored shadows phenomenon. Most explanations of colored shadows place emphasis on the region surrounding the shadows (3) as being mainly responsible for stimulating the eyes to produce a complementary color in shadow 1. So, for example, with a red gel on projector 1, region 3 becomes a pale pink which stimulates the eyes to produce the complementary color, turquoise blue, in shadow 1. However, in this modified version of the experiment, region 3 is yellow-orange (complementary color is deep blue) and shadow 2 remains red (complementary color is turquoise blue). Turquoise blue and deep blue do not in any way produce lime green. The conventional explanations break down here and hence the lack of mention of this experiment. Michael Wilson, in his booklet *What is Color?* (1949) does, to his credit, describe this experiment but I don't think he managed to explain the results adequately utilizing conventional ideas.

The turquoise blue shadow and yellow gel appear to be behaving according to the laws of *Subtractive Color Synthesis* – where layers of transparent color interact to produce new colors.⁹ With a knowledge of subtractive color synthesis, the next step is obvious – to try placing a magenta gel in front of projector 2 (instead of a yellow one). When this is done, the result is a

purple-violet shadow 1 – the turquoise blue and magenta interact to produce the purple-violet, as predicted by subtractive color synthesis.

The experiment can be expanded by producing a pink-magenta shadow 1 (with a green gel on projector 1) which is then modified with cyan and yellow gels on projector 2. A yellow shadow 1 (produced with an indigo gel on projector 1) can also be tested with cyan and magenta gels on Projector 2. In nearly all the variations,¹⁰ new colors are produced according to the laws of subtractive color synthesis.¹¹

I think that this experiment is only comprehensible when we entertain the possibility that unexpectedly colored shadows have some kind of physical presence. In this situation, the new colors produced can be understood to be due to interactions between the unexpectedly colored shadow and the gel placed on projector 2. To insist on the unexpectedly colored shadow being considered purely ‘subjective’ leaves researchers scrambling around for clever explanations which are not convincing. Another possibility for testing the reality of the unexpectedly colored shadows would be to place pieces of colored paper inside the shadow to see if any color changes occur. The answer is yes – place a yellow piece of paper within a turquoise blue unexpectedly colored shadow and the paper *becomes* green! The piece of paper can be the whole size of the shadow or only a small part of it, whereby the turquoise blue and the new green can be seen together. Again, conventional explanations appealing to a pure ‘subjectivity’ of the unexpectedly colored shadow break down here. Why deny the obvious?

The colors interact in a way easily understandable according to the laws of subtractive color synthesis. A special note is required here. Goethe mentions a very similar experiment in para. #562 of the *Theory of Color*. It is significant that he places this experiment well away from the main section discussing colored shadows. I think he knew that this phenomenon jarred strongly with the mainly ‘subjective’ classification he had given to unexpectedly colored shadows. Or, perhaps he hoped that by paragraph #562 the open-minded reader/experimenter would be ready to see dynamic interrelations between ‘subjective’ and ‘objective’!

The experiment with the piece of yellow colored paper can be extended with cyan and magenta papers and with yellow and pink-magenta unexpectedly colored shadows, using a similar technique to that employed with the gels. The results are very similar – the colored paper and the unexpectedly colored shadow interact to produce a new color which can be understood in terms of subtractive color synthesis.¹² I think that we as human beings are intimately involved in producing unexpectedly colored shadows through the activity of our physical visual apparatus and the activity of our soulspiritual members working together. The high fence comes when you entertain the possibility that the unexpected colors may have a physical aspect. At this stage I can offer this possibility for further research – that when our etheric body¹³ becomes active in a certain way within the unexpectedly colored shadow, the color may attain a physical aspect – i.e. to a certain extent, *part of our etheric body may become physical and colored*. As Steiner reminded us, when we have a rich inner experience of color, we feel we are out there in the colors. Previous examples of physical to etheric to physical transformations in cosmic evolution can be found in Steiner’s *Occult Science*.¹⁴ To argue that a rich inner experience of color should not be allowed in color phenomena experiments is to argue against color in the world and against new color being brought into the world. It is true that the phenomenon of colored shadows calls for a reassessment and renewal of natural science.

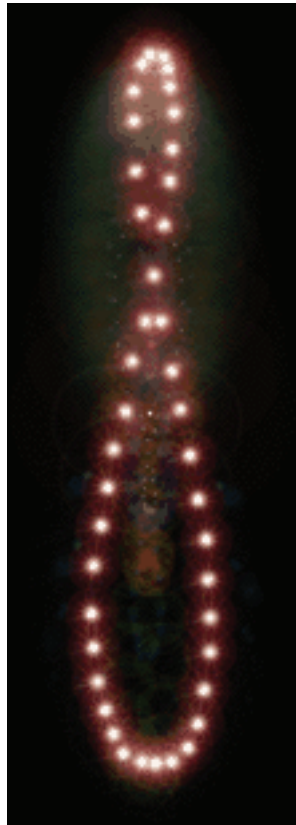
Notes

1. Recent books on the science of color attempt a simplistic reconciliation between Goethe's theory and Newton's theory by granting Goethe the 'subjective' pole and Newton the 'objective.' There is some progress here in that Goethe's theory is being openly credited, but Goethe's theory is about much more than the 'subjective' pole.
2. See article in September 2003 issue of this newsletter.
3. In a Michaelic movement, we should not need to have our backs to the wall in a lecture hall!
4. See, for example, the second lecture of Steiner's *Light-Course* where he describes the relationships that occur between the etheric body, the astral body, and the physical organ of the eye.
5. See March 2003 newsletter.
6. See September 2004 newsletter and September 2003 newsletter.
7. See September 2003 newsletter or paras. 368 and 369 in Goethe's theory.
8. The yellow-orange region 3 is due to the red colored light from projector 1 additively mixing with the yellow colored light from projector 2.
9. Subtractive color synthesis usually applies to layers of transparent color interacting, e.g. in color printing.
10. The only exception to the general results is where a yellow shadow 1 is modified by a cyan gel on Projector 2. In this case, the new color is a greenish yellow but not a full green.
11. For any readers interested to carry out this experiment, I am glad to supply technical details. The general principles are simple but you need to be able to produce strongly colored turquoise blue, yellow and pink-magenta unexpectedly colored shadows. The cyan, yellow and magenta gels need to be of specific hues and less strongly colored (saturated) than the gels placed on Projector 1. The experiment requires careful selection of materials and experience of technique. You wouldn't expect a color printer to use 'any old' cyan, yellow and magenta dyes to produce full color images!
12. Careful testing of a variety of cyan, yellow, and magenta papers is required to see the new colors fully developed.
13. Our astral body is probably involved to some extent in this process as well. How are the beings of the divine hierarchies involved? More research is required here.
14. See Paragraph #54 (Steiner's original numbering) of the chapter 'Cosmic Evolution and the Human Being' in Steiner's *Occult Science*.

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Analemma

If I suggested that there was a unique shape that could reveal minor secrets of the universe, a shape that looked like a lopsided infinity symbol, would you believe me? And would you believe that the universe itself has been described by astronomers as having this shape?



An analemma for planet Earth.

The movement of the sun as observed from the earth takes this shape. The movement is called the analemma. If you go outside at the same time every day for a year and take a snapshot of the sky and combine all these photographs and look at the path the sun takes across the sky. That's the analemma.

The analemma comes to my mind around this time every year because I start to wonder why, after the winter solstice, the days do not seem to get any longer? The winter solstice came and went, but it is still dark out when the alarm clock rings, and dark again by the time supper appears. This is not merely a wintertime illusion; during the first two weeks of January, each day will be barely a minute longer than the day before. Why does this happen?

The answer lies in the analemma. And for the particulars of the analemma's shape, we can blame the Earth's tilt and the fact that our orbit around the sun is elliptical, not perfectly round. If the Earth stood up straight and performed perfectly circular orbits, the sun would appear at exactly the same spot in the sky every day. If you tried the photographic experiment I suggested, you would see not a path of infinity, but a single dot.

Why does the sun take this strange path? There are two reasons and they are completely independent from each other.

1. The Earth is tilted on its axis 23.5° in relation to the plane of its orbit around the sun.
2. The Earth does not orbit the sun in a circle, but in an ellipse.

It is the sum of these two effects that causes the analemma.

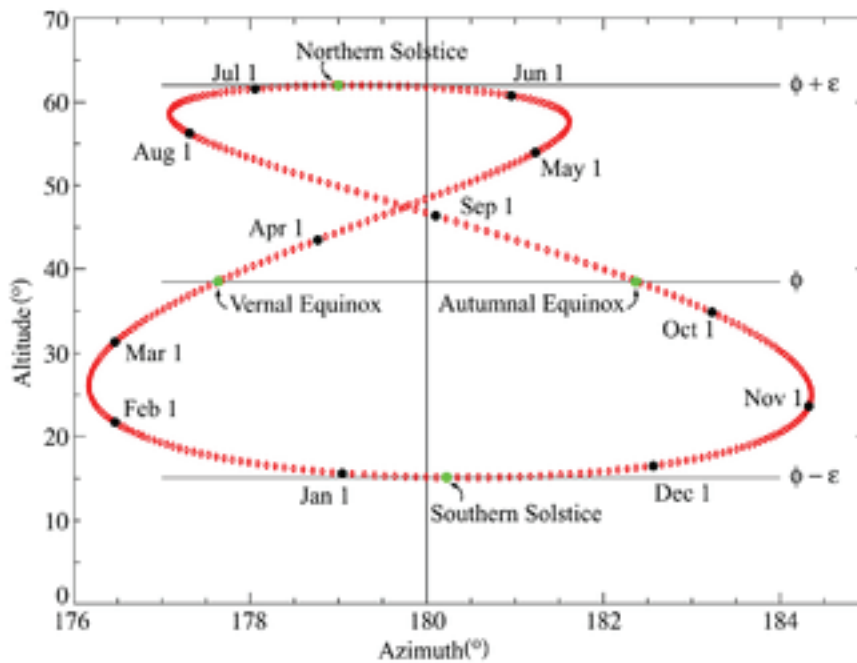
If, conversely, you could line the Earth up so that it spun on a perfectly vertical axis but orbited the sun in its natural ellipse, the analemma would assume a different shape: a horizontal line running east-west along the horizon.

But back to Earth's real analemma. The sun traces out the base of the infinity pattern in the winter, reaching its lowest point at the winter solstice. The tip of the infinity pattern, then, represents the sun's position at the summer solstice, when it peaks at its highest point in the sky.

Between those solstices, the sun has a lot of sky to cover — both vertically (north-south) and horizontally (east-west), because the infinity pattern is tipped at an angle. Around the solstices, the sun's motion along the analemma is almost entirely east-west, meaning that the length of the day barely budes, (see the drawing below).

At the equinoxes, on the other hand, the sun is moving mostly north-south, and the number of daylight hours changes rapidly from day to day.

This may help you to understand the short days of winter.

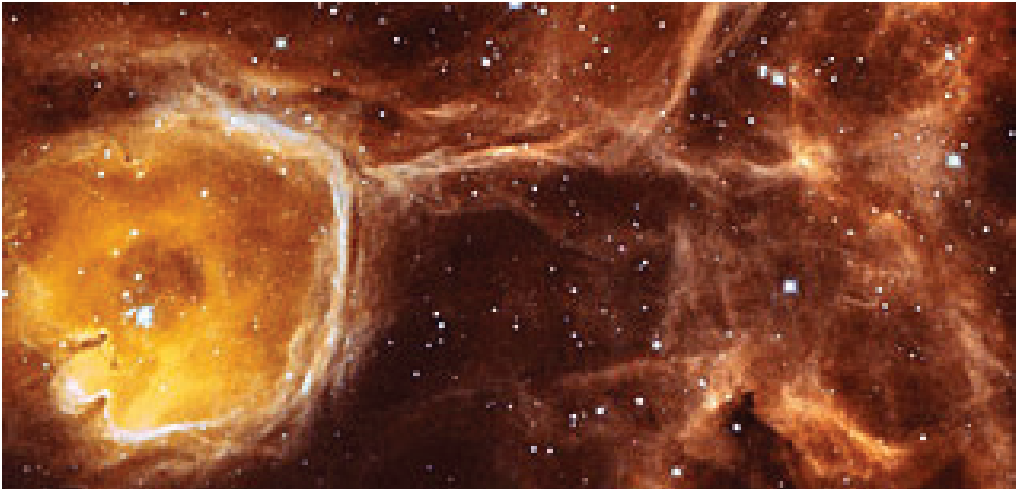


The analemma for Earth as seen from the northern hemisphere with altitude and azimuth to the same scale.

Astro Physics

Photos from Hubble

The ultraviolet images were taken by Hubble's Space Telescope Imaging Spectrograph, (see <http://hubblesite.org>).



Hubble peers inside a celestial geode

In this unusual image, the Hubble Space Telescope captures a rare view of the celestial equivalent of a geode: a gas cavity carved by the stellar wind and intense ultraviolet radiation from a young hot star.

Real geodes are handball-sized, hollow rocks that start out as bubbles in volcanic or sedimentary rock. Only when these inconspicuous round rocks are split in half by a geologist, do we get a chance to appreciate the inside of the rock cavity that is lined with crystals. In the case of Hubble's 35 light-year diameter "celestial geode" the transparency of its bubble-like cavity of interstellar gas and dust reveals the treasures of its interior.



Image of Galaxy M82

This view is a composite of images of the active galaxy Messier 82 from the three observatories: the Hubble Space Telescope, the Chandra X-Ray Observatory, and the Spitzer Space Telescope. X-ray data recorded by Chandra appears here in blue, infrared light recorded by Spitzer appears in red. Hubble's observation of hydrogen emission appears in orange.



Light Echo from Star V838 Monocerotis

The Hubble captures light from a mysterious erupting star as it reverberates through space. Compare this with Van Gogh's painting "Starry Night."



A New View of the Helix Nebula (God's Eye)

When first disclosed this picture was called the "eye of God." The Helix, however, is a planetary nebula, the glowing gaseous envelope expelled by a dying, sun-like star. It resembles a simple doughnut as seen from Earth, but looks can be deceiving. New evidence suggests that the Helix consists of two gaseous disks nearly perpendicular to each other.



Barred spiral Galaxy NGC 1512

This image uses multiple wavelengths to show the vivid colors of this galaxy. The colors indicate differences in the light intensity where newly born star clusters exist in both "dusty" and "clean" regions of the galaxy.

NGC 1512 is a barred spiral galaxy in the southern constellation of Horologium. Located 30 million light-years away, relatively "nearby" as galaxies go, it is bright enough to be seen with amateur telescopes. The galaxy spans 70,000 light-years, nearly as much as our own Milky Way galaxy.



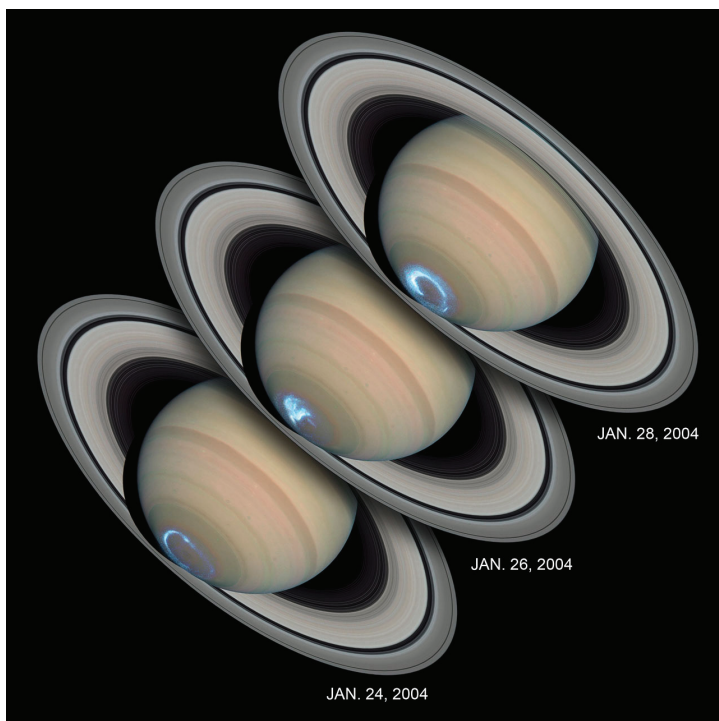
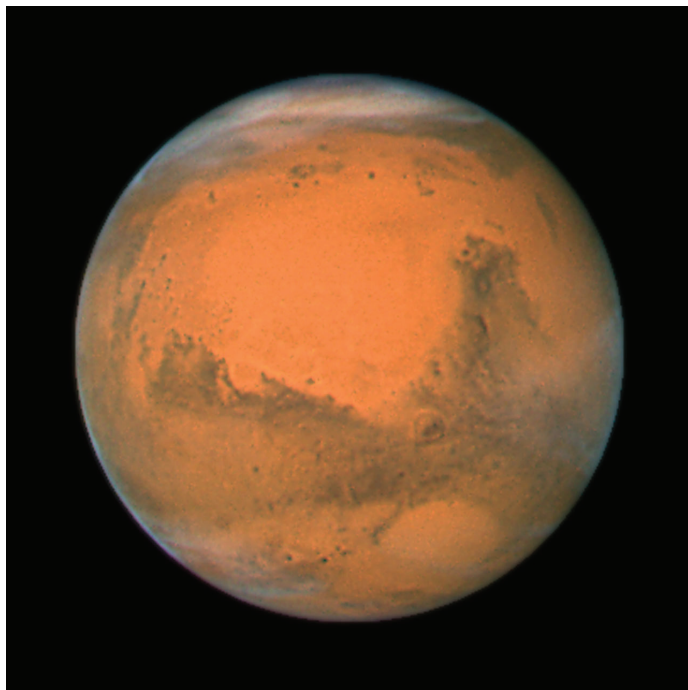
Multiple Generations of Stars in the Tarantula Nebula

In the most active starburst region in the local universe lies a cluster of brilliant, massive stars, known to astronomers as Hodge 301, seen in the lower right hand corner of this image. It exists inside the Tarantula Nebula in our galactic neighbor, the Large Magellanic Cloud.

Hubble's Sharpest Ever Color View of Mars

This view of Mars reveals small craters and other surface markings only about a dozen miles across. The Hubble Space Telescope snapped this image just a few days before the red planet's historic "close encounter" with Earth.

Among the Martian surface features are: numerous craters; several large volcanoes of the great Tharsis plateau along the upper left limb; and a large multi-ring impact basin, called Argyre, near image center. These kinds of features from past and present spacecraft that have orbited Mars are also being studied in detail, but they have never before been seen from Earth with this kind of clarity.



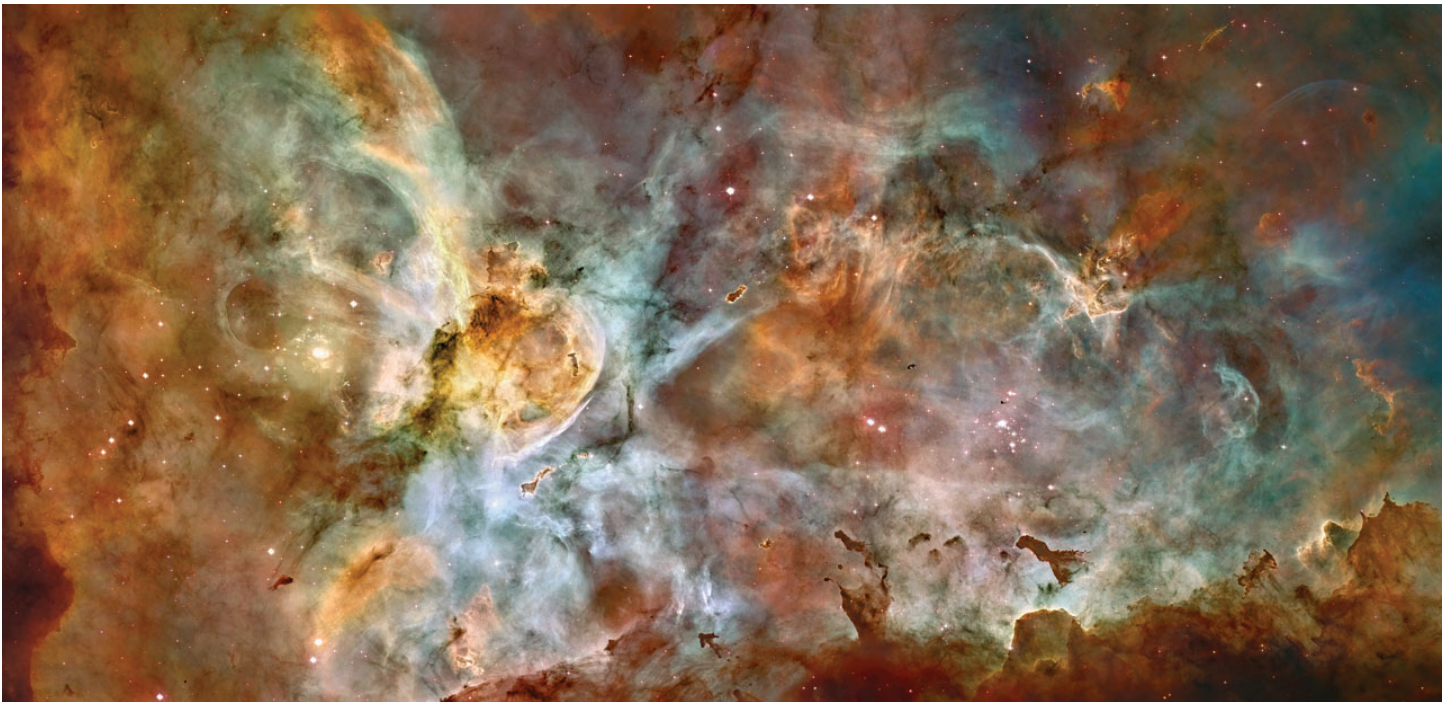
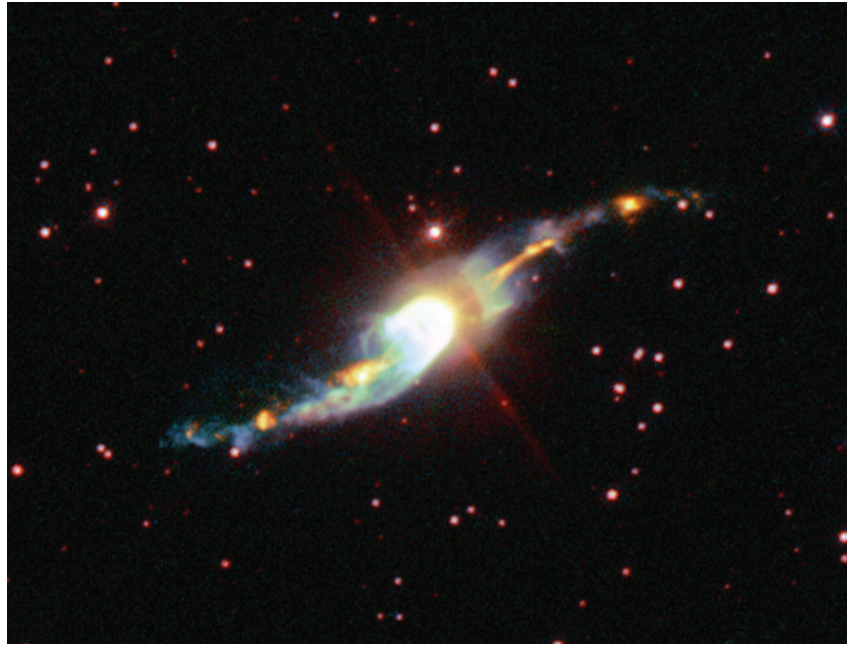
Saturn's dynamic aurorae

These images reveal the dynamic nature of Saturn's aurorae. Viewing the planet's southern polar region for several days, NASA/ESA Hubble Space Telescope snapped a series of photographs of the aurora dancing in the sky. The snapshots show that Saturn's aurorae differ in character from day to day, as they do on Earth, moving around on some days and remaining stationary on others. But compared with Earth, where auroral storms develop in about 10 minutes and may last for a few hours, Saturn's auroral displays always appear bright and may last for several days.

Seen from space, an aurora appears as a ring of glowing gases circling a planet's polar region. Auroral displays are initiated when charged particles in space collide with a planet's magnetic field. The charged particles are accelerated to high energies and stream into the upper atmosphere. Collisions with the gases in the planet's atmosphere produce flashes of glowing energy in the form of visible, ultraviolet, and infrared light.

The mysterious ‘Garden-sprinkler’ nebula

There are many mysterious objects seen in the night sky which are not really well understood. For example, astronomers are puzzled by the ‘jets’ emerging from planetary nebulae. However, the S-shaped jet from Henize 3-1475 is the most perplexing of all. ‘Jets’ are long outflows of fast-moving gas found near many objects in the Universe, such as around young stars, or coming from neutron stars and planetary nebulae. The Hubble Space Telescope has imaged the young planetary nebula Henize 3-1475 and its bizarre jet. Astronomers have nicknamed it the ‘Garden-sprinkler’ Nebula.



Star birth in the extreme

Hubble’s view of the Carina Nebula shows star birth in a new level of detail. The fantasy-like landscape of the nebula is sculpted by the action of outflowing winds and scorching ultraviolet radiation from the monster stars that inhabit this inferno. In the process, these stars are shredding the surrounding material that is the last vestige of the giant cloud from which the stars were born.

The immense nebula is an estimated 7,500 light-years away in the southern constellation Carina the Keel (of the old southern constellation Argo Navis, the ship of Jason and the Argonauts, from Greek mythology).

A Progression through the Mechanics Curriculum of 7th Grade Physics

by

Bob Amis

There are any number of ways to guide your students to an understanding of the principles behind the simple machines during 7th grade Physics. All of the resources that I am familiar with (including *Sensible Physics Teaching* by D'Aleo and Edelglass, *Physics is Fun*, by Trostli, and *A Phenomena Based Physics*, by von Mackensen) have excellent suggestions and advice. Having taught this block five times, and borrowing from the above-mentioned sources, I have developed my own progression through this section of the curriculum that seems to be engaging for the students, brings home the major principles of simple machines, and can be accomplished in five main lesson periods.

On the first day, I have prepared a 5-foot 2 x 4 board by pounding a number of nails into it along its entire length, spaced a few inches apart, with the heads of the nails protruding about an inch out of the board. I begin by inviting a student up to the front of the room and ask him/her to pull one of the nails out of the board by pulling straight up with a pair of pliers. This should prove very difficult to impossible for the student. Then I give the same student a pry-bar (the claws of a hammer would also work) and ask him/her to try again. This should prove much easier. Finally, I produce a much longer crow-bar and have the student remove another nail. Then I have all of the students come up and go through the same process, experiencing the difference between the three methods of removing a nail.



Practical use of the lever

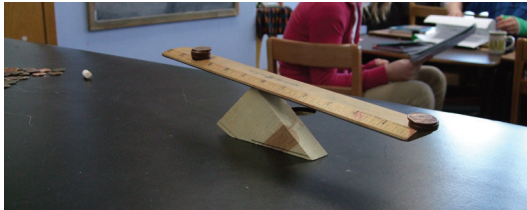


Practical use of the lever

Next, we all go outside to the play yard, where our school has a very beefy sawhorse and several long beams, all of which are sturdy enough to support the weight of many students (A see-saw would certainly work well. In years past I have used one of my own sawhorses from home and a 2 x 8 board. This has worked as long as I am careful about the number of students that sit on it at once). First, we place the beam on the saw horse and find its balancing point. We mark this spot and then keep the beam centered on its balancing point for the rest of the experiment. Next, two students sit on opposite ends of the beam and position themselves so that the beam is balanced. We then begin to experiment with different configurations, moving one student closer to the pivot point and seeing what happens, adding more students on either side, etc. This is a phenomenon that all the students seem to be familiar with and it is tricky to keep them focused and observing carefully. It gets more interesting and fun if your “seesaw” is strong enough to pile lots and lots of students on one side, balanced by only a few students on the other.

Finally, if there is time and opportunity, I have had the students try to use a sturdy metal bar or board and a rock (as their pivot point) to move some heavy objects on the play yard. This challenge gets a very enthusiastic response from some of the students, less so from others. After the first day, then, all of the students have experienced the power of a lever.

During the discussion on the second day, the students usually have a pretty easy time articulating the fundamental principle of levers: a weight that is farther away from the pivot point on one side of a lever can lift a heavier weight on the other side that is positioned closer to the pivot point. I also introduce the terms “fulcrum,” “effort arm,” and “load arm” at this point.



The balance beam

The experiment on the second day requires a large pile of pennies (which will serve as the weights), a number of stiff rulers (not the flexible plastic type), and an equal number of objects to serve as a fulcrum (I have used “Pink Pearl” erasers, set on edge, in years past; they are passable, but are a little too thick. Now I use some small triangular wooden blocks that I cut up from scraps in the wood shop. The corner that will be used as the pivot point should not be too pointy or the students will have trouble getting the ruler to balance; a sixteenth to an eighth of an inch is about right.). One more warning: all pennies do not weigh the same. The older, dark brown pennies are heavier than the newer, shinier ones. In a perfect world you should use pennies that weigh about the same.

I split the students in pairs and give each pair a ruler, a block of wood (fulcrum), and a pile of pennies. Again, we start by finding the balance point of our rulers on the fulcrum, and then keep the rulers positioned over the fulcrum at that point for the rest of the experiment. If the balance point is not very close to the 6 inch mark on the ruler, then we discard that ruler and try another. Next each group positions two pennies on their lever, so that the center of each penny is exactly six inches away from the pivot point on either end of the ruler. The ruler should balance. This is a practice step, to make sure that the students are using the proper technique.

Now we begin the experiment. Each pair of students is instructed to place a specific number of pennies, in a stack, on the right side of the ruler so that the center of the stack is exactly six inches from the



Practical use of the balance beam

pivot point. Different pairs are assigned a different number of pennies. Next, they are instructed to place a stack of pennies on the left side of the lever, also exactly six inches from the pivot point, and find how many pennies are required on the left side to balance the ruler. These numbers are recorded on a chart. Then they are told to move the stack on the left side to a position exactly four inches from the pivot point and, again, add or take away pennies on the left side until the ruler is balanced. This procedure is repeated, moving the stack on the left hand side to positions that are three inches, then two inches, and finally one inch from the pivot point, each time adjusting the number of pennies in the stack on the left until the ruler balances. The results at each position are recorded. It is important to remember that the ruler is never moved from its original position over the fulcrum, and the position and number of pennies on the right side of the ruler remain the same.

I like this experiment because it gets everyone involved. Students are required to be very careful and consistent, and must record their own results. I do give them a format for the chart that they use to record their results. The chart has four columns. The headings are: Number of pennies on the right, Distance from the fulcrum on the right, Number of pennies on the left, Distance from the fulcrum on the left. I have the students skip the five inch distance on the left because the math is problematic, but you can include it if you want.

The next day, during the review, we write each group’s results on the chalkboard. If two or more groups were assigned the same number of pennies on the right side of the ruler, I have those groups average their results. Once up on the board, I ask the students to look for patterns and relationships. With such an open-ended prompt we usually get some

very interesting and surprising observations. Eventually though, they begin to see that, at least for some groups, there is a consistent mathematical relationship that has emerged. That relationship is well explained in *Sensible Physics Teaching*, where it is called the “Rule of Levers,” and states that the product of the number of pennies on the right, multiplied by the distance from the fulcrum on the right, will equal the product of the number of pennies on the left, multiplied by the distance on the left, or: $N_R \times D_R = N_L \times D_L$

On the third day, I combine a brief experiment that takes the rule of levers a step further with a discussion and demonstration of the different classes of levers. In preparation for the experiment, I have located a six-foot bar. Mine is a metal pipe, but it could easily be a wooden 2 x 2 or 2 x 4. On the bar, I have measured off one-foot increments and clearly marked them with a Sharpie or with tape. I also bring a 10-lb weight from home with a small length of rope with which to tie the weight to the end of the rod. There’s nothing special about the 10-lb weight for this exercise, just a heavy object that can be attached to the end of the bar. I also bring two tape measures from home. I use the back of a sturdy chair for the fulcrum.



Measuring distance travelled by effort arm

Having tied the weight to one end of the bar I invite two students to the front of the room. One simply braces the chair that we are using as a fulcrum so it doesn’t tip over. We center the bar across the chair back and then I instruct the second student to grasp the end of the bar opposite the weight and press down on it. I then shift the bar, first moving the weight closer to the fulcrum, and then farther away, each time asking the student to push down on the bar and report how much force is required (i.e., which position is easiest and which is hardest). By now, everyone in the classroom has a clear expectation of what the results will be: the bar will be easier to push down when the

student’s hands are farther away from the fulcrum than is the weight on the opposite side. Now I invite two more students to come up. I give each of them a tape measure and position them at opposite ends of the bar. Holding the tape measure vertically, the student standing next to the weight is assigned to let us know when the weight has been lifted exactly one foot from its starting position. The other student, positioned at the opposite end of the bar, is to measure how far his/her classmate’s hands have to push down in order to lift the weight a foot. The relationship becomes clear very quickly: when the bar is centered over the fulcrum and the student’s hands are the same distance from the fulcrum as the weight is on the opposite side, the student’s hands must push down one foot for every foot that the weight is lifted. When the student’s hands are twice as far from the fulcrum as the weight, the pushing is easier but the student’s hands must travel two feet for every foot that the weight rises. The opposite is true when the student’s hands are half the distance to the fulcrum as the weight. Now we have established not only the “Rule of Levers,” but the fundamental trade-off present with all the simple machines: they reduce the force that is required to move a load, but they increase the distance over which that force must be applied.

Now I move on to a demonstration of the differences between 1st, 2nd, and 3rd class levers by showing the students examples of different devices and asking them to identify the fulcrum, the point of effort, and the point of load. Typically, I use a pair of scissors to illustrate the 1st class lever, or “EFL” (with the fulcrum in between the point of effort and the load), a garlic press or nutcracker as a 2nd class lever, or “ELF” (with the load in the middle), and a set of barbecue tongs or tweezers to illustrate the 3rd class lever, or “FEL” (with the point of effort in the middle). Their assignment for the evening is to find three examples of each type of lever at home, bringing some of them in the next day, if possible.

The discussion of the homework assignment the next day could take up the whole main lesson if you’re not careful. Lots of good examples of levers are brought in, and some that take some careful observation and thinking to determine exactly what type of lever they actually are. Fortunately, my demonstrations on the fourth day don’t necessarily take up a lot of time; I introduce the wheel and axle, and then the crank (or wrench).

In order to demonstrate the wheel and axle, I went to the hardware store and bought a short length of threaded pipe and, magically, a round metal disk that already had a threaded hole that would receive my pipe, and several smaller holes appropriate for screws. I then cut a two-foot diameter circle from a piece of 5/8" plywood, screwed the metal disk onto the center of my wooden circle, threaded the pipe into the disk, and voila, I had a \$10 wheel and axle (I am sure there are other, better, ways to do this). The wheel and axle can be used as two different types of levers. First, I have two students come up to the front of the room and do a "turn-of-war." One student grasps the edge of the wheel while the other holds on to the axle, and they are instructed to try and turn the device in opposite directions. The student turning the wheel can easily overpower the student grasping the axle. To demonstrate the other aspect of the wheel and axle, I detach the axle from the wheel, put a mark on surface of the axle, and then have a student roll the axle across the top of a desk exactly one revolution. We then measure the distance the axle (in my case, it's about three inches). Next, we reattach the axle to the wheel, set the wheel on edge on top of the desk, and instruct the student to rotate the axle through one revolution. Of course, as the student does this, the wheel travels much further than the axle did alone (in my case it travels roughly six feet). This demonstration will be fodder for much discussion the next day.



A turn-of-war with wheel and axle

The crank can be demonstrated by taking the students out to your car and having them try to loosen the lug nuts on a tire, first with their hands, then with a short lug wrench, and finally with a longer lug wrench or a lug wrench with an extension, or "cheater bar," attached. A quicker demon-

stration (not requiring the class to go outside) can be achieved with a bolt that is passed through a hole in a block of wood and then tightened down with a nut. Again, you can first use fingers, then a short-handled wrench, and then a longer-handled wrench. Although not one of the six simple machines, the crank is a very important variation on the wheel and axle, so I include it.

On the fifth day I set up demonstrations for pulleys and the inclined plane. Over the years my school has acquired several sets of pulleys and rope from the "seconds" bin at a sailing store or marina. Hardware stores have less expensive options. I set up three sets of pulley systems outside, hanging them from a platform ten feet above the ground, and attaching each to a bucket with about 10 lbs of sand in it. The first is a single, "fixed pulley," hanging from the platform. The second is two pulleys, one attached to the platform, and the other attached to the bucket, a "moveable pulley" system. The third is a proper "block and tackle" system, with two pulleys attached to the platform, and two to the bucket. The students are given the chance to experience the effort required to lift the bucket of sand with each system. Then we use the tape measures to determine how much rope must be pulled through each system in order to raise each bucket one foot. This does a nice job of tying the principle of the pulley back to the lever.

Next we move over to a set of steps where we set up two ramps, using planks. One ramp is about five feet long, and the other is ten feet. The exact length of the ramps doesn't matter, but the longer ramp should be at least twice the shorter. We then tie a length of rope onto the handle of my neighbor's little red wagon, pour 10 lbs. of sand into it, and give the students the chance to pull the wagon up the two ramps.

During the discussion on the sixth day, I hope for the students to see the connection between our earlier work with levers and the trade-off at work within the pulleys and the inclined plane.

If I have more days at my disposal, I can cover the screw (using a bolt, or my threaded car jack) and the wedge (using an axe or a knife blade). Bringing in a bicycle and looking for all the levers on this complex machine is also a lot of fun and a valuable learning experience.

Teaching Sensible Science Course to Begin in June

The next Teaching Sensible Science Course will begin in Saratoga Springs, NY, in June. 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 dates for the three sessions are:

- Session One : June 13 to 19, 2009
- Session Two: October 7 to 12, 2009
- Session Three: February 15 to 21, 2010

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

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Waldorf Science Newsletter edited by David Mitchell & Bob Amis, © AWSNA Publications

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

AWSNA Publications	E-mail: publications@awsna.org
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