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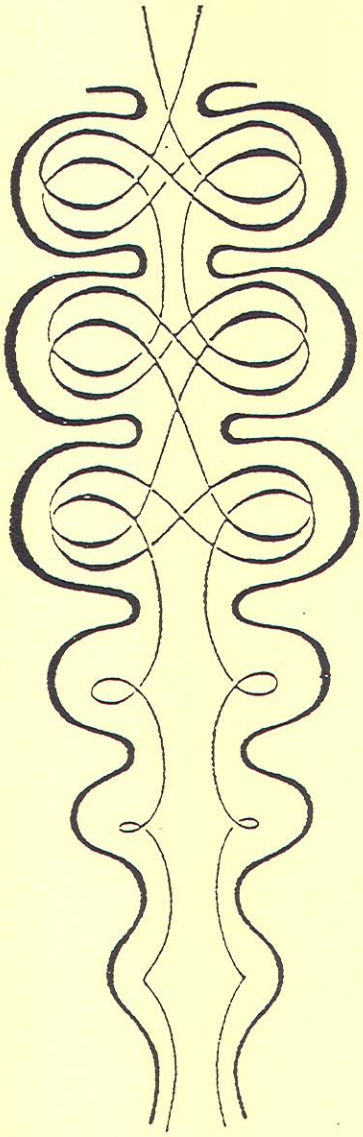

WALDORF SCIENCE NEWSLETTER

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HUMOR

(Adapted from *Journal of Chemical Education*)

As a change-of-pace, try having students write a limerick! Some results:

1.

There once were two chemists with zeal,
Those guys, Boyle, and Charles were for real.
So they combined their gas laws,
Though we know they have flaws
'Cause their gases weren't really ideal.

2.

Our teacher's last lecture did tell
The maximum temperature of Hell
But, adding sinners to sulfur
the boiling point alters,
Colligatively, Hell would be hotter to dwell.

3.

The Ode sisters were employed in a cell
Ann and Cathy, I knew those names well.
But, as they got old,
Ann Ode did corrode
And their glavanic potential fell.

4.

Al K Hall is a guy with no pride
With his name he was not satisfied.
So with no trepidation,
He underwent oxidation
An then was renamed Al de Hyde.

* * * * *

BOOK REVIEWS

THE METAMORPHOSIS OF PLANTS

by Jochen Bockenmülhl and Andreas Suchantke

The Novalis Press in Cape Town, South Africa has just released a book entitled *THE METAMORPHOSIS OF PLANTS*, essays written by Jochen Bockenmühl and Andreas Suchantke, ISBN #0-9583885-2-0.

The back cover reads: "Two hundred years ago the German scientist J.W. von Goethe described the metamorphosis of plants as an 'open secret.' When studying the plant world today, can the scientist penetrate to the 'inside' of nature? Is it possible, by putting the microscope on one side for a moment, to go beyond the conventional methods of plant analysis and learn to 'think as nature thinks?'

By applying the Goethean scientific method - the chief tools of which are not the microscope but unbiased thinking and applied imagination - authors Jochen Bockenmühl and Andreas Suchantke have shown how accurate naked-eye observation of the leaf, stem and flower forms can reveal so much that is hidden from conventional microscopic analysis."

The book has 31 line drawings by the authors.

- DSM

FORMING CONCEPTS IN PHYSICS

by Georg Unger

Why is it that 'scientific' explanations often seem so dry and foreign to life? One area where the findings of modern science seem extremely strange and far-removed from every-day life is in modern quantum physics. The increasingly strange findings in this arena seem to cast doubt on the validity of our thinking to truly grasp 'reality,' or at least give us pause as to what 'reality' we are in fact speaking about. One attempt to work though these issues, and rebuild the conceptual basis of modern physics is the newly available: ***Forming Concepts in Physics***, by Georg Unger, recently published in English.

This deceptively short book (203 pages) is a carefully-wrought work of Dr. Unger's reflection on the puzzles of modern quantum physics. The book begins by exploring "A New View of Nature" (chapter 2) and the role of thinking in it "The Method of Gaining Knowledge" (Chapter 3); this is followed by more detailed chapters on the "Transition to 20th Century Physics", "New Phenomena (Phenomenal Atomism)" and "Quantum Theory," "Probability," and "Relativity." Final sections on "Phenomenology and Mathematics of the New Science" and "Physical World and Spiritual Science" round out the explorations.

Although it may not be 'an easy read', it *is* essential reading for any high school physics teacher, in order to really work though, in themselves, what role thinking can play in modern science, and thus what it can begin to mean for their students. But, it could be of use also for anyone interested in the epistemological underpinnings of the 'Goethean' approach we strive to activate in our Waldorf science lessons. As Dr. Unger says in his introduction, "although in what follows there results not one new experiment," nevertheless "human thinking is not limited" and the "revolution in thinking in the 20th century is not yet

radical enough." Finally, he shows "reality is not behind things but in them, although it is veiled at the beginning. Thought brings this new kind of reality to existence within man."

This book is not a text, but a journey – albeit a challenging one – to discover in inward experience what thinking really means. Real inner work is necessary, but the payoff is getting some glimpses of an approach to the most challenging findings of modern science. Certainly, we could ignore this whole field altogether. But, why then has humanity been allowed to uncover this 'Pandora's box' of paradoxes? I suspect it could be seen as a stimulus to push the boundaries of consciousness and learn new faculties, in thinking and in doing. But, this requires a kind of apprenticeship and practice; the Author's reflections take you though just such a schooling in pure thinking, with no reference to metaphysics (at least until the last chapter, where he speaks more personally about his own views out of Anthroposophy). In the process, he also provides a useful summary of the key findings of modern physics.

You can order ***Forming Concepts in Physics***, by Georg Unger, translated by Hanna Edelglass, edited and revised by Stephen Edelglass and David Booth. It is available for US$24.75, from the publisher, Parker-Courtney Press, at 307 Hungry Hollow Rd., Spring Valley New York, 10977.

– JP

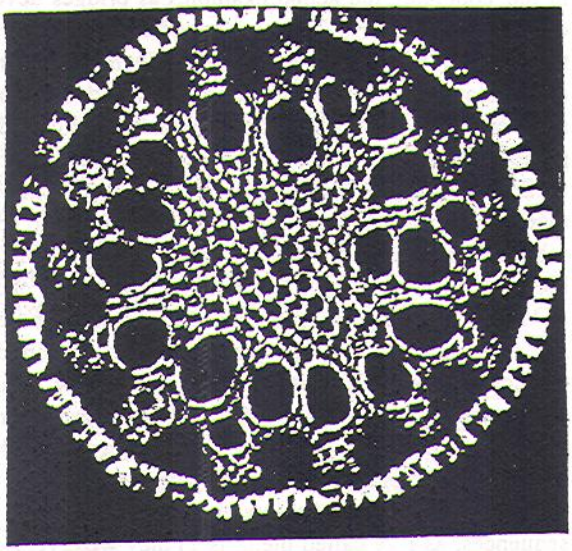
MOUNTAINS AND CANYONS

edited by Mark Longman

If you're looking for some 'relief' you might want to check out a beautiful photographic description of the Rocky Mountain West called ***Mountains and Canyons*** edited by Mark Longman. The large format 11"x12" book includes 50 large b&w images as well as many other interesting tidbits. The photos are selected from thousands collected by Jack Rathbone, who has been photographing the mountains for 40 years. They are arranged geographically to describe Colorado in great detail, with succeeding chapters on Arizona, Nevada, North Dakota, Utah and Wyoming. Each picture has a brief descriptive text by Mark Longman, and interpretive line drawings by Darwin Spearing a museum designer and now a volunteer ranger at Rocky Mountain National Park, who has illustrated numerous geology textbooks.

This is a great source of geographic 'phenomena' for various geography classes. "Mountains and Canyons" edited by Mark Longman, was published in 1995 by Rathbone Press, for US $43.95. If you have trouble obtaining it, you could call the Rocky Mountain Assoc. of Geologists in Denver at (303) 573-8621.

– JP



Mandala pattern in the stem of a lily.

LETTERS TO THE EDITORS

It was good to hear from a few of you out at the various schools! We got an interesting letter from Christian Sweningsen (contact by e-mail, 70404.3241@compuserve.com) suggesting an article by Wilhelm Rauthe on the **Development of The Faculty of Judgment** in the high school years, as a guide for teaching. A draft translation by John Barnes of this article surveys the details of the stages thinking and judgement undergoe in the high school years, and was studied by the Hawthorne Valley faculty, who found it very stimulating. We hope to "serialize" the article in in future numbers of this newsletter if John Barnes is supportive.

Christian also mentioned how he had struggled with reconciling his inner sense experiences and the theories of science, especially in mechanics.

"I was quite puzzled when told that a wall, when pushed on, 'pushes back.' When discussing this with Hans Gebert (then of the Waldorf Institute of Mercy College in Michigan), Hans said, with a twinkle in his eye, 'Oh, but it *does*.' So after chewing on that for a few years, I believe the solution lies in the contrasting phenomena of 'cohesion' and 'elasticity' — archetypal phenomena of matter, and so it seems to me essential to a curriculum. An indication for the 10th grade is that the world be 'made transparent for thinking.' My 'investigative sequence' was

natural objects to structures of shaped objects to structures thought out as the essence of 'reaching' and 'supporting'; these were then 'filled in' with materials, iron and steel, which had been discovered to be a kind of essence of strength within natural materials. The beauty is in the 'concrete'; the actual examples as bridges developed through history. There is a wonderful transition in the Coalbrooksdale Bridge in England, where the form of the stone arch bridge has been abstracted, and constructed of cast iron. The sequence lends itself to slides photographed from books; there is a great deal of aesthetic appeal for girls, strength for the boys, and achievement for all. Again, these can be done in a day, and provides a transition and introduction all the topics of the block. Michael Faraday's lectures *On the Various Forces of Nature* are very good on phenomenal presentations and / or derivations of the concepts of matter, cohesion and elasticity; I like to lead it over to Hooke's Law, which quantizes the 'pushing back' of the wall, which is of course what is called 'elasticity' – in a wall cohesive enough that this comes into play in interaction with the pusher.

"What especially interested me about these sequences, as I've called them, is 1) they were very well received by the students; 2) they *felt* true to the world, to the 'phenomena'; 3) they seemed particularly appropriate to the age groups they were addressed to, in terms of the indications Rauthe derived from Steiner."

Christian also asks: "Have you given any thought to an accessible repository of curriculum and/ or teaching materials? I think every teacher has a collection of stories, photographs, anecdotes etc. that are particularly telling and so, economical. Yet one's own collection is never all that is wanted, and there are new teachers and new needs continually. It would be wonderful to find a way to share the resources. The Newsletter is one excellent step; but the collection I'm referring to might be beyond its possibilities. I remember the hours I spent at the Emerson College library, and later at the teachers' library at the Sacramento Waldorf School, during my teacher training; resources I gathered and referred to gradually over many years."

At the newsletter, John Petering still has not heard from anyone else re his request for really good color perception exercises, perhaps usable in grade 12 physics of light and color. He will report on further work with Michael Wilson's experiments in Fall 1996.

Again, we gratefully accept questions, struggles or contributions either in hard-copy via US Post, or in e-mail (see URL addresses above).

* * * * *

CURRENT RESEARCH

John Barnes, in Harlemville, is inaugurating the Goethean Science Series, as many of you may already be aware. He sent us the following prospectus:

I. BACKGROUND

WHAT IS GOETHEAN SCIENCE, AND WHAT IS ITS IMPORTANCE TODAY?

The technological triumphs of modern science are incontestable. Yet, when this technologically oriented science is applied in agriculture, for example, the short-term success achieved through industrial methods – monoculture, chemical fertilizers and pesticides, etc. – ultimately leads to the degradation of soil, crops, and of the natural environment as a living whole. But it is not only the external application of technological thinking that is cause for concern. The reductionistic tendency of this thinking, its inability to grasp our immediate experience and the deeper, generative forces that speak through it, is undermining our fundamental, aesthetic-moral relationship with the world.

Two hundred years ago Goethe developed a participatory science which leads to *concrete insight* into nature's creative principles. By recreating her works in exact imagination, he came to see them as the manifestations of organizational principles that work from the whole into the parts: principles of a higher, non-material nature which can only be grasped through intuitive perception. Goethe's living concept of metamorphosis opened up a whole new understanding of organic nature, and his qualitative approach to the study of color laid the basis for a renewal of the inorganic sciences.

A hundred years later Rudolf Steiner developed Goethe's science significantly further. Fully recognizing that higher levels of reality are only accessible to us through our own active inner participation, he extended his research to the human soul and spirit – into realms no longer accessible to empirical observation. He therefore described his work as anthroposophy, or spiritual science.

Goethean science is generally distinguished from spiritual science through the fact that it bases its research on empirical, sense-perceptible observation.

In rising from the observation of natural phenomena to an intuitive perception of the spiritual principles manifesting through them, Goethean science establishes an intermediate realm of research bridging natural and spiritual science.

Steiner's research has provided the basis for practical applications in many fields, among them the comprehensive new methods of big-dynamic agriculture, anthroposophical medicine, and Waldorf education. Over the past seventy years these methods have proven their effectiveness in working with nature in a healing and productive way. And yet, to a large extent, their underlying principles – as well as many other results of Steiner's spiritual research – are still lacking confirmation on the intermediate level through systematic, empirically based research. Herein lies a significant task of Goethean science.

Beyond this, however, a new, participatory understanding of nature has become an existential question. At a time when science again stands at a crossroads with the emergence of genetic engineering, insight into the deeper, generative dimensions of nature is no longer merely a matter of academic debate but of far- reaching consequences for the future development of life on our earth.

Goethe's scientific method leads towards a world view which recognizes the primacy of divine, creative principles in all life and all evolutionary processes. Breaking with the ideal of a value- free, objective science, it leads to a deeper, aesthetic moral relationship to the world. Thus Goethean science can be seen as a vital source of healing for our times.

These considerations may serve to indicate the underlying thoughts out of which this initiative to publish works in Goethean Science has arisen.

More specifically, this initiative wishes to meet the following needs:

1. Goethean science needs to be introduced to the American public and the scientific community.

2. A considerable amount of research in Goethean science has been done over the last 75 years. For the most part, it has been conducted in German speaking countries and has been published in German. Much of this work still needs to be translated and made available in English.

3. English speaking scientists working in the spirit of Goethean science today need a means of presenting the fruits of their research to the scientific community and to the general public. Funding the publication of their work would help them to complete and formulate their research.

* * * * *

Strange Theories

Once, a young student wanted earnestly to know *why the chicken crossed the road.* Since the student's parents wanted only the best answers for their youngster, they eventually sent them to a highly-reputed college. After the youngster had settled in, they went around the campus asking questions. They received the following answers:

• **Biology Professor** Natural selection drives it all. Those chickens who cross the street will have a better chance of finding food and mates and, thus, survive to produce more eggs. The ones across the road have thus been selected as fittest.

• **Molecular Biologist** Obviously there is a gene that controls pavement-crossing activity. We have not yet isolated this gene or its expression. However, the PGP (Poultry Genome Project) will soon release a report on loci of locomotion genes. . . .

• **Physical Chemistry** Gibbs' law of free energy determines the change gradient in a system. In this case, $G^\circ = \{G^\circ_{final} - G^\circ_{initial}\} < 0$. Hence, the process is spontaneous.

• **Mathematics** That is the only way all points in n-space become equally accessible to all vectors in the system.

• **Psychology** All behavior is learned. It all depends on the hierarchy of rewards.

• **Philosophy** Causal explanations are inherently naiive. Hence, the question, 'Why?' is unanswerable. The chicken crossing a street is presents a problem in either ontology or epistemology. In the first case, the relevant question is: 'Does the chicken or the street exist?' In the second case, the question is 'How do you know what you think you know?'

• **Physics** Consider a spherical chicken of radius R. Let the potential energy be an exponential function of distance. . . .

– Modified from a story by G.K.Vemulapalli at the Univ. of Arizona.

SCIENCE EDUCATION SHOULD INCLUDE WONDER

By Len Barron

This last year has been a high time in the world of science. The Hubble Space Telescope and other ventures have opened doors of discovery that promise more to come about the history and nature of the planets, the universe.

Yet, for all the wonder of science, science education is still too often laden with a methodology of filling students' minds with information. That is not science.

Physicist Victor Weisskopf says: "Science is not flat knowledge, formulae, names. It is curiosity, discovering things and asking why. Indeed, science is the opposite of knowledge. We must always begin by asking questions, not by giving answers." And he adds: "You can teach only by creating interest, by creating an urge to know."

That is a lovely notion offered by Weisskopf but one buried in the practice of many science curriculums; there is too much emphasis on data and too little on inquiry and romance.

There is, however, no shortage of romance in the George Gamow Memorial Lectures, a series that began in 1971. It is one of the wonderful times at the University of Colorado and this year was no exception when Eric Cornell and Carl Wieman of NIST and CU were the guest speakers.

Cornell and Wieman, assisted by CU students and post-doctoral scholars, produced a new form of matter by cooling atoms to about 0.1 millionths of a degree above absolute zero, thus confirming a prediction made by Einstein 70 years ago. Einstein would have been delighted with their work and their presentation, as was an appreciative audience that evening in November.

Weisskopf doubtless would say that Cornell and Wieman were motivated by "an urge to know." If Weisskopfs thoughts were more influential in science education we would surely witness a difference.

It also might be fruitful if added to the curriculum were stories about intuition and the childlike wonder and playfulness – and sense of beauty – inherent in the ways of superb theorists and experimentalists. It might well encourage a more passionate engagement on the part of students and add to the pleasure of teachers.

How do fertile minds think and are there commonalties in their perspectives? Let's look at two of the grand men of science in the 20th Century: Einstein and Niels Bohr, the great Dane from Copenhagen. Everyone knows some of Einstein, but few in America know very much about the life of Niels Bohr.

Einstein first met Bohr in 1920 and a short time later wrote to Bohr: "I am studying your great works and when I get stuck anywhere, I now have the pleasure of seeing your friendly young face before me smiling and explaining."

Oh, how these men adored one another and what charming poetry that they should be awarded the Nobel Prize, one after the other, Einstein in 1921 and Bohr in 1922.

Einstein said of himself: "I am a horse of a single harness." Bohr, on the other hand, always worked with other physicists. Many of the young great physicists in the 1920s and '30s, including Wolfgang Pauli and Werner Heisenberg, Erwin Schrodinger and, indeed, George Gamow, visited and worked with Bohr at his Institute of Theoretical Physics. Revolutionary work in physics was common practice in Copenhagen.

Beyond work there was much play at the institute. Bohr was fond of American films, especially Westerns. He loved to take everyday circumstances and turn them into scientific questions and one evening after watching a Western he said he could not figure out how the bad guys drew their guns first, yet the good guys always won the shootout.

He wondered on that problem and then declared that he had the answer. The bad guys would have to make a conscious decision as to when to draw and thus were no match for the good guys, who would instinctively draw – giving them the edge.

Einstein's admiration for Bohr went far beyond science. Einstein knew that he had given up certain parts of himself to work as he did, but Bohr was able to include everything in his life. He was a gifted athlete and the finest ping-pong player in the entire scientific community. He had a 50- year romance with his wife Margrethe, he was a wonderful father to his

five sons, and no one took greater pleasure in being a grandfather than did Niels Bohr.

And never was Bohr more the grandfather than at Tisvilde, the family's summer home. In this setting on the edge of the forest, Bohr read the children the old fairy tales as he had a few years earlier to their fathers. He took them on walks through the forest where, as everyone knows, the trolls dwelt, and on the way to the beach on his bicycle a child or two would be carried aboard.

There was a playhouse for the children and Bohr would often be there in the middle of the games. "I love playing with children," he would say. "In their joyful eagerness one witnesses the potentialities of human life at its best. Children have expectations of everything."

Einstein and Bohr shared the same thoughts about the wonder of children, but they often fought vigorously over physics. Once while working on a problem together, Einstein looked up and said: "Oh this is so simple, so beautiful, God could not have passed it up." To which Bohr replied: "Einstein, stop telling God what to do."

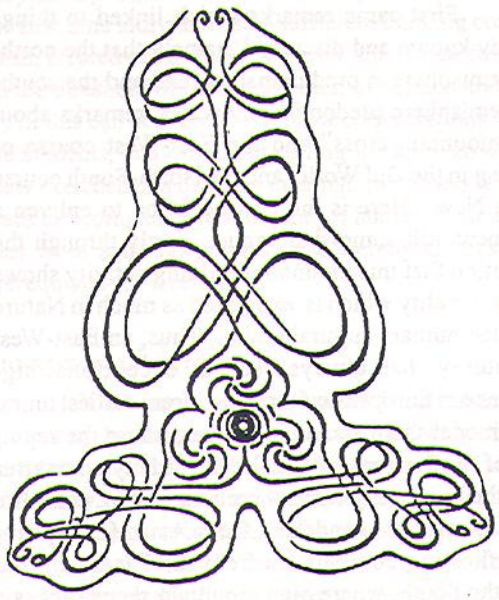
Bohr, like Einstein, was far more fascinated by the unknown than what is known. And certainly Einstein spoke for both of them when he wrote: "The most beautiful experience we can have is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science."

Victor Weisskopf, now in his nineties and still active, was one of the brilliant physicists who spent time at Bohr's institute and like many of the physicists around Bohr, his interests were rich and varied, including a deep passion for education.

In his charming and informative autobiography, *The Privilege of Being a Physicist,* from which I have already quoted, Weisskopf rails against the prevailing argument that America needs to improve science education in order to increase its competitive edge in the world market. Weisskopf is clear that that is an unhealthy argument for education.

Instead he offers: "Quality science education contributes to a more interesting and thoughtful life by instilling a deeper awareness of what we see around us. Yes, that is its true purpose . . . something that I like to call the joy *of insight,* a sense of wonder about nature."

Twenty-five years ago Victor Weisskopf was the first guest-speaker for the Gamow Lectures – a lovely beginning for such a grand tradition.



The pattern of a flow form

The Human Earth

Towards a Geography for Gr. 10
by Andreas Suchantke, Zurich
translated by John Petering
Erziehungskunst Vol XLI, No. 12, Dec. 1977

To the students' surprise, the main lesson unit didn't begin with the usual long presentation by the teacher, but with an invitation to thoroughly examine the large world map: in its entirety as well as in details, to juxtapose and compare the parts of the earth, and completely objectively describe what strikes their attention. It wasn't that the teacher was inadequately prepared. But, it had been a long time since he had stood in front of this class, and the students had changed in the meanwhile. It was now a question of finding the sort of style and mood appropriate to their present state of being. Accordingly, this first lesson could not be presented as a finished thing, but rather must be developed and shaped together with the students, if the teacher doesn't want to run the risk of teaching 'over the heads of the students.'

What arose in this lesson and was to be further elaborated in the following days and in later main lesson blocks, served to hold fast to the theme of the whole to which the 10th grade Geography is devoted – and has been confirmed in the meantime to be an excellent entry-point into the unit. It is also useful since it is open-ended, allowing itself to be developed

further.

Planetary-Directions

First came remarks which linked to things already known and discussed, namely that the northern hemisphere is predominately land and the southern hemisphere predominately water; remarks about the "mountain-cross" and the East-West course of faulting in the Old World, and the North-South course in the New. Here is the first occasion to enliven a statement still somewhat vague: partly through the indication that this mountain-building activity shows a directionality which is expressed as much in Nature as in the human, cultural realm. Thus, an East-West dichotomy has always been of exceptional significance in European culture, even from earliest times. As a model there stands in the beginning the repulsion of the Persians by the Greeks. Many emissaries into [the European] hemisphere's animal- & plant-life are post-glacial wanderers from Asia; [European] butterflies in good part are from the Far East – not from the South, where high mountain ranges act as a barrier.

In the two Americas, there comes instead an intense North-South expression along the migration-paths of the Cordillera and the west coast. If it was primarily from the North that land dwellers penetrated southwards – the humans, and also many animals, the llamas, the puma, etc., – then from Antarctic and sub-Antarctic regions of the South arrived primarily sea-dwellers and members of a moist-cool Oceanic climate: the Galapagos penguin up to the Equator, the circum-antarctic Fucsia [Onagraceae spp] into the rainy mountain forests of the fire-land up to Mexico. Also the humming-bird penetrated from Alaska.

Anatomy of Continents

Next, the students ought to look at the spatial relationships of the continents and put the question to themselves whether there is there any sort of knowable order, or whether chaotic divisions prevail.

The first thing which is always named in connection with this is the corresponding trace of the East coast of South America, and the West African coast. We will postpone this phenomena and leave open what it signifies – it will be the starting-point for the concluding treatment of Continental Drift and Plate Tectonics.

The students quickly notice a correspondence in the morphology of both American continents. We can look for this and verify it in their individual characteristics: the overall-form is repeated in miniature – in the North they are quite broad, while their Southern parts are lost as tiny peninsulas extending into the ocean. Both continents thereby repeat the anatomy of the entire Earth, which consists of a Northern land- and Southern ocean-hemisphere. Further correspondences exist in having young, high mountains in the West, while in the East lie older, less-high mountains. Between these intervene mighty river systems, which have deposited vast alluvial [Great] plains.

Continent-pairs exist also in other regions – Africa and Europe for example. Here indeed the relationship is completely different: instead of a correspondence, we find the greatest conceivable differences. In the North, Europe is a smaller, richly membered continent, exhibiting every conceivable landscape and soil-formation – compact and shaped in strong detail in the West; great undifferentiated plains in the East; a coast of islands and peninsulas, where land and water interpenetrate in the most intimate way. Africa is totally different: poorly-detailed, with high plains and deep lands of mightiest scale, and the simplest coastline conceivable. Also, a "history-less" continent through long spans of earth history [no major tectonic upheavals since Cambrian], entirely different than Europe. Africa's robust organization has origins reaching back into farthest times – as if the rich and stormy cultural development of this continent corresponded to the preceding early geological development.

With the third continent-pair of Asia and Australia, the differences increase to extreme polarity: in the North lies the mightiest land mass on Earth, with regions showing the greatest distance from the ocean of all points on solid land. In contrast, in the South is a continent which consists predominantly of water, (considering not only Australia but the whole of Oceania) here is greatest isolation of lands from one another by surrounding ocean.

We cannot speak of an indiscriminate distribution of the continents; on the contrary, three continent pairs, in which we may discern a polarity no less clear: in the West conformity prevails, in the East the greatest possible contrast between the respective Northern and Southern partner. It is as if we thereby have to do with three stages of development and maturation: the East, exceedingly powerfully formed, seems to have exhausted all possible formations and to have embodied them– age. The West, in contrast, makes an undifferentiated impression, and seems in the simplicity of its forms to be just in the beginning – youth. The middle pair contains something of both, from the West and from the East, in the poorly-formed Africa and the overly-richly membered Europe.

With the east continent pair of Asia and Oceania, the relationships are, however, still more intricate. Between these is inserted an intervening region of transition and intense intermingling of land and water in innumerable islands and peninsulas, from India through Indonesia to Japan. Does this middle zone have any sort of individuality to show us, or is it simply a transitional region between North and South, without its own character?

With this question, we arrived at a decisive inspiration; in midst of the lesson and the stimulating conversation, in mutual seeking and groping of student and teacher: this middle region in south Asia is, in its northern part, the cradle of the great high cultures.

The next question about the situation with the other continent pairs, led the glance to the Mediterranean region as the space between Africa and Europe, on whose coasts, islands, and peninsulas the great occidental cultures arose and gained independence. The same picture can be seen in the Americas: in the Central American region arose the high culture of Mexico. Indeed, a different Indian culture, the Inca, penetrated far into South America – an interesting polarity to Asia, where the early high culture of China reached correspondingly far into the North. The question of what is thereby expressed, must be investigated in the corresponding pictures of these cultures, against the background of the connections presented below.

Cultural Geography and the Middle

The next question considered the modern relationships in this middle realm. What has happened since the Indian, Mediterranean, and the Central-American regions lost their obvious culture-creating significance? Or better, since they gave it over to other regions?

The answer of a student came promptly: generally the cultural center-point has shifted to the North on the surface of the Earth. In Asia: to China and Japan and in to the Asiatic part of the Soviet Union; in America to the USA; and, especially beautifully visible in the middle region, from Egypt through Middle East, Greece, and Rome, to Central, West, and Northwest Europe.

The last example shows that it is not simply just a matter of a northward shift, but a simultaneous shift of the center-point of decisive cultures Westwards. Both of these are shown in a glance at the whole Earth: from India, the path leads through the Middle East and the Mediterranean to North America.

How has culture changed thereby? A question which must now be taken up by the teacher, and so presented with examples, to make visible the transition from a macrocosmic consciousness in the ancient eastern cultures – the existence of the divine world had a higher degree of reality than the earth on which mankind lived – up to the agnosticism and materialism of the modern Northwest civilization. In the center of this journey stands the Greek culture. She placed the Human in the center, for the first time, the harmonically proportioned human –bodily beauty as the expression of a soul harmony of inner and outer. The world is filled with the divine still, but reason [Gewissen] is not [yet] an inner soul force, but rather experienced as personalized and circumscribed in the [Erynnien]. And yet, in the great philosophers, for the first time individual, self-sufficient thinking comes forth, created out of their own soul: the Greek culture on the threshold of inner and outer, of cosmos and the I. All this can be linked up in slow conversations with the students, and – without calling it such – an overview sketched of a birth, an incarnation process which leads to a complete "detachment" of human consciousness from spiritual powers, and thereby creates the prerequisite for freedom.

Bio-regional Anatomy

If the impulse for *cultural*-historical development up to the present runs in an east-west direction, the same may not be said for the realm of *natural*-history. This isn't a contradiction to the east-west movement experienced initially; in contrast, the animal and plant world of the northern regions corresponds so much that Europe, North America, and Asia southwards to the Himalayas are grouped as a single bio-geographic zone, the "holarctic." The same applies for the southern continents; although they are conditioned by spatial separation to possess distinct genera and families, they nevertheless correspond greatly in their overall life-forms (e.g. pollinating birds: humming-birds in America, nectar-birds in Africa and southern Asian, honey-suckers in Australia) and in their landscapes (tropical rain forests and savannas, etc.). No, the greatest differentiation in nature shows up in a north-south direction, between arctic, equator and the southern hemisphere. In this polarity, in connection with the cycle of the year, a strong dynamic prevails – think of the bird migrations in the north, and the southern monsoons. These are rhythmic processes in a differentiated spatial structure – the breathing processes of an immense organism.

The passage from east to west, the journey of people though time, mirrors a *spiritual* development. In the rhythmically modulated north-south axis, a spatial organization – *the form* – of the human being is expressed.

Since the students are familiar with the threefold character of the human being since their early grades, it shouldn't seem foreign to them to rediscover a corresponding threefoldness in the north-south form of the earth – in any case, at first glance a polarity between the form and movement poles: in the north, not only the solid layers dominate, but also we experience here especially strongly differentiated forms, and in this hemisphere the cultures developed from inner feeling and perceptive experience into thinking and intellect. The southern hemisphere is the metabolic and limb region, and here great movement systems prevail over the surface of the earth, as much in

the ocean currents as in the dynamics of the earth's crust as evidenced in the wide movements of the fragments of gondwanaland (now south America, Australia, Antarctica, Indian subcontinent and Africa). The southern hemisphere is actually more strongly characterized by movement than the tectonically rigid northern hemisphere. And considering how the mobility of our modern culture has encircled the whole globe, the southern continents actually form a metabolic pole – for example, providing a source of raw materials – while the technical, scientific, and commercial intelligence is concentrated in the north.

That both regions are strangers and increasingly stand in polarity to each other is expressed in cultural-geographic terms in the way the middle becomes increasingly insignificant. This very zone which was the cradle of civilizations, in the absence of any sort of brotherhood, and in the weakness of the ethical-moral attention given it by the increasingly estranged polar hemispheres, fails to provide the necessary forces, which cannot arise from either an intelligence alone nor from a mere 'will to develop,' but rather can only truly arise out of the middle, out of the heart realm. So, today, we constantly have polarities which one-sidedly intensify and support antagonisms, which confront one another without any commonality, between whites and colored people, between industrialized and developing nations, etc.

If the tenth grade human biology block has already occurred, then a further connection can be noticed. In the human organization, there is a characteristic difference in the interplay of organs and processes between the metabolic-limb pole and the nerve-sense pole in the human body. In the metabolic systems the organs and activities are 'under cover' and collapse together so much that they can hardly be distinguished, and the processes in the organs and their tasks cannot be investigated; so the brain and nerve system are already exceptional in that with their activities – conscious sensation and thinking – have been separated so strongly, that they can no longer be found or investigated in them. The observation of the conduction of stimuli in the nerves or the investigation of the brain tissue no longer supports an understanding of how thoughts form or become reasoned thinking, nor even less how qualities arise from sense impressions. In contrast to the metabolic pole, we have to do with two separate regions, which we merely know that they somehow relate to one another; that the nerves are some kind of physical substrate, the pathway or roadway of our conscious experience. This division is not there from the beginning. It comes in the same degree as the brain develops, and its growth reaches its goal. Then, the developing, forming forces are drawn out of the organ, they 'excarnate' to a certain degree and become available as the force of thinking. Through this severing of the formative forces, the organic substrate is more or less transcended and runs the danger of dying or decaying, a process which must be endowed with life forces only by the intensive care from the opposite pole, the metabolic system. In this head region, the life forces are not fully active in the organs as they are in the life-pole which therefore has only a weak consciousness.

If we now compare the **forms of consciousness** of the northern and southern peoples, this lends itself also to parallels. Thus, the 'I' of the nature-people of the tropics lives sleeping, dreaming in the surroundings, not in the cosmic heights as the earlier cultures of the orient, but rather in the forces of nature, the animals, plants, the earth and the weather phenomena in the cycle of the year, in the organic processes and organisms of the earth. Quite differently the bearers of the technical-scientific civilization of the north, which not only in their thinking, but even more in their lifestyle habits have achieved an estrangement and separation from nature's influences which is unequaled. A direct consequence of this is that living nature is generally dying wherever it is exposed to this estranged consciousness.

Naturally, we should not remain there. The detachment of human consciousness from the constraints of nature is simultaneously a process of liberation which provides new possibilities, now unconscious and instinctive no longer, but rather of working with the connections to nature consciously and guiding evolution out of conscious knowledge. Something, that in the stagnating culture of the nature people is not possible.

The Earth As Image of Humanity

The Earth: an image of mankind, as much in its spatial as in its temporal form – under this motto, the correspondences we have discovered can be arranged. They enable an experience of the belongingness and relatedness of the human with the earth, an important experience for young people whose inner engagement becomes world-wide in these years, which forms a needed counterweight to the daily impressions of in a humanity torn by tension and opposition.

And the more so, as the connections we can discover will enable us to see though many of these oppositions, without trying to explain them in a simplistic way. Did the modern intellectual thinking develop because the cultures shifted northwards, or did they wander there as the time was ripe to develop these forms of consciousness, and since it was possible sooner in northern regions? The second form of the question appears appropriate in a situation where we have more to do with classification, parallels, correlations, than with causal roots. Such a way of considering things is freeing, it doesn't organize one phenom-

enon hierarchically underneath another, but shows the phases of human cultural development clearly *in correspondence* with the geographic factors, but not dependent upon them.

In this way, both domains – the human cultural development and the formation of the earth – mutually illuminate each other. We begin to understand why Rudolf Steiner laid such importance on connecting geography and history.

"And this geography, which is geography proper, can be further built up upon all kinds of descriptions which have been given earlier in preparation. We can even describe distant countries, but we must have described these previously, have told the children something about them [culturally]. If we have properly prepared them through such descriptions, let us say of [the botany of] some region in America or Africa, then at about the twelfth year the moment has arrived to lead them on to instruction in geography. What is of importance for such a geography depends on showing, starting from the earth, from the climactic, *how what humanity has already developed in history depends upon everything that the earth produces of suitable formation and structure in its various localities.* After we have presented a concept of the connection of land and seas, of the climate in ancient Greece, we can trace back to what we have already developed about the character of the Greeks purely as symptom of the inner evolution of humanity. *An inner connection can then be found between the geographical image we gave of the earth, and the historical development.* Really, the indications we give about the regions of the earth and the indications about historical development should play into one another."

This certainly can happen at various depths – it will not always be possible and often not even necessary to push forward into the underlying connections. We can remain completely in the apparent foreground images and base our work on the expressiveness of these images. For example, when treating the extreme climactic contrasts in North America, we could present it in such a way that the agressive hardness of this continent comes to an experience, its nature and its landscape, which has nothing soft, inviting, comfortable, but rather offers resistance – a nature which fosters a "pioneer spirit" and to an extent prepares the field in which characteristics such as courage, tenacity, endurance, cold-bloodedness, but also recklessness and thoughtlessness are developed. Characteristics which, in contrast, could not possibly exist in a gentle climate such as in Italy.

The questions which are presented by the prevailing north-south orientation of the geographic structure of this western continent lie at another level; in a realm, as we have seen, discolosed by the physical formation of the earth organism, but is not the course of cultural and spiritual development. With this fundamental point in the background, perhaps certain tendencies of the modern culture which comes out of America can be clearly grasped or be more clearly presented.

Certainly, such results of mutual discovery of teacher with student as introduced in this essay, are rare events and are festive times, not suitable for just any day. And, yet, they might be more possible to achieve in geography than in many other subjects. The image-language of the form of the earth organism has remained unread for many years; its forms and processes still provide infinitely much to discover, and understand completely anew for a future morphology and physiology of the earth.

* * * * *

Rudolf Steiner's Counter Space, a Thought Form that Still Needs to be Made More Concrete

excerpted by Stephen Edelglass from Chapter XI,
FORMING CONCEPTS IN PHYSICS
by Georg Unger

Georg Unger attended the first Waldorf school in Stuttgart, Germany where he was taught mathematics and physics by Hermann von Baravalle. Later, he studied physics and acquired a thoroughly practical knowledge of geometry, acquired in part while teaching draftsmanship to technical students. He was the leader of the mathematical-astronomical section of the Goetheanum when Louis Locher and George Adams began relating concepts of projective geometry to certain intuitions of Rudolf Steiner.

In 1965 he wrote the third of three volumes on physics: ***Forming Concepts in Physics****. This third volume was independent of the previous two. It surveyed twentieth century physics from an unusually inward perspective.*

The Science and Mathematics Association for Research and Teaching situated in Spring Valley, New York has prepared an English translation of Unger's book ***Forming Concepts in Physics****. The text has been revised by the author. The passage that follows has been abbreviated. It introduces a section - not reprinted here - in which Unger surveys the experimental evidence for dualforces.*

The Duality Principle

Intuitive space in the field of sense perception was taken as a valid and undoubted basis for all scientific treatment of the sense world from the beginning of scientific geometry right into the 19th century. Euclid's geometry was able to gain, in a few decisive axioms, so much from observation that all relations between purely geometrical phenomena could be connected to the fundamental geometrical elements in a strictly logical system. If we disregard the logical structure of geometry and draw conclusions from its development, it is the Euclidean motions as measure preserving transformations which constitute the essence of measure. Likewise, nonEuclidean spaces rest on other more general transformations which share with the Euclidean the traits of elementary measure.

Projective geometry which does not use measurement can introduce a new definition of measure more mobile or flexible within itself. However, it is almost always presented in such a manner that a certain trait is still taken unchanged from a naive intuitive vision. This is the special role of the point as spatial element. It is true, geometry of the 19th century knows the transition to other spatial elements, e.g., to spheres. Here, however, the emphasis was not on an expansion of vision but on the group structure of the relations and on the possibility of attaining many new theorems of geometry merely by transferring elementary facts of point-geometry on to geometry of spheres. Eventually, therefore, one returned to the space of intuitive vision having used new "geometry" as a formal aid, more than taking it seriously as an independent geometrical world.

The same holds true to this day for the duality- principle. This gives the simplest transition to other spatial elements. The *planes* of projective space possess such relations among themselves, having *straight lines* (as pencils of planes) and the *points* (as bundles of planes and rays), so that they correspond exactly to the known relations of incidence of points. This correspondence extends to the degree to which every proposition of ordinary geometry, which only contains statements of incidence, gives rise to an equally accurate proposition if one appropriately substitutes the terms *point, line* and *plane,* with *plane, line* and *point.*

The *principle* consists of the fact that the basic structure of relations contains a symmetry which enters naturally into all derived concepts and all proofs, so that the truth of this principle of transformation needs no further proof. . . .

A geometry resting on the duality principle in which the plane as element of space was taken intuitively as fundamental has not been worked out. The abstract possibility of the translation was given as we know. After all, during the 19th century, textbooks on projective geometry once in a while were written in such a way that in two columns not only the axioms, but all considerations and proofs as of course also the basic assumptions, were dually formulated and constructed to one another.

Counter-Space

Rudolf Steiner's indications towards such a working out as was just mentioned to be possible, rest on his *immediate* imaginative insight. This distinguishes the course taken here from the hypotheses that one meets elsewhere. That is not supposed to mean that one should on account of its origin use such suggestions in any different way than as a new possibility of thinking which is to be researched within the framework of physics with regard to its fertility. We are mentioning the imaginative origin of the idea of counter-space for another reason. One can gather from Steiner's description that it did not merely *occur to* him, and that this is not a case of an expert in projective geometry "having this idea" to apply it dualistically to the usual geometry. Steiner was merely pointing to projective geometry in general, because a thinking that seeks training can become more mobile and formative being less bound by sense-perceptible forms. He gave a concrete description of that space, which in contradistinction to the physical world is not a space of centralized forces which are active between points (e.g., mass-points or charged particles) but a space whose *origin* of coordinates lies at a periphery in the infinite distance, a space of *universal forces* and not of central forces. Specifically on account of his direct imaginative manner of description it could not be expected that his audience would immediately make the connection to the duality principle of projective geometry. Only later on Adams and Locher independently from each other carried out the *geometrical* concretization. . . .

To begin with we are only concerned with mastering a more mobile and encompassing geometry using it as a tool just as we learned to handle analytical geometry as part of our university entrance exams. . . . I may add that the incorporation of these objects which are thought of counter-spatially into our visual space leads to the most various "appearances." A "negative sphere" does *not* need to appear as a sphere in Euclidean space. . . . It is a pity that these purely geometric discussions have not been taken up into the teaching of mathematics at all, and not even into university courses to any great degree. . . .

Possible Physical Applications

It has been known for a long time that the double nature of the basic equations of electromagnetism by Maxwell shows a kind of duality. . . .

We can only raise questions: Is not the particle a concept of point-space? Should not a plane car-

rying negative space characteristics correspond to it, just as much as the particle symbolizes positive-spatial characteristics in location and speed?

If one has freed oneself from attaching physical quantities to models in a naive realistic manner, and if one instead takes the particles only as an adequate expression of possible observations, then the assumption that spatial-counter- spatial models do much more justice to the behavior of so-called particles than do the previous point-wise models gains some weight. One may think, for example, of the quantum jump which is an unrealizable idea. Namely, a wave which, in theory, fills the whole of space would have to assume totally different characteristics the moment the particle it describes makes a quantum jump. This total transformation must occur all at once and throughout space.

We see that this idea is being stripped of its physical contradiction, in popular conception, by virtue of being thought of as a probability wave, i.e., as something that has no claim to any physical existence. If need be one grants such non- physical behavior to a thought-construction.

How would it be, if one used point-like and plane- like models next to one another, whose spaces interpenetrate, of course, but may only then be considered in interrelation when those physical events take place which contradict the customary (classical) mode of viewing . . . ?

Non-relativistic Simultaneities

This final example has a relationship to the non- conceivability of absolute simultaneity of distant events, which has almost become a dogma. Distant events, taking place in point-space, can be extraordinarily near to each other in counterspace, so that here the prohibition against signal transmission at speeds greater than that of light becomes meaningless. One only has to get accustomed to the idea that an elementary plane, which would be the polar counterpoint to a mass or charge point, possesses physical presence in relation to all its points, in the same way as we grant it without question to all planes of a point under isotropic conditions. Naturally, also "anisotropic" planes are conceivable for those theories under development, just as, depending on the circumstances, one has to conceive of a dipole not as being a simple point, but as going in the direction of an anisotropic configuration.

Also the transmission of information, taking place instantaneously, which has to be postulated if one wants to somehow imaginatively picture the Pauli-principle, suggests the availability of two interpenetrating spaces polar to one another. Whatever appears quite separate in a space can belong to one and the same configuration elsewhere. The following remark does not want to advocate the introduction of new universal constants. It is merely intended to help connect with the customary concepts of today. A aufficiently small universal constant, which couples space and counter-space, would, when set equal to zero - in analogy to Bohr's principle of correspondence - yield the usual formulas. But, if different from zero, it would give a mathematically conceivable form to the otherwise inexplicable derivations.

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

Chapter XI -
Physical World-View and Spiritual Science

"The elaboration of the preceeding chapter are not intended to pre-suppose Anthroposophy in any way in the sense that it could be a support or a basis for the deliberations undertaken here. For the Author it serves as a background for his world view just as any scientist is served by his convictions. As stated earlier in the introduction, the method of presentation shall speak for itself. In the considerations directly following, I will proceed differently. I will use a picture of nature and imaginations of "fundamentally knowable" spiritual realities as they were given by Anthroposophy in generally available description in the early years of the 20th century. In spite of that I am not addressing "believers," but turn to people who in view of the non-perceptible nature of modern physics harbor the question: Do not the facts of the so-called micro-world reveal conditions which could be described differently than contemporary physics dares in its voluntary self-limitation? ..."

[1] George Adams, *Physical and Ethereal Spaces*, Rudolf Steiner Press, London, 1965.

[20] Louis Locher-Ernst, "*Einführung in die freie Geometrie ebener Kurven,*" Birkhaüser, Basel, 1952.

* * * * *

The Cow

by

Ernst-Michael Kranich
translated by Arthur Auer

INTRODUCTION

Contemplate a herd of cows, as they slowly move and graze on a meadow and then lie "sunken into themselves" chewing their cud, and you will be impressed by a great restfulness.) These animals direct very little of their activity toward their surroundings. Their essential processes appear to occur mainly in the interior of their organism. Certain animals are only really understood by studying how they are active in their environment. But examining cattle in this limited manner yields only superficial information about their rank in the herd, their social contact and conflicts. Such an external study of the cow is less valuable than in the case, let us say, of the wolf, bear, or goat. Each animal demands its own particular approach if we are to discover its uniqueness.

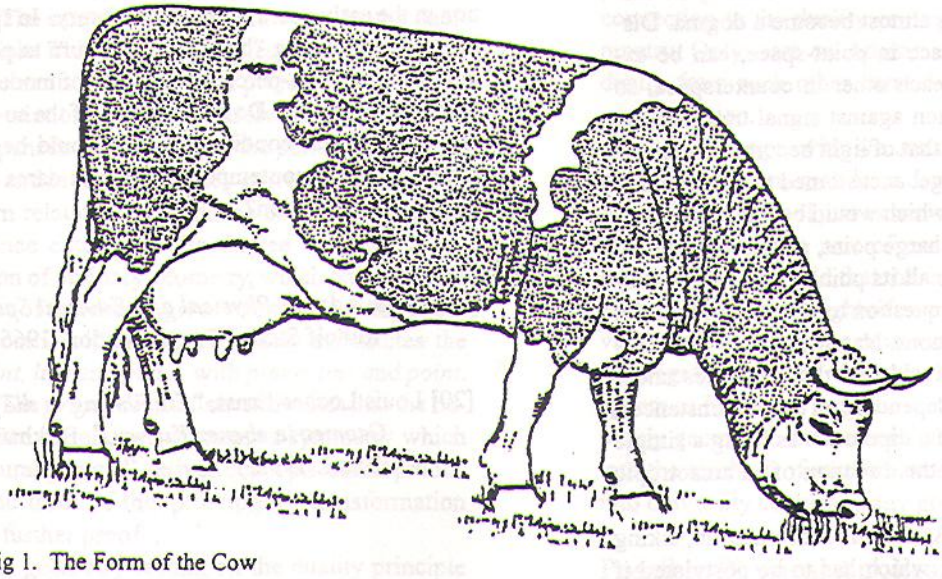


Fig 1. The Form of the Cow

FORM

Observing a horse next to a cow reveals how the cow's form is concentrated in a massive trunk. The head is much less separated from the rest of the body than it is in the case of the horse. When the cow lifts its head, its short neck continues the very striking horizontal line of the back. There is no real gesture towards the widths of space. The legs are short and act sturdily to support the bulky body. Quick graceful movements are not possible when the mass of such a main body/ torso weighs down so heavily on the limbs. The burden of this weight reflects itself in the entire skeleton, particularly in the strongly angled joints of the legs in the heavy rib cage, and the neck.

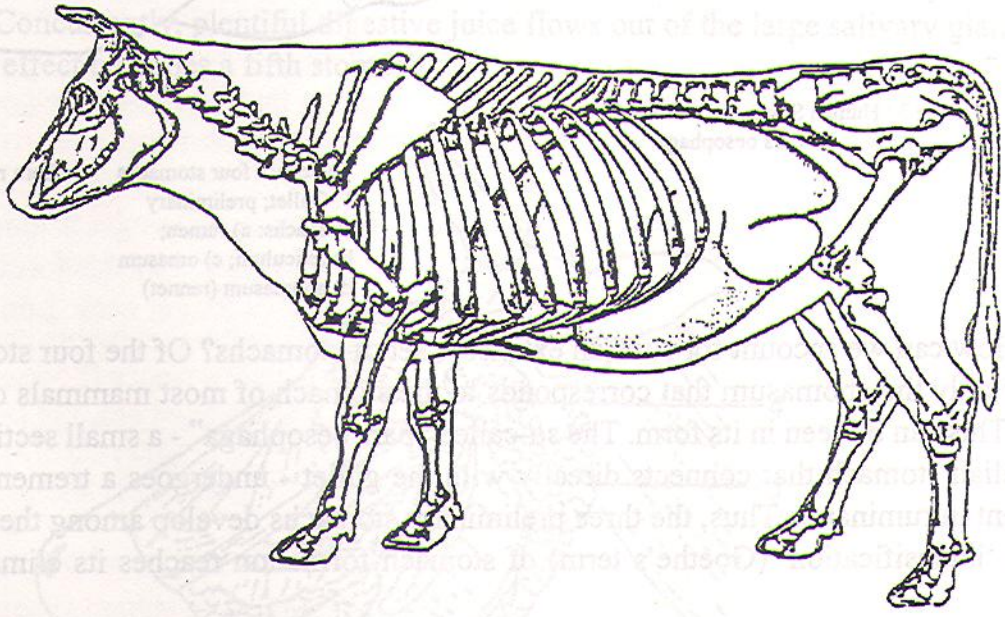


Fig 2. Diagram of the Cow's Interior, with skeleton and rumen. The body weight becomes impressively evident in the skeleton. The rumen on the left side of the abdominal cavity stretches from the diaphragm almost to the end of the cow. At the eighth rib, a part of the rennet bag can be observed underneath. (Credits: Tank, *Tieranatomie für Kunstler*, Ravensburg, 1984. and Berg, *Angewandte und topographische Anatomie der Haustiere*, Stuttgart, 1974.)

What makes the torso so voluminous are the digestive organs. Every child learns in school that cattle do not just have one stomach, but four. The largest of these, the rumen, fills the left side of the abdominal cavity completely. It stretches from the diaphragm all the way to the back; it has a volume of about 150 Liters (40 gallons).

The other stomachs (the reticulum, omasum, and abomasum) are smaller. The total volume of all stomach, large and small is approximately 200 liters (53 gallons)! In no other animal does the stomach play such a predominant role in the total organism as it does in the cow.

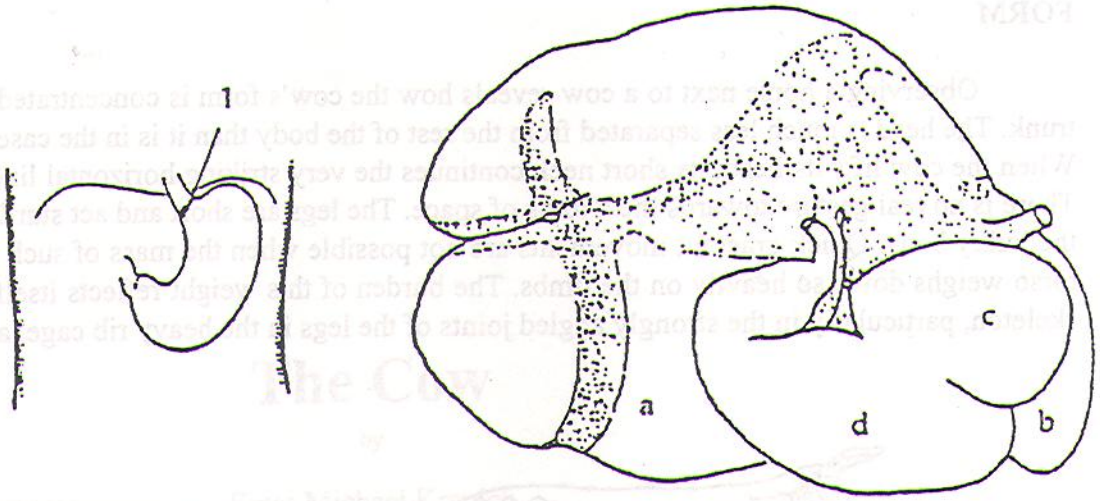


Fig 3. Human Stomach
1. Pars oesophaga

The cow's four stomachs (from right side)
1. Gullet; preliminary stomachs: a) rumen; b) reticulum; c) omasum d) abomasum (rennet)

How can we account for such an extensive set of stomachs? Of the four stomachs it is really only the abomasum that corresponds to the stomach of most mammals or human beings. This can be seen in its form. The so-called "pars oesophaga" - a small section of the mammalian stomach that connects directly with the gullet - undergoes a tremendous enlargement in ruminants. Thus, the three preliminary stomachs develop among the animals, and the 'intensification' (Goethe's term) of stomach formation reaches its climax in the cow.

DIGESTION DOMINATES

This is the key perspective from which to observe the cow. How does this 'enhancement' or swelling of the digestive organs imprint itself on the organism and behavior? Everyone knows that pangs of hunger arise in an empty stomach and how they can be stilled with adequate food. Such feelings play a dominant role in the life of the cow. They express themselves in its powerful compulsion to consume grass, hay and other plants and in the devotion with which it connects itself to its nourishment by grazing. The cow's skin over the mouth at the front of the head is soft and moist. Rich in glands, the mucous membrane, which lines the oral cavity, continues outside onto the wet upper lip. This mucous tissue is unprotected and directly exposed to the environment. The cow does not pull the grass out with its lips, nor bite it off with its teeth. Rather, it embraces grass with its moist tongue and feels its quality by means of an uncommonly fine sense of taste. With a gesture of sympathy the cow draws grass and plants into its mouth and swallows several such portions together into the rumen.

Early each morning for two to three hours, the cow ingests the grasses and plants of

the meadow. In the mighty cavity of the rumen, the digestive process commences with slow contractions. A large profusion of tiny, unicellular organisms takes part in this process. Powerful digestive functions are required to break down the dense substance of talks and leaves. When the rumen is about half full, the second stage of digestion, chewing the cud, begins after a pause of one-half to one full hour. Most cattle lie down; the heavy bulls move more frequently than the cows. The bulls are even more strongly preoccupied with the interior of their organisms. Out of the rumen, little portions of partially digested plant matter are returned up through the gullet back into the wide space of the mouth cavity. Here through a rhythmical process of crushing in the 'grinding mill' of the molars the cud balls are further disintegrated. This activity occurs with great regularity. A cow chews every portion for more than an hour, one after another, and each with 49, 50, or 51 poundings of the jaw! Concurrently, plentiful digestive juice flows out of the large salivary glands. The mouth in effect becomes a fifth stomach.

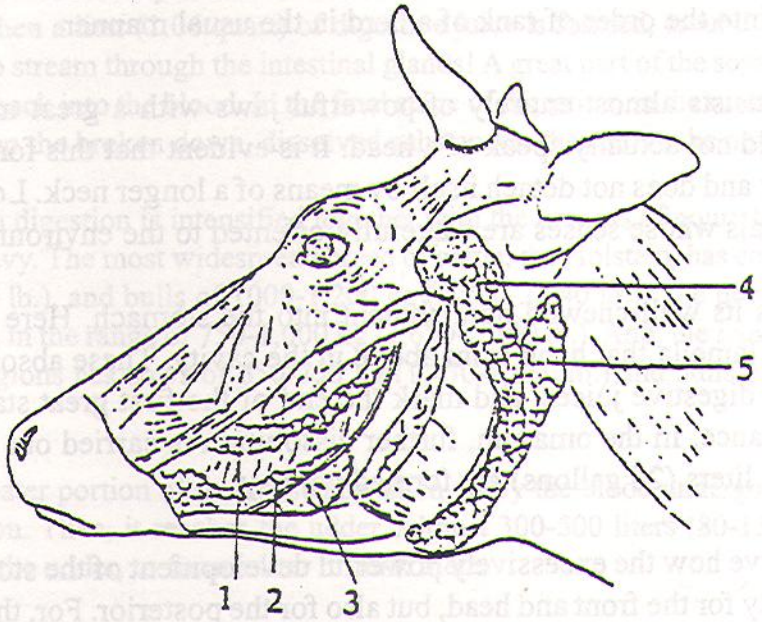


Figure 4, The salivary glands in the Cow's head: 1) upper cheek; 2) middle cheek; 3) lower cheek; 4) lower jaw; 5) ear

The intensity with which the process of digestion continues in the head is indicated by several remarkable statistics. Cows graze 8 to 10 hours a day on the meadow; the time of drowsily chewing cud is almost as long. During this time, the digestive processes proceed further in the stomachs and intestines. The cow is now preoccupied from end to end with the transformation of ingested substances. When it ingests fresh green fodder, the salivary glands of the head discharge 110 liters (29 gallons) of saliva per day; dry hay requires 180 liters (48 gallons). The salivary glands are many times larger than the brain. And the blood flow through the head serves the saliva formation far more than it does the life processes in the brain. The cow certainly receives impressions through its eyes and ears. The more significant sensory processes, however, are taste and smell. In its head the cow is at least as strongly oriented toward inner processes as its is toward outer ones. The instinctive feeling for the

wholesomeness or harmfulness of different plants as well as pleasure and disgust in tasting and smelling are very significant factors in the life of the cow.

These one-sided characteristics express themselves right into the bony formation of the skull. As a process of dissolving, digestion is opposite to the process of building up form. Thus, it is no surprise to find that tooth formation in the cow is weakened. No canine teeth develop; above all, no incisors in the upper jaw. Like other ruminants, the cow lacks a physical tooth barrier against the outside world, otherwise formed together by the lower and upper incisors. The frontal skull bone stretches far to the back of the skull. The parietal and occipital bones do not appear externally around the place where these parts of the skull would begin, horn form as skin dies. A dead casing made of horn develops around the horn sockets of the frontal bone as well as a network rich in blood circulation. Here inner functions are very strongly divorced from the surrounding so every connection to the outside is suppressed. The significance of horns is demonstrated by the fact that de-horned cattle do not integrate themselves into the order of rank of a herd in the usual manner.

Thus, the head consists almost entirely of powerful jaws with a great mouth and nose. In reality, one should not actually speak of a head. It is evident that this formation is closely united to the trunk and does not detach itself by means of a longer neck. Long necks are characteristic of animals whose senses are wakefully-oriented to the environment.

The cow swallows its well-chewed nourishment into the stomach. Here it arrives between a multiplicity of lamella that hang from above in the cavity. These absorb a great part of the liquid and the digestive juices, and mark the end of the first great stage in the breakdown of plant substance. In the omasum, further dissolution is carried out with new digestive juices; here 100 liters (26 gallons) are formed per day.

Now, we can observe how the excessively powerful development of the stomach is a determining factor not only for the front and head, but also for the posterior. For, the abomasum is followed up by an intestine that is more than 50 meters (162 feet) long in most cases. It is here that the last phase of digestion plays itself out as well as the absorption of the dissolved substances into the blood and lymph. Left over substance is excreted. The large intestine has the form of a flat spiral as is the case with other ruminants. The cow's large intestine has 1.5 to 2 centripetal coils as opposed to 3-4 for sheep and goats, and is thus comparatively weakly formed. As a result, water is not strongly absorbed; the process of dissolution in digestion are not strongly checked. Feces flows readily out of the animal. The cow does not have a clear barrier in its posterior organization. It is more elemental bound up with its surroundings and the burgeoning life of nature than other animals. As a creature of digestion, it lives right in the middle of its food. It eats and excretes simultaneously.

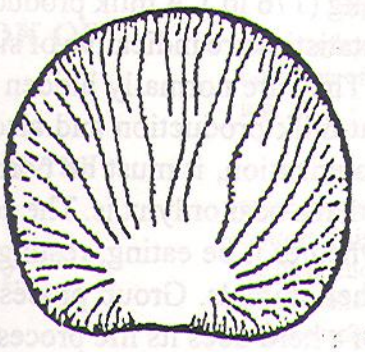


Figure 5, Cross section of the Omas ... logy of Domestic Animals, Stuttgart, 1974)

THE BLOOD IN SERVICE OF DIGESTION AND MILK-FORMATION

Considering what has been described thus far, it becomes clear that the formation of the stomach gives its stamp to the entire organism of the cow. This reality expresses itself in many other facts of which only a few can be mentioned. It is well-known how the blood serves the digestion. When a liter (1.06 quart) of digestive juice is formed, around 300 liters (79 gallons) of blood have to stream through the intestinal glands! A great part of the separated fluid will then also be absorbed back into the blood. In the final stage of digestion, in the rumen and small intestine the blood takes up the broken down, dissolved substances; they serve the nourishment of the body.

When digestion is intensified together with the process of nourishment, the body becomes large and heavy. The most widespread breed of cattle, the Holstein, has cows weighing 600-700 kg (1,320-1,540 lb.), and bulls of 1000-1,200 kg (2,200-2,640 lb.). The powerful Herefords (brown-white) weigh in the range of 750-1,000 kg (1,650-2,200 lb.). And, the *brown* Jersey cow (brown) of the alpine regions has cows of 650-750 kg (1,430-1,650 lb.) and bulls of 1,000-1,200 kg (2,200-2,650 lb.).

A greater portion of the substance taken up by the blood undergoes a profound process of transformation. Then, it reaches the udder. Almost 300-500 liters (80-130 gal.) of blood have to flow though the udder, to form a liter of milk there.

For a cow to give milk, it has to give birth to a calf every year. After a pregnancy of nine months, the calf is born. Several hours before the birth, the cow separates itself off from the herd and seeks out a protected place. The mother nurses the calf for several months. At first, the newborn calf's rumen is very small - less than half the size of the abomasum. But, already in this period of suckling, the calf starts to consume rough fodder. As a result, the preliminary stomach enlarges. Calves only three months already have a rumen twice as large as the abomasum.

Through the art of breeding, humanity has increased milk production far above its original levels. A cow today is able to produce over 20 liters (5 gal.) of milk per day. Bearable limits have certainly been exceeded in the case of a high performance milk cow. A cow should not be degraded to the level of a physiological milk production machine.

Milk creation and feeding are closely intertwined with each other. Milking a cow induces in it the need to drink and eat. A cow's day is organized by a changing rhythm of eating and cud chewing. Normally, four such periods follow each other from early morning into the evening and late night. On a typical day, cattle consume large amounts of fresh fodder; small breeds around 50

kg (110 lb.), larger ones about 80 kg (176 lb.). A milk producing cow drinks up to 100 liters (26 gal.) of water per day. These statistics are indicative of significant processes involved in the transformation of substance. They are normally hidden from view, but have a tremendous importance because of what milk production and also meat contribute to humanity. Throughout the preceding characterization, it must be born in mind that the cow is not a single creature in the same sense that a bear or lynx is. The cow lives as a member of a herd. What the single member does, whether it be eating, resting, or chewing its cud, is carried out most often in a herd with other animals. Group processes are involved. Only when a cow lives within the wholeness of a herd does its life processes reach their fullest intensity. An isolated cow eats less, drinks less, and produces less milk.

Much of the nature of the cow can be learned by listening to the sounds it makes. The dull 'mooo' sound is generated by the larynx working in conjunction with the jaws and mouth cavity. What is heard seems to press forth out of the very depths of the body. One can experience the nature of a cow's soul in its dark voluminous warm tone. Numerous investigations have revealed how sensitively the stomach and intestines react with glandular secretions and movement to emotional disturbances and feelings. The cow's soul element is deeply interwoven with its life processes. As these processes proceed largely in an unconscious manner, the soul's emotions are determined by the unconsciousness of the digestive organs and functions. This accounts for many aspects that confront us in a cow's behavior, especially its power laden torpor. When a loud noise sounds on a meadow, birds instantly flock upwards, and horses react immediately. We observe however, how the cow registers only a dreamy, dull response after a period of latency.

There is scarcely another animal that so intensively connects itself with the substances and forces of the earth. This reality gives the entire creature its stamp - in its form, the shape of
its organs, its life-processes, and its behavior. Rudolf Steiner succinctly formulated some key reasons for the cow's uniform behavior:

"The digestive organs as they are in the human being have been developed in a one-sided way by the cow."[1]

"It can be said of the cow that it is all stomach."[2]

Just as in the digestive organs, the cow's soul nature dives down into the life processes, this animal joins itself deeply with the forces of gravitation. Bulls, in particular, give us the impression with their dull energy of will, that they are permeated with these forces and are bound to the earth as hardly any other creature.

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1. Steiner, *The Spiritual Cround of Education,* GA 305, Oxford, 16-25 August, 1922.
2. Steiner, *The Renewal of Education,* GA 301, Basle, 20 April-1 I May, 1920.

SPELL OF CREATION

Within the flower there lies a seed
Within the seed there springs a tree,
Within the tree there spreads a wood.

In the wood there burns a fire,
And in the fire there melts a stone,
Within the stone a ring of iron.

Within the ring there lies an O
Within the O there looks an eye,
In the eye there swims a sea,

And in the sea reflected sky,
And in the sky there shines the sun.
Within the sun a bird of gold.

Within the bird there beats a heart
And from the heart there flows a song,
And in the song there sings a word.

In the word there speaks a world,
A word of joy, a world of grief
From joy and grief there springs my love.

Oh love, my love, there spring a world,
And in the world there shines a sun
And in the sun there burns a fire

Within the fire consumes my heart
And in my heart there beats a bud
And in the bud there wakes an eye,

Within the eye, earth, sea and sky
Earth, sky and sea within an O
Lie like the seed within the flower.

– Kathleen Raine

EXPERIMENT

Colored-Flame Flash Paper

Sometimes, a change of pace is needed to add spice to a lecture. One classical experiment involves showing the rapid combustion of flash paper or gun-cotton. A recent contribution in *Journal of Chemical Education[1]* suggests an interesting method for coloring flash-paper flames. This could be used in grade 9 (carbohydrates or nitrocellulose, an early synthetic plastic) or grade 10 (flame tests for various salts) or grade 11 (atomic spectroscopy, chemistry of nitrogen) chemistry main lessons.

The key point is to have the nitrating acid solution quite cool so the cellulose (paper or cotton) will not clump up. As other authors indicate, a ratio of 1.25:1 nitric:sulfuric acid is used,

a) Prepare 50 pieces of thin, very dry paper (try single-ply toilet paper) by drying them thoroughly in a drying oven

b) Mix approximately 100 ml of nitric and 125 ml of conc. sulfuric acids in a clean dry beaker; this mixture is sufficient for about 100 pieces, and must be freshly prepared; the nitric will not last overnight. **caution** *use adequate ventilation, care, and protective gear in mixing.*

c) Cool the mixture down to at least 40°C; this is important to prevent pulping or clumping; **caution** *do not allow ice or water to get in contact with the concentrated nitrating acid mixture.*

d) Test the mixture with a section of single-ply toilet paper (If the paper scorches or clumps, the acid mixture is still too warm, and should be cooled further). Lay a piece on the surface of the acid mixture; push it under the surface with a glass rod; allow to soak for 15 minutes.

e) Carefully lift the paper out with clean forceps, and immerse it together with others in another beaker of wash water (they will turn biege to brownish). Then, place the wash beaker under running water for at least 3 min. so papers tumble about and acid gets thoroughly washed out.

e) Gently lift each paper out, allowing excess water to drip off, and dab dry on a paper towel. The paper must be completely dry before use. After a few minutes of soaking, you could speed up the drying with a hair dryer. **caution** *do this well away from any other solvents or combustables, and avoid touching the flash paper, to prevent accidental ignition.*

f) Make sure flash papers are *very* dry before using (you may have to warm them after storage to remove the small trace of moisture often adsorbed).

The novel part is to coat the papers with alkalai salts to color the flame. The following salts are mentioned and are relatively non-toxic.

red-orange	$Sr\,SO_4$
blue	CuBr
yellow	NaCl
violet	KCl or KNO_3

In order to avoid having to re-dry the papers, coat them with dry, powdered salts like 'shake-n-bake' chicken, shaking in a plastic bag! You may need to pulverize the salts in a mortar and pestle. This works best with porous toilet paper, rather than the commercial flash-paper, which is quite smooth.

[1] *Quick Method for Making Colored Flame Flash Paper*, S. Solomon, C. Hur, A. Leo, K. Smith, *Jour. Chem. Educ.*, Vol 72, No. 12, December 1995.