Colloquim on Life Science and Environmental Studies

AWSNA
High School Research Project
March 2002

Works in Progress

Research Project #5

Colloquium on Life Science and Environmental Studies

Sponsored
by
the Waldorf High School Research Project

Planning Group: Andy Dill, Douglas Gerwin, Antje Ghaznavi, David Mitchell,
and Betty Staley

May 2002

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Photography: David Mitchell

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Life in its activity is like a plant. The emerging plant contains not only what it offers to external life, it also holds a future state within its hidden depths . . . so, too, the whole of human life contains within it the germs of its own future. If we are to tell anything about this future, we must first penetrate into the hidden nature of the human being . . . a practical conception of the world that comprehends the nature and essence of human life.

— Rudolf Steiner

Overview

Front Row: Craig Holdrege, Kenneth Melia, Jim Henderson, Keith Badger,
Back Row: Ed Edelstein, Hartmut Döbel, Andy Dill, Gary Shemroske (guest), David Mitchell

On a steely grey, cloud-covered, Northeast, March weekend, eight experienced biology teachers met at the Nature Institute in Harlemville, New York, to discuss how metamorphosis appears throughout the high school life science lessons. We also looked at how environmental studies are being presented. Our task was to share ideas, explore conundrums, and dialogue about each others' insights and experiences how the curriculum could be enriched.

Our activities included observations of an elephant skull, a walk and exploration of a wetland bog, miscroscopic study of equisitum spores and a storksbeak excitor, and a phenomenological experience of three areas in a habitat.

Our discussions were both lively and varied. There was a wide range of approaches and this *Proceedings* attempts to make these visible. We ask that you not consider what is presented here as a recipe, but rather view the content as a stimulation for your own thinking. The work is not complete, and the members of the colloquium would appreciate any comments, suggestions, and dialogue that would make our efforts live into the future.

We invited two members from the Hawthorne Valley School as guests to our meeting. Gary Shemroske, Hawthorne Valley's life science teacher, attended the entire colloquium, and Michael Pewtherer, who has been actively involved in initiating a practical environmental program in Harlemville, participated in that portion of the colloquium where we discussed this topic.

You may notice that the colloquium was high in testosterone. This was not intentional but was the result of two women not being able to attend. We also had hoped to have the presence of Dr. Tom Cowan, but he also was not able to attend because of illness.

We are extremely grateful to Craig Holdrege and his colleagues at the Nature Institute for hosting us and also for the gracious support of the Harlemville community. Our gratitude is also extended to our good friend Wolfgang Schad, who allowed us to translate and use three of his writings which are included as addendum to this manuscript.

Please send us your thoughts after you have perused these *Proceedings.*

— David Mitchell

The Nature Center in Harlemville, New York

AWSNA

Agenda

Environmental/ Life Science Colloquium

Harlemville, NY

.

Colloquium participants:

Andy Dill, Kimberton Waldorf School
David Mitchell, Shining Mountain Waldorf School, AWSNA High School Research Project
Kenneth Melia, Summerfield Waldorf School
Jim Henderson, Green Meadow Waldorf School
Keith Badger, High Mowing School
Craig Holdrege, The Nature Institute
Hartmut Döbel, Washington Waldorf School
Ed Edelstein, Toronto Waldorf School
Dr. Tom Cowan, Peterborough, N.H.

Location:

The Nature Institute
169 Route 21C
Ghent, NY 12075 e-mail nature@taconic.net

Colloquium organizers:

Andy Dill	David Mitchell
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610 - 469-6208	

Dates: March 15-18, 2002

Tasks:

Our goal is to review the life science and environmental studies curricula in grades 9-12 and explore the theme of metamorphosis as it appears there.

A spin-off of the colloquium will be the publishing of our *Proceedings* which will be made available to all Waldorf High Schools in North America. Each participant will take on a portion of the writing. Participants are encouraged to send relevant articles, papers, etc., to David Mitchell before the colloquium so that copies can be made available for all participants.

The following individuals will be the scribe and be responsible for polishing the following items:

9th Grade	Andy Dill
10th Grade	Hartmut Döbel
11th Grade	Kenneth Melia
12th Grade	Andy Dill
Environmental Issues	Jim Henderson
Experiential aspects	Keith Badger
Achievement tests and College prep	Ed Edelstein
Collator:	David Mitchell

Finances:

Lodging in private homes and meals will be provided for in Harlemville, unless you choose to make your own sleeping arrangements in a motel. Your transportation will be covered by the AWSNA High School Research Group. Please pass copies of your receipts to David Mitchell.

Schedule:

Friday, March 15

6:00 P.M. Supper
8:00 P.M. Metamorphosis—Introduction to the Theme
Opening lecture by Craig Holdrege

Saturday, March 16

9:00 A.M. Discussion
The 9th grade—how is metamorphosis encountered?
Anatomy/Physiology
10:30 A.M. Coffee Break
11:00 A.M. Discussion
The 10th grade—how is metamorphosis encountered?
Embryology
Earth science

12:30 P.M. Lunch
2:30 P.M. Artistic activity
3:30 P.M. Discussion
The 11th grade—how is metamorphosis encountered?
Cytology
Botany
6.00 P.M. Supper

Sunday, March 17

9:00 A.M. Discussion
The 12th grade—how is metamorphosis encountered?
Zoology
10:30 A.M. Coffee Break
11:00 A.M.
12:30 P.M. Lunch
2:30 P.M. Discussion
Activites fructifying the life sciences
Labs
Trips and outings
The school environment
4:30 P.M.
6.00 P.M. Supper

Monday, March 18

9:00 A.M.
Preparing for achievement tests and college
10:30 A.M. Coffee Break
11:00 A.M. Discussion
How can Waldorf schools become more effective as leaders in environmental education?

12:45 P.M. End

AWSNA
Waldorf High School Research Project

Mission Statement

Formed in August 1998, the Waldorf High School Research Project is charged with strengthening the Waldorf high school movement by creating an updated picture of adolescents today and stimulating curriculum development within the Waldorf high schools.

As a designated committee of the Association of Waldorf Schools of North America (AWSNA), the Planning Group of this project is specifically responsible for

a) identifying and articulating changes in the needs of North American teenagers
b) formulating research questions concerning adolescence; commissioning qualified educators and other professionals to undertake research into these questions
c) sponsoring subject colloquia as well as conferences on adolescent development and needs for those working in Waldorf high schools
d) preparing North American conferences for those working in Waldorf high schools—to share and deepen research; to stimulate dialogue; to activate meaningful change for youth in the twenty-first century
e) developing publications and other media resources to assist those working in Waldorf high schools
f) stimulating Waldorf high school educators to examine and strengthen their programs
g) seeking funds to support the commissioned research, colloquium, publications, conferences, and follow-up initiatives in the Waldorf high schools in coordination with AWSNA Development in line with the overall AWSNA priorities.

—revised April 7, 2002

Metamorphosis and Metamorphic Thinking

by

Craig Holdrege

This essay is a summary of the introductory talk at the Waldorf High School Life Science / Environmental Studies Colloquium on the theme "Metamorphosis."

Metamorphosis is a central theme in Waldorf high school biology teaching. When we speak about metamorphosis, we're not only concerned with a specific content, such as the metamorphosis of a tadpole into a frog or the metamorphosis of leaves in an annual flowering plant. We're concerned more fundamentally with a way of thinking, a whole approach to understanding life. It's an approach that Goethe brought into science and that Steiner elaborated upon and deepened. If we want to understand what makes the Waldorf approach to biology different from the conventional approach taught in public and prep schools, then there's no better theme to focus on than metamorphosis.

External Cause-and-Effect Thinking

Let's begin by looking at what metamorphic thinking is not. It's not, very simply, the way all textbooks and biology courses teach us to think about life. There we learn that to understand life is to explain it by reducing any given phenomenon to some underlying physical and molecular mechanisms. In modern genetics, for example, the metamorphosis of the foliage leaves into sepals or of the sepals into petals—which Goethe discovered over two hundred years ago—is explained by finding genes that influence the development of those different parts. Researchers have discovered genes that will cause a plant to make only sepals and no petals, or vice versa. Once such a causal connection between the underlying gene and the appearing plant part has been found, the part is felt to be explained and one moves on in the search for further causal mechanisms.

When we approach life in this way, then we are applying a type of thinking that is satisfied when an external phenomenon (the petal) can be traced back to some other more fundamental phenomenon (gene). One external entity is felt to explain another. Steiner characterizes this type of thinking in the following way:

> In our ordinary thinking everything is arranged spatially. Consider that even time is expressed by the movements of the clock. The same process, in fact, is also contained in our physical formulae. In short, we must come to the conclusion that ordinary thinking is a combining way of thinking, one that collects scattered elements. We use this way of thinking in our ordinary sound conditions of life, and in ordinary science. (10, p. 10)

It certainly is possible to approach the living world exclusively in terms of spatial concepts that reflect causal relations. The question is whether we experience the explanations of life that stem from this approach as satisfying our longing for understanding. I, for one, became interested in the Goethean approach to biology precisely because I was not satisfied with all the reductive explanations I learned in biology classes and texts.

What is Metamorphic Thinking?

Goethe's seminal essay "The Metamorphosis of Plants" was published in 1790. This work contains Goethe's discovery—for which he is well-known in the history of botany—that leaves, sepals, petals, stamens and carpels are all, in fact, metamorphoses of one and the same plant organ. Goethe writes:

> We will familiarize ourselves with the laws of metamorphosis by which nature produces one part through another, creating a great variety of forms through the modification of a single organ. Researchers have been generally aware for some time that there is a hidden relationship among various external parts of the plant which develop one after the other and, as it were, one out of the other (e.g. leaves, calyx, corolla, and stamens). The process by which one and the same organ appears in a variety of forms has been called the metamorphosis of plants. It can be seen to work step by step from the first seed leaves to the last formation of the fruit. By changing one form into another, it ascends—as on a spiritual ladder—to the pinnacle of nature: propagation through two genders. (2, p. 76)

Goethe saw a unity in the plant as it develops in time. He calls this unity the "same organ," by which he does not mean some underlying material mechanism. Rather, he wants to understand by participating as far as possible, in the plant as a living, transforming process:

> If I look at the created object, inquire into its creation, and follow this process back as far as I can, I will find a series of steps. Since these are not actually seen together before me, I must visualize them in my memory so that they form a certain ideal whole. At first I will tend to think in terms of steps, but nature leaves no gaps, and thus, in the end, I will have to see this progression of uninterrupted activity as a whole. I can do so by dissolving the particular without destroying the impression itself.

> If we imagine the outcome of these attempts, we will see that empirical observation finally ceases, inner beholding of the developing organism begins, and the idea is brought to expression in the end. (2, p. 75)

Goethe was interested in finding the unifying, dynamic idea that unfolds as the observer actively participates in the way in which an organism like the plant develops. He goes beyond normal, spatial cause-and-effect thinking. Steiner describes this way of thinking as "morphological thinking."

> This way of thinking is not limited to space; it lives within the medium of time, in the same way ordinary thinking remains within the medium of space. This thinking does not link up one thought with the other; it sets before the soul a kind of thought-organism. When we have a concept, an idea or a thought, we cannot arbitrarily move from one thought to the next. Similarly, in the human organism we cannot arbitrarily move from one part to the next. Rather, we must proceed from the neck, then to the shoulders, then to the thorax, etc. Just as the organism must be considered as a whole, so must the kind of thinking I call morphological thinking be inwardly mobile. It must be so inwardly mobile—living in the medium of time and not space—that it calls forth one form (Gestalt) out of the other. This thinking differentiates in an organic way; it continually grows. (10, p. 10f.)

It is easiest to apply metamorphic thinking in areas like embryology, where we actually have to do with a developmental process. We can follow the developing human, animal, or plant from stage to stage and witness how form unfolds out of movement. Even mitosis or meiosis at the cellular level can be considered as dynamic processes of transformation. We bring the students' thinking into movement by following the movements of life. Another area is comparative morphology and evolution. When we compare, say, the morphology of the circulatory system or nervous system in different groups of animals we also see a kind of transformation and can begin to discover patterns that give unity to the phenomena. We see, for example, the increasing internalization and inner differentiation of organ systems within the vertebrates when we compare fish, amphibians, reptiles, birds, and mammals.

The Whole and the Part—The Example of the Elephant

When we practice this first stage of metamorphic thinking—carefully following processes and building up dynamic pictures and concepts of them—we can make a further step. This is when we learn to see how the whole is revealed through every part. We can do this by considering individual organisms (4, 5, 6), by studying the relations between systematic groups (7, 8) and even by looking at the organismic quality of whole habitats and biomes (1, 3, 11).

Let me give you an example out of my studies of the elephant. The massive and voluminous elephant stands firmly in the world carried by its long pillar-like legs. The short, high-browed head connects to the torso with a very short neck that is hardly visible behind the large ears. This compact appearance is accentuated by the clear boundary of the nearly hairless, gray and fissured skin. Internally, the elephant's weighty being finds expression in the high density of its limb bones and in the continual production of dentine and enamel in the tusks and molars.

Craig Holdredge exhibiting his elephant skull

The head is not only uniquely shaped for a four-legged mammal, but from it emerge the most characteristic elephantine organs: trunk, tusks, and large ears. These organs reinforce the elephant's enormity. When you view an adult African elephant that has its ears spread out from the front, the animal appears as a massive wall, being broader than it is tall. But trunk, tusks and ears also have a very different character from the rounded, self-contained head and torso. They radiate outward as organs of activity and expression. While the tusks protrude in rigid radiance, the trunk and ears move almost continually. Their large, sweeping motions, which lack any hint of nervous haste, heighten the elephant's grandeur.

While living through trunk and skin at its body's boundary in intensive tactile contact, the elephant also spreads out through its keen senses of smell and hearing to encompass a large environment. The trunk reaches out to caress or slap another elephant and takes in scents wafting through the surroundings. Its trumpeting calls and infrasound rumbles bring the elephant into a truly expansive world.

Metamorphosis becomes visible in bony form

Craig Holdredge discussin contraction and expansion

The trunk unites power and agility in singular fashion. As biologist Silvia Sikes writes, "The rapid alternation between movements of fastidious delicacy with which tiny berries and buds are selected and eaten, and movements requiring tremendous brawn that send gigantic trees crashing to the earth, is always astounding"(9, p. 78). This unity of largeness and delicateness, of enormity and sensitivity, we find in modified ways in nearly all elephant characteristics. With its finely modulating feet, a soft-treading elephant has little trouble moving silently through a forest, but it can, in another moment, crash through the same forest, bowling over trees or crushing a lion under its foot. The thick, leathery skin that appears so tough is also extremely sensitive, warranting continual care. The elephant's large, moving ears are ideal for taking in and locating tones coming from afar, but the elephant can also hear the quietest tones and distinguish between subtle modulations. The elephant's unified being speaks through contrasts.

There is no more physically flexible organ in the animal kingdom than the elephant's trunk. While the trunk is clearly the elephant's focal instrument for living out its flexible nature, this paramount elephantine feature in fact expresses itself in the whole animal—physically, physiologically, and behaviorally. The elephant doesn't have to eat food of one type it can shift from one food source to another. When given the opportunity it goes for variety. The elephant can live in different types of habitats—from the climatically uniform and food-rich rain forest to the extremes and dearth of the desert. But most elephants live in the more

The jaw bone of an elephant

rhythmically changing savanna and monsoon climates, where they move with the changing seasons and the changing sources of food they bring.

An elephant goes through life-long changes in its long life. Its primary growth phase lasts around two decades, but it continues to grow slowly until death. The tusks grow life-long. Like no other mammal, the elephant's change of teeth in the molars never stops. This is an ongoing development of the new and discarding of the old—continual physiological renewal. At the behavioral level we find this characteristic mirrored in the elephant's pronounced and life-long learning ability. At any moment the elephant can adjust to new situations with its own unique form of elephantine intelligence. In the elephant, the ability to change never ceases.

The elephant's overall openness and adaptability in behavior throughout the course of its long life express themselves at any given moment in the activity of the trunk. The trunk, like the human hand, makes visible what open, explorative learning behavior is all about. The part reveals the whole, and the whole is manifest in every part.

Conclusion

To work with students on metamorphic thinking is a real joy and gift. We're all on a path together. As teachers we can take the lead, but if we bring the phenomena to the students in as concrete a way as possible, then they begin to see connections we haven't seen. I still remember how a student raised his hand and said, "Mr. Holdrege, the elephant's skin is just like its legs." He saw how the tough and thick skin of the elephant nonetheless reveals a great sensitivity and mobility, just as the massive legs are, in the feet, able to modulate finely so that the giant animal can tread silently through a forest. He helped us to see the elephant.

When we start practicing this kind of approach, we lead students into an understanding of how an organism is truly an integrated being. It is not merely an assembly of different parts that happen to work. We can fully overcome—for a few moments at least—the building block, spatial mode of cognition that dominates our thinking and colors all of our understanding. In this way we're working with the students on building up a capacity to understand the dynamic and interconnected nature of life that humanity direly needs in times that are so dominated by fragmentation. This is why working towards metametamorphic thinking in high school biology classes is so important.

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Ed Edelstein listens intently as Craig Holdredge speaks

Ed Edelstein parcipating in a phenomenological field exercise. (It is impossible to keep a group of biologists inside for more than four hours!)

Conference participants engaged in curricula discussion.

The Ninth Grade

by

Andy Dill

As we look at the environmental/life science curriculum in the Waldorf high school with the theme of metamorphosis in mind, two primary aspects emerge. The one is a consideration of what content is appropriate for students at the different developmental stages and why. The other is an exploration of how to approach the material in ways most effective for the adolescent at the different grade levels. Within these two broad areas, we find numerous examples of the various principles of metamorphosis and metamorphic thinking introduced in our opening session.

Approaching the Ninth Grader

The following group of principles represents a consensus of the participants:

• The ninth grader is an active learner, coming into the thinking primarily through the will. Activities, labs, direct experiences should, therefore, be at the heart of our approach to ninth grade life sciences.

• Strong feelings of separation and alienation are part of the ninth graders' experience of the world. Our teaching must help them awaken their senses and develop capacities for careful observation of nature.

• At a time when many students, especially boys, can become quiet and withdrawn, it is important to help them develop the skills to effectively articulate their observations. These include presentations in a variety of media: verbal (oral and written), artistic (drawing and sculpting), and kinetic.

• Although the will of the ninth grader is typically strong, it is also characteristically undisciplined. While the activities of the ninth grade are often fun, they must also help the students begin to discipline their will. An additional help in this regard is instruction and practice in reading and understanding scientific writing.

• We can use the theme of polarity, so strong in the ninth grader, to begin to heal the breach between the human being and nature. One approach to this is through a discussion of life, sentience, and self-consciousness and how they apply to us and the world.

The following principles, though not applied by all, are used by some of the participants in their teaching of ninth grade:

• The inclusion of the animal kingdom in comparative anatomy (and, to some degree, physiology) in the ninth grade human physiology block can have a number of beneficial effects. It helps bring the students into an experience of the relationship of the human being with the world. It encourages the beginnings of metamorphic thinking (i.e. learning to see the whole in the part and the part in the whole; reading the function in the form; allowing the material world to become transparent through our thinking). And it brings additional breadth and depth into the study of systems to which the students have been introduced in the middle school.

• The use of microscopes beginning in the ninth grade gives the students access to "direct" observations when they are available rather than only working from the teacher's drawings of something he has observed.

• Numerous aspects of human physiology can be brought into practical application as basic first aid. Ninth graders respond well to such an approach.

Suggested Topics for the Ninth Grade

In reference to the ninth grade biology curriculum, Stockmeyer quotes Steiner, saying simply:

> "Continue what you started in human biology in the eighth grade adding on as if in concentric circles."

Although this doesn't give us much to go on, it does point to the mirroring which is present in the curriculum between the high school and lower school. Clearly, the ninth and tenth grade "human biology" is to reflect the curriculum of the life sciences in the seventh and eighth grades at a new level, in an age appropriate way. (This obviously calls for conscious collaboration between the high school science teachers and the class teachers.) The following are examples of topics that have been developed for the ninth grade by the participants.

The Skeletal System — perhaps the most material / mineral part of the body and at the same time most easily observable in its outer form. This framework can be experienced by the ninth grader as an inner foundation for him / herself as a human being. It also stands as a symbol of death at a time when the students are waking up to their own mortality. A thorough exploration of the shapes, relationships, development, and function of the bones and the skeletal system is undertaken. The following are examples of activities and approaches:

- Observe, draw, and sculpt representative human bones.

- Observe and compare animal (especially mammalian) bones and skeleton.

- Begin to see in the structure and relationships of the bones in the skeletal system the movement possibilities, gesture, and posture of different vertebrates (example: lion and horse). This leads to an appreciation of human uprightness.

- Observe and draw X-rays of developing bones (i.e. 11-year-old and adolescent hands). Discuss the formation of bones and ossification in relation to activity, will, and gravity.

- Assemble vertebral columns of human being and representative mammals. An organic jigsaw puzzle.

- Explore the three-foldness of the skeletal system, sub-systems, and individual bones.

- Observe the internal structure of the long bones in a longitudinal section (cut on a band saw).

- Consider examples of pathology (rickets, osteoporosis, scoliosis) in the context of normal development.

The Muscular System – can logically be taken in relationship to the skeleton and is readily available to the immediate experience of the students.

The Skin – forms our physical boundary with the outer world. It is easily observed. The skin is also a part of the body that is of great concern to young people of this age. It has a role in many aspects of our body: protection, sensation, excretion, regulation. Examples:

- Observe and draw the form, gesture, texture of different sections of the skin.

- Investigate the sense of touch—discrimination, localization, etc.

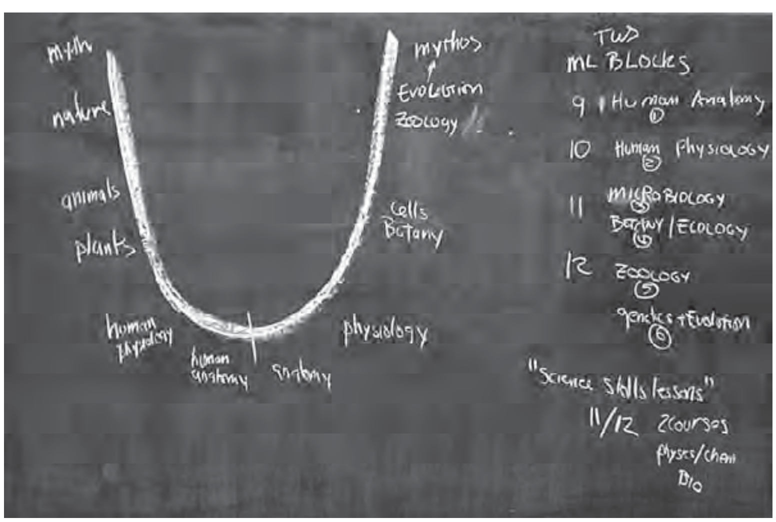
- Explore fingerprints, observe and compare patterns, individuality, inheritance, forensic applications.

The Senses – are a primary means by which we learn about the outside world. This area lends itself to numerous activities that help heighten the ninth graders' experience of how we perceive through our senses. Direct observation of the sense organs themselves is not so easily achieved, however. Examples:

- Blindfold (sensory deprivation), afterimage, optical illusion, blind spot, and many other sensory exercises.
- Compare the experience of peripheral ("scatter") vision with pin-point, focused vision and the movement between the two.
- Awakening sensory capacities through such activities as bare-foot "fox walking."

The Circulatory and Respiratory Systems – are sometimes included in the ninth grade curriculum. When a separate physiology block is available in the tenth grade, most leave these inner systems until then. When taught in the ninth grade, an emphasis can be placed on observation and activities. Examples:

- Investigate heartbeat, pulse, blood pressure in relation to exercise, health, disease, and also in comparison with animals (i.e. how to take a horse's blood pressure).
- Observe human (and animal) blood and blood cells (macroscopic and microscopic).
- Experiment with human lung volumes and breathing rates.
- Observe blood circulation and heart formation in fish and/or snail embryos.



The life science curve through the school years

The Tenth Grade

by

Hartmut Döbel

In the freshman year the student has focused on studying the more concrete aspects of the human body, mainly answering questions that begin with "what?." However, towards the end of the ninth grade year, a tension is building up in the student, leading to a stronger sense of inquiry. It is this growing urge wanting to know more and to understand oneself better, which opens the door to a more complex world, asking increasingly more difficult questions.

As one can easily imagine, the student would become thoroughly restless if he had to continue at the ninth grade level of concreteness and immediacy. He longs to understand the functions and the complexity of the human body. He wants to know how his own bodily systems function, or how diseases can interfere with his normal life.

However, there is another interesting aspect to the tenth grade year that must be noted. Entering the last stage of his hormonal transformation, the sophomore starts to put himself on top of the world, thinking he already knows everything. If given the opportunity, or he will always have an answer to any and all imaginable problems. He knows it better, pretends to be "more wise," and loves to put up a good challenge – always. Now, as we all know, the sophomore is certainly only right sometimes, deceiving himself most of the other times. In consequence, these acts of sophistry are enticing invitations to name him on occasion a "wise fool," the meaning of the word "sophomore."

Having stated the obvious, frightening, and humorous aspects of the sophomore year, it is paramount that two important aspects of Waldorf pedagogy perfectly mesh to meet the needs of the sophomore: a grade appropriate and balanced curriculum, as well as a teacher who is filled with humor, understands his own limitations, and is willing to admit that he does not know everything. After all, the tenth grader knows it best by definition. As these two pedagogical aspects are not subject of this report, the author asks the interested reader to consult other sources.

Suggested Topics for the Tenth Grade

The main focus in the life science is human physiology and can include embryology, although some schools prefer to offer the latter subject in the junior year. A common approach is to introduce the subject matter by an in-depth study of the integumentary system which in turn represents, in one aspect or another, the other nine bodily systems of the three-fold human being:

- Skeleton
- Endocrine System
- Nervous System

- Muscular System
- Respiratory System
- Circulatory System

- Reproductive System
- Lymphatic System
- Digestive System

While not all of these systems can be studied in great detail, the curricula of most schools focus on the endocrine and reproductive systems. However, some of the participants preferred or added the comprehensive study of other bodily systems, e.g. the circulatory system, or the lymphatic system.

Example questions and topics for the study of the endocrine and reproductive systems:

- What are hormones, how do they work?
  - Compare with nervous system.
- Endocrine vs. exocrine glands
  - What are the reciprocal and dynamical relationships between hormones and their target tissues/organs? Remark: try to avoid the mechanistic downfalls of a “cause-and-effect” approach.
- How do we maintain shape and form?
  - What is homeostasis? How is it maintained?
  - How do we maintain a balance in our bodies?
- How do we grow?
  - How do bones grow?
- How do we deal with stress?
  - The adrenal glands
  - Fight-and-flight mechanism
- Emotions and sensations
- Sleep and dreams
  - How many dreams are there?

    - What happens when you sleep?
    - Melatonin shift and the ever soporific sophomore
    - Rhythmic cycles
- Study of the ovarian and menstrual cycles

Sample Questions and Topics for the Study of Embryology

The study of the ovarian and menstrual cycles can be used as an easy bridge to the study of embryology, if the students are mature enough to tackle this topic during their tenth grade year. (As mentioned above some, teachers prefer to introduce embryology in the junior year.) The following topics can be introduced in a sophomore life science class.

- Introduce stories of the beginning of life:
    - Time line on views of the beginning of life from ancient India and Greece to modern times.
- Oogenesis and spermatogenesis
    - Mitosis and meiosis
        Lab on mitosis in onion roots; microscopy
    - Fertilization / conception
        Responsibility, true love, sexuality, coitus, etc.
        What is a man / woman, husband / wife, mother / father.
- First cell divisions, cleavage
    - Lab with sea urchins and *Obelia* medusae using the microscope
        Release of gametes
        Fertilization
        Cleavage
        Embryonic cell layers
        Comparative embryology:human being vs. animals
        Sexual vs. asexual reproduction

- Embryonic trimester of human being
    - Nodal points of development in each trimester
        Use drawings on the chalkboard; have students draw; use imaginary exercises to picture the human embryo.
    - When does life begin?
    - When do we start to think? Does the brain think?
    - Development of the nervous system
- Mendelian genetics

Laboratory Exercises

While the above examples show you a wide variety of approaches and ideas, it is important to intersperse the lessons with activities in the laboratory whenever possible. In our discussion on appropriate laboratory exercises for sophomores, we also touched on the controversial (for Waldorf schools) topic of dissections. While organ dissections (e.g. heart, lungs) are done in several schools, they are done on fresh material obtained from a local slaughter house in a very carefully prepared environment. The idea is to give the student as much as possible a realistic, living, and hands-on understanding of the anatomy of selected organs. For example, seeing and touching a fresh heart, finding the heart valves, and investigating the supply of blood can be fascinating lessons – if prepared correctly. On the other hand, it may turn off some students. Also, dissection of whole and preserved animals is more problematic and could become very quickly a purely mechanistic undertaking.

Other activities that can be done in a sophomore life science class are:

- Onion root mitosis: preparation of slides and microscopy
- Observation of gametes (*Obelia*; sea urchins) and fertilization under the microscope
- Investigating cheek cells
- Blood typing (check for local health rules!)
- Investigation of urine: color, smell, chemistry
- Determination of the volume of the bladder
- Measuring heart and pulse rates before and after exercise
- Determination of blood glucose level
- Determination of the two-touch-threshold on various places of the skin

Above: Craig Holdrege points out a uniqueness in the Skunk Cabbage.

Right: Craig points to the peculiarities of a two species of tree emanating from a decaying tree stump.

The Eleventh Grade

by

Kenneth Melia

Botany

If the study of plants is mentioned to many teenagers, it doesn't always bring up swells of interest and excitement. But I have found that for most eleventh grade students the contact with plants can bring out subtle and deep appreciation for the living landscape and the diversity of plant forms and also for the use of botanicals in medicine, cosmetics, food, spices, flavorings and symbolic and ceremonial uses.

If we start out with flowering plants, we have before us all the aspects of their growth and devlopment and metamorphosis to consider. The plant allows us to experience one of the clearest aspects of polarity in the living world. The presentation of geotropism and heliotropism, as seen in the radicle and plumule, displays this polarity powerfully. The cotyledons, which present themselves first, display a more universal and less differentiated form, and then come the first true leaves of the particular species. If we are studying an annual plant, we have the possibility to present the leaf metamorphosis patterns which are so powerfully seen in plants with terminal flowers and which go through their expansion and contraction of leaves along the stem. The contraction phase in some plants terminates in minute leaves right up to the calyx. One of the most powerful stages of metamorphosis now occurs. The emergence of colorful petals from inside the flower bud is a powerful transformation.

In plants in which the flowers appear in the leaf axils along the stem, e.g. Veronica (brookline), the plant doesn't stop growing when the flowers appear, and we see little metamorphosis of the leaves along the stem. We can present a picture on the archetypal plant, and then comes the interesting aspect of how nature develops all the themes and variations. In a book like Gerbert Grohmann's *The Plant, Vol 2* or in books on useful and ceremonial plants, we can develop aspects that are important to high school students about how to approach understanding these organisms.

Phyllotaxis and the relationship of spirals in flowers and seed heads to Fibonacci numbers are a particularly resonant study for the form and beauty they bring to consciousness.

In presenting gymnosperms in contrast to angiosperms we find that the seed is enclosed in a type of capsule or embedded in a fruit in the angiosperms, and thus, `1+6+6it develops a true enclosed, inner space. The gymnosperms' ovules (seeds) lie along the flattened woody carpel leaf and thus are "naked" (gymnos). There is a complete lack of the polar metaporphosis we saw in the annual plants of the angiosperms in this group.

Ferns are plants that specialize in leaf development. The production of sporangia on the underside of the leaves of most ferns is characteristic here. The spores produced are the consistency of pollen, but have a bit of the aspect of a seed. When the spores reach moist soil, they grow into an intermediate stage most people have never seen, the prothallium. The prothallium has a heart shaped structure and a texture like algae. On the underside of the prothallium, antheridia and archegonia are formed, and sperm cells swim in moisture to fertilize the egg cells. As soon as development takes place, we see characterisitcs of vascular plants and the development of complex leaf patterns. Allowing students to see the development of prothallia from spores is a particularly interesting activity.

Horsetail (equisetum) is a great compliment to ferns. The concentration on the stem aspect of the plant is particularly apparent. Here is an opportunity for students to experience the uses made of this plant. The origin of the common name of scouring rush is easily shown in using the plant to scrub a cooking pot. One of my favorite demonstrations has to do with the equisetum spores and the hydroscopic ribbons or elaters. Each spore has four elaters expanded out when seen on a microsope slide. If moisture from breath contacts them, they contract powerfully and wrap themselves around the spore. Soon afterward they expand rapidly to fully extended position, but after a few exposures to moisture, they have managed to form clusters of spores linked together by their elaters. The prothallium of the equisetum is not monoecious (producing both sperm and eggs) but is dioecious with each prothallium only producing either sperm (antheridium) or eggs (archegonium). So, therefore, the clustering effect of the elaters manages to bring these minute, thin gametophyte stages close to each other for fertilization.

Mosses are mysterious in their own way, because the stage we have seen in life cycles of ferns and horsetails only with great effort—the gametophyte—is the main body of the moss plant and makes up the green carpet of small plantlets we normally associate with "moss." The stalks have antheridia or archegonia at their terminal tips, and when an egg in an archegonium is fertilized, it turns into the sporophyte generation, which in many species looks a bit like a stamen. This is the smaller and less conspicuous of the two generations, and it has a special structure, the peristome (a circular structure of minute teeth), around the capsule which responds to moisture.

Lichens provide an opportunity to study symbiosis. Algae and fungi which don't exist in nature separately have produced another plant type. Lichens can exist in some of the most challenging terrestrial landscapes. Often they are THE pioneer plant in certain areas, and they will grow directly on exposed rock.

Fungi as organisms lack the ability to produce their own food as autotrophs and so are involved in metabolic breakdown of one sort or another. Many species of fungi can spring up in the ground overnight and can be dissolved almost as rapidly. The spores and the mycelia they grow into are particularly important as a part of the digestive system of the soil.

It is important to have an overview of the main ideas of polarity and metamorphosis in presenting the plant kingdom. I had many questions about how the overview and some seemingly simple answers could apply to some of the "exceptions to the rules." A book such as *The Metamorphosis of Plants* by Bockemuhl and Suchantke deals with some of the compexity of these processes and takes on some of the more difficult examples found in the plants.

Genetics

Genetics is another subject which is often treated in the eleventh grade curriculum. The presentation of botany and the metamorphosis of flowering plants and their interactions with the environment provides a particularly good basis. This is the the kind of foundation that we find in the first chapter of Craig Holdrege's book *Genetics and the Manipulation of Life*. We then have the possibility of presenting pre-Mendelian ideas of heredity and then to cover the work of Gregor Mendel. Often the intellectual pattern of Mendel's work is not seen in context. Here we have the reduction of the many traits of pea plants to a few that can be separated into "either / or" phenomena. To separate out from the powerful diversity of the world those aspects which follow the patterns and to put aside those many plants and traits which didn't follow the clear pattern was Mendel's mode. Craig Holdrege does a particularly good job of showing the process of development of the concept "gene" and also reminding us of the fact that Mendel's work was published in a small journal in 1866 and caused no stir or recognition of its importance. Then we have the powerful event that occurs in l900, when within a few months of each other three biologists, deVries, Correns, and von Tschermak, each published an article on heredity outlining experiments similar to Mendel's and supporting Mendel's original work.

The connection of chromosomes, the developing concept of "gene,"and the development of the idea of the structure and function of DNA and RNA and the Central Dogma form a story which every biology student should understand. Reading Watson's *The Double Helix* gives a good view into one aspect of how "big university science" works. It also allows the possibility for students to read some of the articles and books that present criticism, commentary and an overview of Watson and Crick's work.

One of the major aspects that can be shown through the debate about how we will understand and view genetics is the recognition of the power of metaphor. Which words and concepts are we going to use to describe these processes? The original picture of the faithful and literal transcription is extended by the idea of "editing," and then we have the presentation of "jumping genes" through the work of Barbara McClintlick and others. Even the concept "gene," which is often portrayed so literally and simply in introductory textbooks, can be shown in its complexity to eleventh grade students. Here we find many examples of how the concept of gene needs to be seen in its context and its wider, interactive perspective. The more we look, the less valid seems to be the picture that most people have in their minds of the animated images of DNA literally controlling and dictating the specifics of life in a one-way command structure.

In the view of DNA as a complex active structure we also have discussion about the various aspects of genetic engineering. *The Future of DNA* has articles which present some of the levels of challenge to the integrity of the organisms, species and even kingdoms of nature. The approach "if it can be done, why not do it?" has many powerful supporters, and because there is very little evidence of what would actually happpen in the long run, the actual decision "compass setting" is often arranged by what our philosophy of the integrity of the organism actually is. Toward the end of Holdrege's *Genetics and the Manipulation of Life,* he effectively presents some examples of questions that are raised by specific current uses or proposed future uses of gene therapy.

Cell Biology

In presenting cell biology the task is taken up to find the appropriate way of portraying the cell in relationship to the organism and the organelle in relationship to the cell. Wolfgang Schad presents an overview of the development of the "General Cell Theory." Schad's article was published in 1989 on the 150th anniversary of the General Cell Theory in l839.

We have our term "cell" from Robert Hooke, who in 1667 viewed a thin slice of cork under the microscope. He named the structures he saw after the "cella" which the ancient Greeks called the closed space of their inner temples. Hugh von Mohl first described a cell division in 1828, and Robert Brown discovered the nucleus in orchid cells in l831.

Goethe had been particularly interested in metamorphosis and in the development of what he called the "archetypal" plant. However, after his death, with the increased research into non-flowering plants, the questions arose about what is going on between root, sprout, stem, leaf and flower, and how this applies to algae, fungi, lichens, ferns and liverworts. Does the archetypal form actually apply to all plants? And if it doesn't, what is the universal principle? As a solution to this question, in 1838 botanist Matthias Schleiden proposed the idea that all plants are formed of cells as their universal structural element. A year later zoologist Theodor Schwann made the same statement for animals. In 1839 Schleiden and Schwann presented the General Cell Theory which stated that plants, animals and humans are all formed of cells as their basic universal structure.

For some biologists there was still a question whether this idea would apply to microorganisms such as vorticella, paramecium and radiolaria. In 1845 Siebold wrote that since these creatures had cell nuclei and other typical organelles, they were to be called "single-celled organisms," or protists and so it seemed that the General Cell theory was proven. In 1856 Rudolf Virchow made the statement "Omnis cellula a cellula!" (All cells come from cells!) The multicellular organism was seen as an additive system, and with that the atomic viewpoint made its way into biology.

Some levels of complexity soon made their way into the system, especially since the cell was seen as plasma enclosed in a membrane with one cell nucleus. As the optics of microscopes got better, it was found that bacteria and bluegreen algae didn't fit in the pattern, because they didn't have a nucleus. Then it was discovered that some of the ciliates have a double unsimilar nucleus with a macronucleus and a micronucleus. Many higher fungi were found to have double similar nuclei (dikaryotic) in the protoplasm of their hyphae. Further work showed that phycomycetes and slime molds have areas with thousands of nuclei in continuous protoplasm unseparated by cell walls or membranes.

Such observatons were made and led a number of biologists, such as Julius Sachs, William Hofmeister, Heinrich Anton de Bary, etc., in the latter part of the 19th century to come to the conclusion that the plant is the governing formative agent morphologically and physiologically over the cell, and not the inverse. Already in the 1880's and 1890's a number of biologists started to find microorganisms with other other organisms living inside them. The amoeba, *Paulinella chromatophora*, was found to contain two bluegreen algae living in symbiosis. These bluegreen algae provided nourishment for the amoeba. Amoeba normally fed upon such small organisms, but with these there was mutual nutrition.

Such symbiosis in the realm of the single-celled organisms and multicellular organisms is not rare. This eventually led some biologists to the idea that the cell is not the elementary organism but a symbiosis or a mini-ecological landscape. The amoeba species we know can produce a temporary mouth, food vacuole, or an anus. These can then be dissolved. Cells can create new nucleoli, nuclear membranes, ribosomes, lysosomes, Golgi bodies, etc. But we also find structures that can only be produced by themselves (sui generis) such as: chromatin (chromosomes), mitochondria, chloroplasts. These contain their own DNA. Analysis has shown that the DNA of mitochondria is identical to the DNA of aerobic bacteria. In fact, the amoeba, *Pelonyxa palustris*, has no mitochondria of its own and contains endosymbiotic aerobic bacteria. This and many other aspects of the organelles and the microorganisms point to a larger and wider picture than the traditional view of the cell as the "bricks of life."

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Kenneth Melia stresses a point about the eleventh grade curriculum.

The Twelfth Grade

by

Andy Dill

Approaching the Twelfth Grader

Clearly, one of the central tasks of the Waldorf life science program in the twelfth grade is to lead the students through as broad as possible a consideration of the animal kingdom and related environmental and ecological aspects to an experience of fundamental questions about the nature of the human being and the evolution of the earth. The goal of developing synthetic thinking is served by bringing in many themes and approaches — social, political, artistic, religious, moral, spiritual – to these questions. What responsibility do human beings have for the world of nature, and how can I, as an individual, take up that responsibility? These are essential questions for the seniors. Suggestions from the participants for approaching the twelfth grade follow.

- An extended field trip(s) away from the school (e.g. Hermit Island, Maine) can provide an experience of immersion in nature and hands-on fieldwork, particularly with the invertebrates. It can also be a context for approaching other themes of the senior year:

  Who am I? (Share individual student biographies/ "maps"; offer individual solo experiences of varying lengths.)

  What can I do? (Study writings and biographies of individuals whose work has made a difference in the world of nature—Rachel Carson, Aldo Leopold, Edward Abbey.)

  Who are we—as a class? (Share reflections on the biography of the class.)

  Where are we going as a class? (Share plans, hopes, responsibilities, fears for the coming year and beyond.)

  Who are we as Waldorf students? (Join with seniors from other Waldorf schools to work, study, and share these questions together.)

How does it fit together? (Combine scientific study with other disciplines such as literature [Transcendentalists], painting, movement, poetry, mythology.)

- With the teachers' help, the seniors continue to practice and develop skills in observation. They then have the challenge of joining individual observations to come to a recognition of archetypes, principles of form and development. This can be approached through the creation of metaphors, aphorisms, myth.

- A historical survey of how the way we look at nature in general and the animal kingdom in particular has changed and a recapitulation of the development of human thinking give the seniors perspective for an understanding of the modern reductionist world view. In this process the use of original sources is very helpful.

- Giving the students the responsibility to research and present to the class topics of their own choosing (animal species, ethical questions, new theories, etc.), after they have experienced examples given by the teacher, can be an efficient use of time and an effective means of engaging the class.

- As with the other high school classes, providing the seniors with the opportunity to present their own ideas, reflections, insights in the form of artistic projects (sculpture, painting, music, eurythmy, poetry, etc.) is vital to the wholeness of their experience of learning.

Suggested Topics for the Twelfth Grade

The main curricular focus of the twelfth grade in the life sciences is zoology. (Stockmeyer does indicate that botany can be finished in twelfth grade, but in practice it is usually completed during the junior year.) In the context of the study of zoology, several other topics are also taken up, either in a single, longer (4 to 6 week) main lesson or as separate blocks. These include evolution, paleontology, and paleanthropology. Genetics is sometimes combined with the study of evolution and/or zoology in the twelfth grade, but also commonly dealt with in other years in connection with botany, cell biology, and/or embryology. How it will be approached will depend upon the grade level of the students and the curricular context (see the sections on the tenth and eleventh grades). Biochemistry or "chemistry in its closest connection with the human being," as it is put in Stockmeyer, was not given much discussion in this colloquium, as it is generally considered more a part of the chemistry curriculum.

Zoology – is a vast area of study to try to cover in a single main lesson. The challenge of deciding what to cover and how to get through it can be daunting for the teacher. Stockmeyer reports the following reference from Steiner's *Conferences With Teachers* regarding the zoology block:

> "The essential thing is for the pupils to gain an understanding of how the various animal species fall into a definite order."

Some practical ways of accomplishing this were offered by the participants:

- The students can be assigned a few animal groups with the task to discover the archetypal forms for each through "heightened observation." (This works best at a zoo or aquarium or some other location where the living organisms can be observed directly in as natural a habitat as possible.) They are given a series of questions, such as, How does the organism move, start, stop, continue? which help them approach the observations needed to come to the archetypes.

- By approaching the diversity of the animals and looking at the human being in the context of numerous polarities (examples below), both within each group and across the kingdom, the students develop an appreciation for the interconnectedness of the world of nature and the human being. They also gain a framework for the later consideration of the theories of evolution.

  - open
  - outer
  - asexual
  - life
  - stationary
  - radial symmetry
  - dividuality
  - regeneration
  - immortality
  - ectotherm

  - closed
  - inner
  - sexual
  - consciousness
  - mobile
  - bi-lateral symmetry
  - individuality
  - death
  - mortality
  - homeotherm

- A study of different approaches to classifying the animals (including Schad's suggestion of protostomes vs. deuterostomes) encourages flexibility in thinking and the recognition that established theories change over time.

- A significant challenge for the teacher is to penetrate Steiner's other references to the animal kingdom and the teaching of zoology. One such indication is the guideline for the classification of the animals given, " albeit with certain reservations," in the *Conferences.* There he divides the animals into twelve groups related to the zodiac and into three groups related to the threefold human being. Elsewhere, Steiner refers to the animals as spread out parts of the human being, and says, "What is held back in the head of the human goes into form in the animals." Clearly, the teacher must work with these ideas and find ways to make them his/her own before presenting them to the students.

- A look at anomalies (such as retrograde metamorphosis in tunicates and echinoderms) and interesting exceptions (such as the upside-down jellyfish) helps keep our view of the animals and how they are related from becoming too fixed.

The study of evolution in the twelfth grade, whether it is covered in the same main lesson or not, is intended to be closely connected with the zoology. Some teachers find it helpful to combine them within a single block, so as to weave the threads between them more clearly. Others prefer to separate the subjects, giving each more time and preventing one from overshadowing the other. Either way, it is important for the students to understand the modern scientific approaches to evolution as well as the historical and cultural context from which they have emerged. Some suggestions from the participants for this include:

- Focus on the life and times of Charles Darwin and have students read portions of his original works.

- Look critically at the evidence Darwin presents so as to first understand his theory and then recognize its difficulties. Here we need to include a look at the fossil record, which many of our students have had little exposure to.

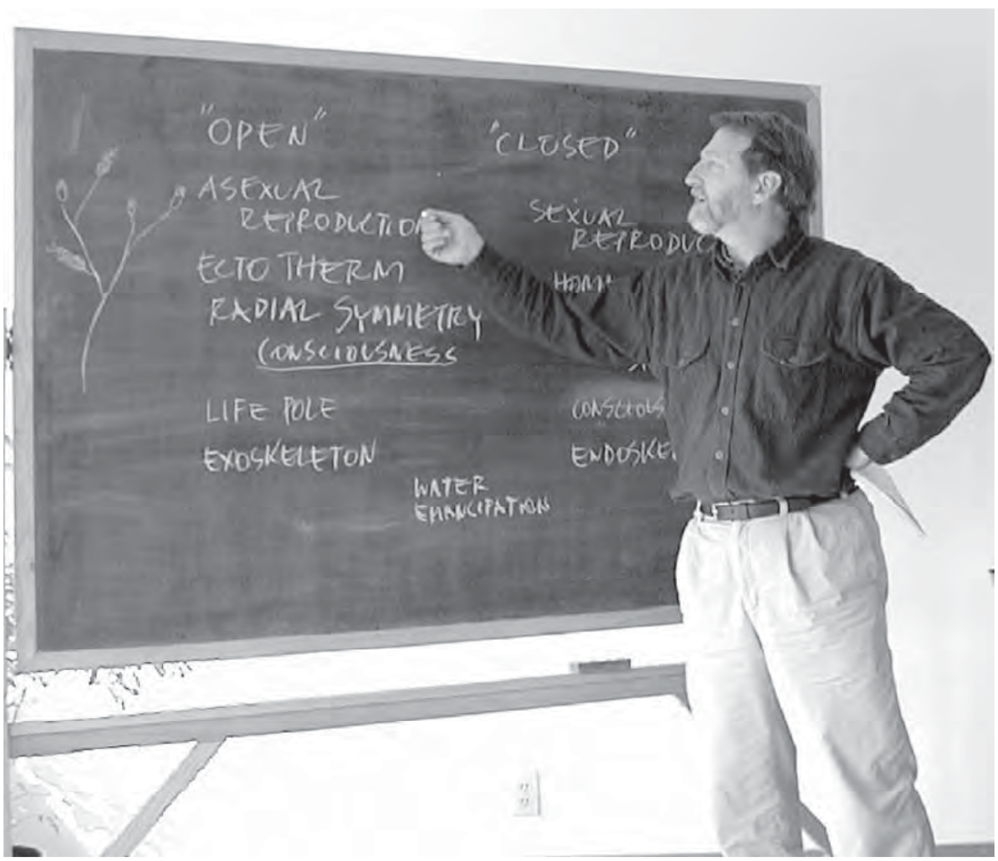
- Survey the changes to Darwin's theory that have occurred since his time to give the students a sense of where we are today. It is important to look at the idea of scientific theory as cultural myth and become familiar with the current neo-Darwinist, gene evolution theories.

- Bring in controversies from the century and a half since Darwin's time. These can be scientific, religious, political (example: the Scopes trial, piltdown hoax, *Darwin Retried*).

- Consider other scientific, religious, spiritual, and cultural perspectives on life and how it has developed (examples: creationism, mythology, Goethe, Steiner).

- Introduce Darwin's *Descent of Man* and the question of where the human being might fit in the picture that has emerged. A consideration of the hominid fossils discovered since Darwin's time and Steiner's indications can be brought. (One exercise is to place a variety of drawings of hominid skulls around the room in no particular arrangement and ask the students to look for trends. They will discover that it is impossible to find a simple, direct line.)

- It is important that the students come out of the block with questions. They should, however, also have a broad enough background to enable them to make sense of those questions and give them the confidence that they can develop and consider new ones as they arise.



The blackboard at the Nature Institute was in constant use.

David Mitchell has his senior classes study and discuss some of Goethe's aphorisms when they are on a class trip as part of a Zoology class or a wilderness "rite-of-passage" expedition. They are asked to find a quiet spot where they are asked to write five of their own aphorisms.

Goethe's Nature Aphorisms

Nature! We are surrounded by her and locked in her clasp; powerless to leave her, and powerless to come closer to her. Unasked and unwarned she takes us up into the whirl of her dance, and hurries on with us till we are weary and fall from her arms.

She creates new forms without end; what exists now, never was before; what was, comes not again; all is new and yet always the old.

We live in the midst of her and are strangers. She speaks to us unceasingly and betrays not her secret. We are always influencing her and yet can do her no violence.

Individuality seems to be all her aim, and she cares naught for individuals. She is always building and always destroying, and her workshop is not to be approached.

Nature lives in her children only, and the mother, where is she? She is the sole artist—out of the simplest materials the greatest diversity- attaining, with no trace of effort, the finest perfection, the closest precision, always softly veiled. Each of her works has an essence of its own; every shape that she takes is an idea utterly isolated; and yet all forms one.

She plays a drama; whether she sees it herself, we know not; and yet she plays it for us, who stand but a little way off.

There is constant life in her, motion and development; and yet she remains where she was. She is eternally changing, not for a moment does she stand still. Of rest she knows nothing, and to all stagnation she has affixed her curse. She is steadfast; her step is measured, her exceptions rare, her laws immutable.

She has thought, and she ponders unceasingly; not as a man, but as Nature. The meaning of the whole she keeps to herself, and no one can learn it of her.

Men are all in her, and she in all men. With all she plays a friendly game, and rejoices the more a man wins from her. With many her game is so secret, that she brings it to an end before they are aware of it.

Even what is most unnatural is Nature; even the coarsest Philistinism has something of her genius. Who does not see her everywhere, sees her nowhere aright.

She loves herself, and clings eternally to herself with eyes and hearts innumerable. She has divided herself that she may be her own delight. She is ever making new creatures spring up to delight her and imparts herself insatiably.

Her crown is Love. Only through Love can we come near her. She puts gulfs between all things and all things strive to be interfused. She isolates everything, that she may draw everything together. With a few draughts from the cup of Love she repays for a life full of trouble.

She is all things. She rewards herself and punishes herself; and in herself rejoices and is distressed. She is rough and gentle, loving and terrible, powerless and almighty. In her everything is always present; Past or Future she knows not. The Present is her Eternity. She is kind. I praise her with all her works. She is wise and still. No one can force her to explain herself, or frighten her into a gift that she does not give willingly. She is crafty but for a good end; and it is best not to notice her cunning.

She is whole and yet never finished. As she works now, so can she work for ever.

To everyone she appears in a form of *his own*. She hides herself in a thousand names and terms, and is always the same.

She has placed me in this world; she will also lead me out of it. I trust myself to her. She may do with me as she pleases. She will not hate her work. I did not speak of her. No, what is true and what is false, she has spoken it all. Everything is her fault, everything is her merit.

She rejoices in illusion. If a man destroys this in himself and others, she punishes him like the hardest tyrant. If he follows her in confidence, she presses him to her heart as if it were her child.

Her children are numberless. To no one of them is she altogether niggardly; but she has her favorites, on whom she lavishes much, and for whom she makes many a sacrifice. Over the great she has spread the shield of her protection.

She spurts forth her creatures out of nothing, and tells them not whence they come or wither they go. They have only to go their way; she knows the path.

Her springs of action are few, but they never wear out; they are always working, always manifold.

The drama she plays is always new, because she is always bringing new spectators. Life is her fairest invention and Death is her device for having life in abundance.

Poetry

Fire and Ice

Some say the world wiII end in fire,
Some say in ice.
From what I've tasted of desire
I hold with those who favor fire

But if it had to perish twice,
I think I know enough of hate,
to say that for destruction ice
is also great
and would suffice.
— Robert Frost

Metamorphosis

Though all the beasts
hang their heads from horizontal backbones,
to man he gave a face that is held high,
and bade him stand erect,
his eyes upon the stars.
— Ovid

Essay On Humans

The beast and bird their common charge attend
The mothers nurse it and the sires defend.
The young dismissed to wonder earth or air,
There stops the instinct, and there ends the care
The longer care man's helpless kind demands,
That longer care contracts more lasting bands.
— Alexander Pope, 1733

While we are born with curiosity and wonder and our early years are full of the adventure they bring, I know such inherent joys are often lost. I also know that being deep within us, the latent glow can be tanned to flame again by awareness and an open mind.

— Sigurd Olsen

Where the telescope ends,
the microscope begins.
Which of the two has the grander view? Choose.
A bit of mould is a pleiad of flowers;
a nebula is an anthill of stars.
— Victor Hugo

The Violent Vegan by Bob Snow (sic)

Vegetarians, even pure vegan,
can't wait to dig those cells:
those harbingers of life,
those carriers of germinal energy,
those sources of new beginnings.

How we crave those bits!
Morsels of mitochondria
green chloroplasts,
savoury cytoskeletons
and minute microfilaments.
Rich ribosomes, and
kernels of nucleic acids.

How we love to crunch these milk-laden membranes,
and cellulose walls,
served in a cream sauce of cytoplasmic juices.

So give it up you bit of bean,
you kerneled wheat,
you banana.
Dissolve and die!
You're about to be born again,
and remember,
even vegetarians, even pure vegan, love those cells.

Space

The first day or so we all pointed to our countries.
The third or fourth day we were pointing to our continents.
By the fifth day we were aware of only one Earth.
— From an astronaut.

The Soul in Man
is not an organ
but animates and exercises all the organs;

It is not a function
like the power of memory of calculation, of comparison,
but uses them as hands and feet.
Is not the intellect or the will,
But the master of intellect and will;

Is the background of our being in which they lie,
an intensity not possessed
and that cannot be possessed.

From within or behind, a light shines
through us upon things,
and makes us aware
that we are nothing
but the light is all.
A man is but the facade of a temple
wherein
all wisdom and all goodness abide.

— Ralph Waldo Emerson

Joy does not come from outside,
for whatever happens to us it is within.
Light does not come to us from without;
light is in us even if we have no eyes.

— Jacques Lusseyran

The earth laughs in flowers.

— Ralph Waldo Emerson

Climb the mountains and get their good tidings.
Nature's peace will flow into you as sunshine flows into trees,
The winds will blow their own freshness into you,
and the storms their energy,
while cares will drop off like autumn leaves.

— John Muir

It doesn’t interest me what you do for a living.
I want to know what you ache for, and
if you dare to dream of meeting your heart’s longing.

It doesn’t interest me how old you are.
I want to know if you will risk looking like a fool for love,
for your dreams, for the adventure of being alive.

It doesn’t interest me what planets are squaring your moon,
I want to know if you have touched the center of your own sorrow,
if you have been open to life’s betrayals,
or have become shriveled and closed from fear of further pain.
I want to know if you can sit with pain, mine or your own,
without moving to hide it, fade it, or fix it.

I want to know if you can be with joy, mine or your own,
if you can dance with the wildness and let ecstasy fill you
to the tips of your fingers and toes without cautioning us to be careful,
be realistic, or to remember the limitations of being human.

It doesn’t interest me if the story you’re telling me is true,
I want to know if you can disappoint another to be true to yourself,
if you can bear the accusation of betrayal and not betray your soul.
I want to know if you can be faithful, and therefore trustworthy.
I want to know if you can see beauty even when it’s not a pretty day,
and if you can source your life from God’s presence.
I want to know if you can live with failure, yours and mine,
and still stand on the edge of a lake and shout to the silver of the full moon, “Yes!”.

It doesn’t interest me to know where you live or how much money you have.
I want to know if you can get up after a night of despair,
weary and bruised to the bone, and do what needs to be done for the children.

It doesn’t interest me who you are or how you came to be here.
I want to know if you will stand in the center of the fire with me
and not shrink back.

It doesn’t matter to me where, or what, or with whom you have studied.
I want to know what sustains you from the inside when all else falls away.
I want to know if you can be alone with yourself,
and if you truly like the company you keep in empty moments.

— Oriah Mountain Dreamer, Native American Elder

The universe is a more amazing place than ever, as you glance along this bewildering series of animated forms—the hazy butterflies, the carved shells, the birds, beasts, fishes, insects, snakes and the upheaving principle of life everywhere incipient, in the very rock aping organized forms. Not a form so grotesque, so savage, nor so beautiful but is an expression of some property inherent in man the observer—an occult relation between the very scorpions and man. I feel the centipede in me—caryman, carp, eagle and fox. I am moved by strange sympathies; I say continually, "I will be a naturalist."

— Ralph Waldo Emerson

I held a blue flower in my hand, probably a wild aster, wondering what its name was, and then thought that human names for natural things are superfluous. Nature herself does not name them. The important thing is to know this flower, look at its color until the blueness becomes as real as a keynote of music. Look at the exquisite yellow flowerettes in the center, become very small with them. Be the flower, be the trees, the blowing grasses. Fly with the birds, jump with the squirrel!

— Sally Carrighar

To look at anything,
If you would know that thing,
You must look at this green and say
'I have seen spring in these
woods,' will not do—you must
Be the thing you see:
You must be the dark snakes of
Stems and ferry plumes of leaves,
You must enter in
To the small silences between the leaves,
You must task your time
And touch the very peace
They issue from.

— John Moffift

Let a man once begin to think about the mystery of his life and the links which connect him with the life that fills the world, and he cannot but bring to bear upon his own life and all other life that comes within his reach the principle of reverence for life . . .

— Albert Schweitzer

And the world cannot be discovered by a journey of miles, no matter how long, but only by a spiritual journey, a journey of one inch, very arduous and humbling and joyful, by which we arrive at the ground at our feet, and learn to be at home.

— Wendell Berry

Silently a flower blooms,
In silence it falls away,
Yet here now, at this moment, at this place,
The world of the flower, the whole of the world is blooming.
This is the talk of the flower, the truth of the blossom;
The glory of eternal life is fully shining here.

— Zenkei Shibayama

College Preparation

by

Ed Edelstein

Science Skills Lessons and the Question of Preparation for Post-Secondary Entrance and Achievement Tests

In summary, there are some schools where the six "standard " biology main lessons of anatomy, physiology / embryology, cell biology, botany / ecology, zoology and genetics / evolution (one version of the six), together with the arts and music and humanities, stand as preparation enough. However, other schools have "science skills lessons" in grade eleven and twelve as additional work on a level intended for the students heading into science at university and college. There are schools which are in between, and offer only one year of "skills" in grade twelve, or a biochemistry main lesson in grade twelve. The "science skills lessons" require three or four single classes per week over the course of a year. Sometimes the classes are doubled for labs, or put at the end of the school day so students can remain after to do larger labs.

Textbooks are used in the "science skills lessons." For Kenneth Melia at the Summerfield Waldorf School, students must read in the summer all of the text and answer the end of chapter questions before the course begins in the fall. Other schools use the textbooks over the course of the year. Kenneth's book is: *Biology, 5th edition*. (Campbell, Reece, Mitchell, ISBN 0-8053-6573-7, 1999. Addison-Wesley.)

Andy Dill at the Kimberton Waldorf School has a senior seminar in biology for those students wishing to pursue medicine or biology in college. This is an elective track class for seniors which meets three periods a week for three quarters of the year. Usually it is scheduled as one single and one double period each week with the double period especially useful for labs. The aims of the course and the specific curriculum vary somewhat from year to year depending upon the needs and goals of the students enrolled. They always include:

• The use of a textbook—We use a college non-major's level textbook (currently *Biology, A Journey into Life* by Arms, Camp, Jenner, and Zalisko) as a starting point in developing techniques for reading a textbook.

• An investigation of biochemistry—We cover respiration and photosynthesis in particular detail.

• Modern genetics—Going beyond the content of the main lesson material, this includes breeding experiments (usually Drosophila).

• An independent research project which includes primary sources and written and oral presentations.

• Topics not otherwise covered in the life science main lessons, such as cell organelles, diffusion and active transport, aspects of ecology, current issues in the life sciences.

In addition to textbooks, some schools have students read scientific journals, some do more intensive work on vocabulary, some do analysis of the textbooks read to show what they answer or not, some spend time on preparation for writing the AP test in biology, and all spend time on labs. The labs include sometimes a portion, perhaps 50% of the AP labs suggested, others do more detailed genetics work with Drosophila, others do more advanced microscopic staining techniques. There seemed to be a wide variety. Kenneth's approach is spend about 50% of his year on AP requirements and the other 50% on "wholistic biology " questions.

Craig Holdrege noted that the Abitur in Germany was more demanding than the entrance requirements currently in North America and compared it to the first two years of college work. Ed Edelstein expressed the idea of working to create a Waldorf "science diploma" which would be somewhat standard across our North American schools for the purpose of direct college and university entrance. Hartmut Döbel felt that AP courses do not properly belong in a Waldorf high school as the level required is really a more specialized one intended for university.

In conclusion, Jim Henderson noted that more and more colleges and universities are seeking out Waldorf graduates as they realize that what they have is more than the ability to do well on the tests.

As the person scribing, I found notable the lack of worry around the table about the need to dwell on the university preparation idea.

The colloquium in deliberation at the Nature Institute

Experiential Aspects of Learning

by

Keith Badger

The idea of, or nature of, process has a great deal to do with this theme of metamorphosis that we are exploring here during these few days together. How to get from one place, or point, to another? Often we get used to just making quantum leaps, especially within the realm of ideas. Take a piece of string, for example. What is our understanding of the process required to bring that string to us? What are the environmental / economic pathways the materials in it take?

Within the human, the most eloquent example of process is the digestive system. We take food into us, and it goes through two phases, if you will. One phase is likened to a descent, or the catabolic phase of digestion, where we literally take the outside world into us and break the substance down, stripping that substance of it's identity. We internalize the outside world and make it part of us! The second phase, or anabolic phase is where that substance passes into us and gets built up into us. It takes on a new identity, or you could say it turns and gets taken up into the ascent of a new possibility within us! In science this is called the "metabolic moment." This movement within, the meeting point of the two phases (the metabolic moment), or turn, if you will, is very much connected to the nature of experience. If the true nature of experience, and experiential learning, is about making it one's own, how do we create opportunities where students have this moment of true learning? If the moment doesn't become part of them, if they can't metabolize the experience, are they being nourished well? Are they healthy? Remember that we literally eat ourselves sick, and digest ourselves back to health or wholeness.

This metabolic moment is a turning point, and thus a crisis! This is the meaning of crisis. Adolescents are by nature also at this point. And they very much need to have true experiences; experiences that are their own and not imitation, or others. Ideas, what can become food for thought, must also find the metabolic moment and become true experiences within our students. We must not let education go the way of fast foods, that fail to nourish the soul, and become mere quantum leaps in terms of process and true experience. Their thinking must not just mirror our thoughts or just become regurgitated. The life of thought-experience must be taken up and become truly part of their identity, or else they become constipated at best, or ill in the extreme. Dead influences.

This moment of turning, or crisis, is closely tied to the quality of our attention in that moment. Our attention, or awareness, in the moment can determine whether we just see things or truly notice what we see.

We must learn to reawaken and keep ourselves awake.
— H.D. Thoreau, *Walden*

Thoreau's experience, that of becoming native to place, of really knowing and understanding the myriad intricacies of relationship within a place, comes the closest to the heart of environmental / experiential education. His keen awareness, and attentiveness to each passing moment—"to improve upon the nick of time"—was the key to making experience his own.

We know much today, and we have great intellectual capacity, yet we must argue whether we exercise as much intelligence. It takes a great deal of intellect to make a bomb, but it demonstrates little intelligence in its use. If evolution of man is the evolution of consciousness—if this is our birthright—then this capacity to behold the whole of the creation is dependent upon our capacity to conceive or conceptualize the moment of beholding. Within the human lies the potential of response to the law of entropy, to stand against the downward flow, and to look back and have a dialog with God. This is how I relate to the idea of phenomenological thinking: the human having a conversation with the creation or the Creator. For this to happen we must not be asleep, and we must reawaken from all that works to keep us so. Goethe warns us to get rid of the theories and return to the phenomena itself in his phenomenological approach to nature. We must learn to observe that which observes within us, and be mindful in the fullest sense of the word.

From the early Christian Desert Fathers we are reminded about maintaining a sense of sobriety in our life of mind. "Drunkenness" in our observations, where we construct a false reality of the world, is due to our being asleep in any given moment. I feel that what is called for today, in moments of awareness or attentiveness, is where we see phenomena with a renewed sense of the sacred.

It is here, that the rite-of-passage experience (and the need for such experiences) enters for me as being of such vital importance. It is here that Waldorf should also be leading the field! Steiner tells us: "With the development of the astral body during puberty, the student is capable of inspired knowledge—scientific and artistic knowledge rooted in direct experience of laws and relationships underlying phenomena, and development of an imaginative knowledge of the world." Experiential learning, rooted in skills of awareness, is capable of developing a renewed enthusiasm for the human journey. The rite-of-passage experience defines this quest!

What will happen should adolescents fail to develop the enthusiasm required for this journey? How will they then celebrate this turning? According to Bertrand Russell, this response to the calling, or the summons toward this journey, often engendered enthusiasm, which means etymologically, having the god enter into the listener. Should this process become fragmented, adolescents will become truly delinquent, which means to leave! What we have to contend with today is the television, computer games and virtual reality. How do these experiences—pathological experiences that they are—bring adolescents into a world of greater sensitivity and relationship? Here is where for me the natural world becomes such a magnificent healer. As Thoreau relates to "nature looking into nature," the human can drink deeply of the opportunity to deepen the wealth of relationship of nature, which is the hallmark of life's offering.

The peak moments, the "highs," or the metabolic moment, where adolescents have a taste of the sacred, or this turning inward, are this turning point where they live. We need to help create this inspired moment! The immersion into the natural world, sometimes seen best within the realms of wilderness experiences, offers the possibility of reentering into the wealth of relationship, and developing the confidence in self that is requisite to the journey. These moments then become their own. Phenomenological thinking enters as the key to maintaining the awareness necessary toward this aim. It is this understanding of process, and of the nature of the journey, that enables the change or transformation, called metamorphosis. Should we fail to keep our awareness while in the moment, there is no guarentee as to where we will find ourselves.

AD "Sometimes sports become a replacement for these kinds of experiences."

DM "Yet bonding does still occur in all cases here! Nevertheless, the real question we are concerned with is the birth of the individual! The rite-of-passage is an essential component within our culture today; students need to know how to listen to their own thoughts. They are retarded on a social/emotional level and are damaged where we meet them in the classroom. They need to develop confidence in the world. They need to meet something in themselves in a quiet moment, at a higher level of conscience.

We have the European models of work, on the farms or going into the factory to work, but is this enough? I often think of the metaphor of the banquet, where we aren't able to take advantage of all that's laid out on the table. This inability to do so is partly due to the lack of parenting in our culture today. Students fail to understand boundaries; they are stunted at this social/emotional level, where they aren't prepared to come to the table and take the meal (banquet)."

HD "Where is the time today in our programs for this kind of experience? Our school day is filled! We have become so highly academic! And this seems to be what parents want. We leave little time to teach one how to walk in Nature."

EE "Could you give us a broad stroke description of what you do in your program? What are some of the things you do within the day?"

KB "Yes. Much of what we do is to build up and enliven the senses, to learn how to observe and train one's mind to develop awareness.

(See attached schedule of curriculum.)

CH “Is there a danger in going in this direction? We live in such a highly technological world. Will they learn to become dissatisfied with this? This life in Nature could become so much more appealing that they may just turn away from where we are in our culture?”

DM “Or, it can be considered an enrichment!”

KB “One can’t learn to drop out. The human journey is forward, not back into a past. What we need is to open the heart, to open up into greater degrees of relationship where one ultimately learns to bring something back to our fellow community members, to others. It can’t become a selfish thing.”

AD “Our tendency today is to hang on to the peak experiences, and we need to find ways where we can bring kids down safely from them today. But this can happen with any experience that has the ‘high’ moment, like a sports event, theater performance or the like, and we lose kids here just as easily.”

DM “There is something else here that’s just being explored, and that’s the HAND! When you learn to put your consciousness into your hand, and learn new skills, you’re opening neural passageways to the frontal cortex. Frank R. Wilson has done some interesting research which has shown that the more you develop abilities with the hand, the more this can lead to new capacities later for thinking. Steiner once said he would shift the curriculum 180 degrees and do more artistic activities with the hand.

(Much reference here to the work of Angus Gordon, and the Ruskin Mills, where much hard work is going on in relationship to this question of working with the hand)

We must work toward greater efforts in the field of sustainability in all that we do.”

CH “There are many areas of experiential learning, and there is a certain danger in saying we should change the curriculum to a nature-based one. We need many different models of experience where youth can learn to witness, and model, the passion of adults. There could be examples of socially-engaged schools, schools of culture, art.”

KB “Learning really emerges out of one’s capacity to celebrate life, and that can vary according to our individual passions and uniqueness. You can’t franchise it. It has to be as varied as the people who wish to bring these offerings across.”

KM “We are looking at the possibility of the school mandating each student to do two summers of involvement in some type of project work. Most work experiences are often poor, or negative, so why not bring possibilities where students experience work as something that could be very positive? There could be many types of offerings from social work to ecological work experiences."

EE "At Toronto there are work and social experiences built right into the four year curriculum."

DM "Many, likewise, in Boulder at the Shining Mountain Waldorf School!"

(The group, after taking a break, engaged in a field exercise in phenomenological thinking, then returned to the Nature Institute to share observations.)

CH "There needs to be a tension between working out of concepts, and opening up to where we have less structure in our thinking. A balance between the two needs to part of our observations."

DM "To look with two sets of eyes! The one that looks within, and the one that looks without."

(The group came to the question of time and the need to experience nature over and over again, in time—to form an image, then to let it go again. Yet, even our perceptions in a moment can live imaginatively where something speaks to us. How do we bring students to this capacity where it becomes a threshold into new thinking?)

JH "How are we sure that what we listen to in phenomenological thinking is not just subjective? Where is this coming from?"

DM "Today's youth are born with new capacities. Through nature-studies students can open up to, and develop, these new ways of thinking. We must become midwives to this!"

"All truly wise thoughts have been thought already thousands of times; but to make them truly ours, we must think them over again honestly, till they take root in our personal experience."

— Goethe

The Naturalist Program

by

Keith Badger

The Naturalist Program has developed over a period of years where the natural history studies have become interwoven with work in practical crafts (what has been referred to in the past as woodcraft), wilderness survival skills, rites-of-passage experiences, and experiences in place-based education. In many ways it could be seen as more of an exploration into the realms of language than anything else, as it really has a focus on relearning the language of nature, and reestablishing a living relationship with the world within which we live. Never before in our historical experience have we, as a culture, had such a disconnect from the natural order, and the implications of this state reverberate throughout our common collective experience, as well as within our physical and spiritual well being.

Much of the approach is based on the old adage of the fisherman:

> *You can give a man a fish, and feed him for an evening, or you can teach him how to fish, and feed him for a lifetime!*

This learning how to learn is the key concept, which is transferable to any initiative, or endeavor, we undertake in life. It is related intricately to the nature of process, and thus real understanding. Much of education today involves the mere learning of facts without any true understanding of knowledge because we have not had a true experience that brings us into a relationship with that knowledge. We are a generation satisfied with quantum leaps and end products. Fast food for the mind and soul! It has been my conviction that adolescents today need more than ever the healing affects of the natural world and that the true focus of natural science will emerge out of a deeper understanding of it's natural rhythms. It provides the balance, as well as the inspiration, so needed today in a culture rife with hopelessness, cynicism, and despair.

The program itself is built up out of the recognition of levels of experience, as opposed to grade level, yet these levels parallel the developmental scheme worked within our Waldorf curriculum, where each level operates out of a seminal question that mirrors one's inner development of soul experience. The what, how, why, and who questions are built upon over the years and form the questioning approach that we take in our studies. The breakdown is roughly as follows:

Year / Level	Science	Skills	Arts
9th / #1	Earth Science	Tracking, orienteering, shelter making, leather work (hide tanning)	Moccasins
10th / #2	Water Studies	Fire making, cordage,	Capote, baskets bowyers art
11th / #3	Habitat Studies	Storytelling, herb-alism, edible plants	Journal keeping
12th / #4	Ecological and Bioregional Studies	The Vision Quest, self service to others	Wood bow and tackle

Each year introduces new ways to see the same things with new eyes! Skills, which begin in year one, such as tracking, are continued and developed in a deeper way over the years. One begins with learning how to observe, and then one begins to draw comparisons with other signs in the landscape. Finally, the track is placed within a greater context in the wider environment, and ultimately to the question of what role and purpose the animal plays in this great dance of nature. One must learn to be patient, and to let Nature slowly reveal her secrets to the observer—a language that we grow more and more familiar with!

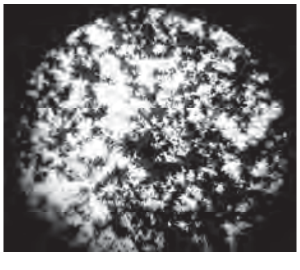
There are many ways to interact with the natural world; we do it every day, yet we are truly asleep to the blessings bestowed. Seldom do we explore the pathways in which matter enters our life, the ways we utilize things. From the food that sustains our bodies daily, to the articles of utility that make our life so convenient, we are disconnected. What are the ecological / economic pathways that these things take, or follow, in order for us to make such common use of them? Are these pathways healthy and sustainable? Do I have a responsibility toward them, or an ethical obligation to them? Am I cognizant of the nature of reciprocity? Many of these opportunities to enter into realms of relationship are lost to us because we rarely ask ourselves the question anymore. Working with my hands directly, especially with natural materials, which serve and feed me, is an ideal way to explore the wealth of relationships that bind us to, tie us to, the natural order.

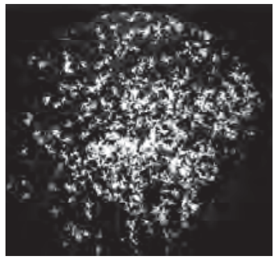
Ultimately, all the skills that we learn should bring us into a deeper sense of ourselves, and to beg the larger question of what role we, the human, play in the great dance of life. With my knowledge of place comes the understanding of obligation. What can I offer? What is my unique contribution to the whole? How can I best sing my song? These are the questions that our youth should be asking. Not statements of cynicism and despair. Forever let us be rid of the "whatever" response, or attitude. Youth need to explore the wealth of opportunities to do identity work. To find out how to move through process, how to learn to fish in the ocean of life, and to love the dance. We must create the invitation to that dance!

Rudolf Steiner has often remarked upon the difficulties created by the separation between Science and the Humanities; it has separated the human from the world in which he lives. We have become displaced through an organic wish to understand that has led us to a dispassionate, cool, calculating manipulation of that which we were once so much a part of. To blend scientific inquiry with the heartfelt human wish to celebrate our collective, as well as individual, journey requires a grass roots level of contact that engages our heart and soul, as well as our bodies and mind. To get down to the "muskrat level," as Thoreau would state it! Rite-of-passage experiences cannot only be a bridge between childhood and adulthood; they may also serve as a bridge connecting the human to the world.

For Henry David Thoreau it was large doses of time, where he lovingly gave himself over to embracing the world through his back door of Concord. His contemplation of his surrounding woods and fields, at all times of day throughout the seasons, was an experience of natures rhythms that helped him hear the call of a different drummer, and to embrace a world of relationship where he discovered not only his "place," but ultimately himself. This double task of harmonizing the self while developing a creative relationship to the external world is likewise the task of Waldorf education. In fact, Steiner tells us that if the adolescent is not drawn out into the world at this time, they will inevitably fall back into themselves, and be consumed by questions of power and sexual gratification. In a culture such as ours where these themes hold such sway to begin with, the imperative for such rites-of-passage moments seems almost doubled! For Thoreau he said,

> *I went to the woods because I wished to live deliberately, to confront only the essential facts of life, and see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived.*





Microsopic views of Horsetail spores (equisitum). When moisture from the breath is applied the elators (hydroscopic ribbons) [left photo] become stimulated by the moisture and begin a vigorous the dance [right photo].

Environmental Education

by

James Henderson

Environmental education, like any subject of study within a Waldorf education, occurs in the context of the fundamentals inherent in any Waldorf School. This discussion assumes those fundamentals and so does not elaborate on them per se, rather it focuses on environmental education in the same way that a math curriculum or a handwork curriculum might similarly be be discussed.

Given that assumption, what are the goals of an environmental education within the more general goals of a Waldorf school? There are four fundamental questions an environmental education should address:

Where do the objects that I consume come from?
What do I know about the place where I live?
How am I connected to the earth and other living things?
What is my purpose and responsibility as a human being?

Indeed, these are pretty fundamental to our existence in general and can certainly be found throughout the Waldorf curriculum. As such, the argument can be made that the entirety of the Waldorf curriculum, properly taught, is environmental education. David Orr, in his excellent book *Ecological Literacy*, makes the following elements fundamental in any education, but also as keystones for living sustainably on the earth:

All education is environmental education

- Environmental issues are complex and cannot be understood through a single discipline or department.
- For inhabitants, education occurs in part as a dialogue with a place and has the characteristics of a good conversation. The way education occurs is as important as its content.
- Experience in the natural world is both an essential part of understanding the environment and conducive to good thinking.
- Education relevant to the challenge of building a sustainable society will enhance the learnerís competence with natural systems.

One of the most effective tools can be a study of place, an unhurried examination of a particular place, looking for themes to emerge through an intense phenomenology. An exemplar of this is the work of the Nature Institute, which was host for our conference. David Orr offers a metaphor that is useful in this regard, wherein he compares a good conversation with a study of the environment:

> *Good conversation is unhurried.. It has its own rhythm and pace. Dialogue with nature cannot be rushed.. It will be governed by cycles of day and night, the seasons, the pace of procreation, and by the larger rhythm of evolutionary and geologic time!The form and structure of any conversation with the natural world is that of the discipline of ecology as a restorative process and healing art.*

An effective activity that can reveal the unity of environmental issues is to take a simple object and trace all of the connected elements that led to its being in someone's hand (like a pencil). Thich Nhat Hanh put this poetically:

> *If you are a poet, you will see clearly that there is a cloud floating in this sheet of paper. Without a cloud, there will be no rain; without rain, the trees cannot grow; and without trees, we cannot make paper. The cloud is essential for the paper to exist. If the cloud is not there, the sheet of paper cannot be there either. So we can say that the cloud and paper inter-are. "Interbeing" is a word that is not in the dictionary yet, but if we combine the prefix "inter" with the verb "to be," we have a new verb, inter-be.*

Each Waldorf school has a different emphasis on environmental education. There is High Mowing, which has an extensive program that extends through elementary and high school, where students are taught environmental observation, tracking skills, survival skills, in a thorough and intensive curriculum. Others include an extensive gardening program, while others may have nothing specific. But it is clear if you even cursorily examine a Waldorf curriculum that the entire curriculum could be, should be, environmental education. Perhaps it just needs to be made more conscious. But environmental education is fundamental to not only biology and earth science, but also to history, economics, and literature, as well as arts and crafts. For if Waldorf education is anything, it is one which places the human being in the context of the world, and the context of the world, rightly understood, can only be environmental at its core, with the human being as an integral part of the world, the micro of the macro.

At a time when many Waldorf schools are actively building, we noted that if you speak in the classroom about environmental responsibility, and then as a school community put up a structure that ignores issues of sustainable construction, then you are speaking to the children in one way and acting another, and they will certainly see the disparity, if not lie, between words and deeds. As David Orr puts it in his book *Ecological Literacy*:

> *Students taught environmental awareness in a setting that does not alter their relationship to basic life-support systems learn that it is sufficient to intellectualize, emote, or posture about such things without having to live differently. Environmental education ought to change the way people live, not just how they talk.*

And later:

> *Students learn that it is sufficient only to learn about injustice and ecological deterioration without having to do much about them, which is to say, the lesson of hypocrisy. They hear that the vital signs of the planet are in decline without learning to question the de facto energy, food, materials, and waste policies of the very institution that presumes to induct them into responsible adulthood.*

Our facilities, with their energy use, waste flow, materials consumption, are the tangible connection between our schools and the world at large. If we put up new facilities that do not take this into account, our education is a lie, pure and simple. We should be setting standards of sustainability by example. We should orient our environmental education around issues of human survival in this age, a cross-disciplinary opportunity. We should be providing leadership by example within the curriculum and within campus life, fructifying the young wills in our charge to create a humane and sustainable future rather than living on the sidelines, passively, following the examples of their schools. Environmental education should be our opportunity to affirm that Waldorf education is life affirming.

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WALDORF ENVIRONMENTAL CURRICULUM

Subjects from the Waldorf Curriculum in Relation to Environmental Education

DSM revised after Steiner School in Zürich model

KIND.	1,2	3	4	5	6	7	8	9	10	11	12
The exploration of man, animal, and nature through wonder and activity	Animals, plants in fairytales, fables, and stories		Developed out of the animal kingdom	History	Nutrition and hygiene	Man as synthesis of the animal kingdom, nutrition, health	Inner organs, sense organs, skeleton (overview)	Muscles, skeleton, homeostasis	3-Fold process in man	Cytology (Microcosm)	12- Fold animal kingdom in relationship to man
		More exact description of animals and relationship to man		Lesser known animals; the animal and its habitat	Deepen study of animals, plants and minerals			Cooking Erosion, minerology,	Embryology and the development of the infant	History	Zoology, (Metamorphosis) Evolution
			Man and animal block	Plant and soul qualities of man		Astronomy	Meterology	Oceanography Earth science	Crystalo-graphy	Botany, plant kingdom	Plant metamorpho-sis
		Class garden	Class garden								
		Farm & Building block		Class garden	Gardening Ground preparation and care Harvest vegetables, flowers & fruit Garden design			Gardening Improvement of soil: compost fertilizers, care and study of trees and shrubs			
				Care of the school surroundings				Care of the land and design / organization			
								Practical farming and farm economy	Surveying Practical forestry	Practical gardening	Ecology
Care of indoor plants and possibly animals in the classroom								Practical mountaineering			
	Nature stories, walks and observations	Nature stories, walks and observations	Nature stories, walks and observations	Visit Arboretum, Botanical garden	Geology and minerology in relation to the bio-region	"Water" in Chemistry Weather Biographies	Application to industry Biographies				
Cooking, baking, cleaning	Local walks in nature, baking	Farm trips, trips to artisans and craftsmen	Trips to zoo state capital	Trip to island or other contrasting habitat	Mineral dig	Raft trip, wilderness experience	Class trip devoted to a practical theme	Work on a farm	Trail building, forestry	Work on an assembly line in industry	Take on a task to restore nature
Local walks	Local walks	Local geography and nature and economy	The state and the region	The United States, Canada	Central & South America	Africa & Europe	Australia, Antartica, Asia	World Geography	Physical geography, hydro, litho, and biosphere	Astronomy, Cartography	Earth History, paleontology, ethnography
Cooking	Cooking	Baking				Inorganic Combustion, limestone cycle and metals	Organic, starch, sugar, protein, fats	Organic, plants, alcohol, esters, ethers	Acids, bases, salts, metals	Periodic Table of the Elements, nuclear chemistry	Bio-chem-istry, life processes, industrial, medicial

The following is taken from *The Educational Tasks and Content of the Steiner Waldorf Curriculum,* edited by Martyn Rawson and Tobias Richter as research produced on behalf of the Pedagogical Section of the School of Spiritual Science at the Goetheanum, Dornach, Switzerland. ISBN 1 900169 07 X published by Steiner Schools Fellowship, 2000.

— David Mitchell

WALDORF HIGH SCHOOL LIFE SCIENCES

Classes 9 - 12

Points of view and general themes:

The essential question in high school teaching is not how to spread the enormous range of content in the life sciences over the timetable, but rather what best serves the developmental process of adolescence.

What role can the life sciences play in helping young people in their discovery of themselves and their understanding of the world? The pupils are not there for the subject, rather the subject is there for the pupils. Adolescence engages a deep range of hidden questions that young people become aware of and opportunities are needed throughout the curriculum for them to be articulated.

One area of immediate interest to the adolescent and one that holds the potential to address fundamental questions about life, death and the human condition is the study of what is conventionally known as human biology. However, biology implies the study of organisms, so this sets up an expectation that real knowledge about the human being comes through a study of the human physical body and its constituent parts and processes, cells and genes, all of which add up to make a person. Biology implies animals and plants; human biology being the particular study of its particular organism, a species of mammal whose nature can be explained as any animal can be—reproduction, survival, etc. A higher animal, but animal, nevertheless.

Classes 9 and 10

The title “Human Science” already allows the possibility that such a study can include all human experience from self-awareness, creative genius and inner feelings, to bruises, sweating and digestion. This approach can engage Classes 9 and 10, and the question of whether humans evolved from animals need, to be left as an open question for study in Classes 11 and 12, rather than treated as an assumed truth all along.

Alongside the human science main lessons (10/12 weeks over the two years in blocks of 3-4 weeks), other life science studies are taught.

Class 9 needs to engage in practical fieldwork with observations and projects which have an emphasis on the care and renewal of the land—composting, planting trees, tending ponds and hedgerows, for example. These would then become the basis for classroom studies, which could retain their link to the whole context of the environment from which they arose.

In Class 10, the increased powers of thinking are well met through laboratory-based studies of a more conventional kind, where the control of different variables in the growth of plants or the relationship of water to soil, brings the forming of a hypothesis and the concept of experimental proof into focus. By postponing the usual early emphasis on hypothesis, measurement and proof until Class 10, intellectual clarity will not be at the expense of a much wider perspective on the living world.

Another feature of life science study in Classes 9 and 10 is the introduction of biographies through which scientists can appear as real human beings with whom young people can identify. The qualities that are needed in real scientific investigation, rather than cardboard textbook cameos, come to life: single-minded dedication, passion, meticulous observation, inspiration, creative and lateral thinking, co-operation with others, fortuitous meetings and conversations, as well as practical ability and clear thinking.

Class 11

In Class 11 young people's thinking powers have matured to form the basis for a power of judgment, which had been all too easily clouded by the passions and extremes of adolescence or swayed by peer group pressure.

With their thinking more in hand, they are ready for a focus on the ideas and ideals in contemporary science, such as cell theory and genetics (paralleled by the atomic theory in the earth science curriculum). By taking an historical approach, there is a context for the theories showing how they arose out of the previous ideas through particular personalities and key experiments.

The study of botany provides a good basis for this, with practical work on plant cells and use of the microscope and with practical genetics through the germination of seeds. Narrowing the view of life through the microscope needs to be balanced by a macroscopic perspective The study of landscape and of the major vegetation zones of the earth can provide this, and help in translating from one realm to the other can be given by projective geometry. The history of science provides a context, too, in which analytical and classificatory thinking (e.g. Linnaeus) rose to prominence, spawning a growth in knowledge about plants and a technology that advanced from fertilizers to genetic engineering. At the same time it reduced our relationship with the biosphere to a mosaic of factors, but no real wholeness.

The problems of the environment are the direct result of a certain way of thinking about the living world, which can be contrasted with Goethe's in a study of his method and approach to plants which emphasises exact observation, while retaining the context of the plant in its environment and its relationship to the whole.

The study of botany also provides the basis for consideration of the theory of evolution in general and Darwin's in particular, a theme to be taken up more strongly in Class 12.

Class 12

A wholistic life science curriculum needs to make the human being central to inquiry into the nature of life. This has been an implicit theme throughout the Steiner Waldorf curriculum from the kindergarten, articulated in ways appropriate to the age of the children.

Now, in Class 12, the issue needs to be raised in the fullest possible way so that environmental and ecological aspects can find their context within fundamental questions about the nature of the human being and the evolution of the earth. Social, political, spiritual and moral questions lie at the heart of all environmental education, and all the Class 12 curriculum themes are relevant. The focus in life science for Class 12 is zoology. The immense range of animal life is examined through considering the architecture of the main Phyla. Each Phylum establishes a new aspect of independence (e.g. from the water in reptiles, from the temperature in mammals) and consciousness (e.g amoeba, insect colonies, dolphins). The question of evolution and a detailed study of Darwinism lead inevitably to the issue of the responsibility of the human beings for the earth and for all life, now that they possess the commercial power to exploit it to extinction and tile technological power to manipulate it down to the gene The Darwinian mechanism delivers clarifying power within a certain range of phenomena, but it is rooted in reductionist thinking and Victorian ethics and young people need to emerge from school with a clear sense of its limits and the sure knowledge that new ways of interpreting nature are always being nurtured among small groups of scientists. The history of science shows that these will replace current ideas during their adulthood. The nature of the human being needs to receive the fullest consideration—a naked ape or a spiritual individuality clothed in a physical body.

Class 9,
Content suggestions:

The rationale is elaborated with some examples out of the wide range of topics that could be chosen for a particular class.

STUDY OF THE SKIN AND SENSE ORGANS

Adolescents are exploring inner and outer boundaries They are also intensely occupied with their surface appearances and their senses. The skin and the sense organs have a natural interest for them.

- Structure of skin, eye, ear, organs of smell, taste, movement and balance: adolescents are exploring inner and outer boundaries. They are also intensely occupied with their surface appearances and their senses. The skin and the sense organs have a natural interest for them.
- Health and social issues: sweat, spots, cuts, bruises, fingerprints, skin color (and racism), eye care, glasses, blindness, deafness (how do we relate to those we meet who are deaf and blind? How does society treat them?)

STUDY OF THE RHYTHMIC SYSTEM - HEART AND LUNGS

Heart beat and breathing are very direct bodily experiences and carry health issues which are relevant to an adolescent (e.g. smoking, fitness).

The central heart and the peripheral circulation need equal emphasis, with heart and capillaries as polarities. The circulation of blood is not a closed system, and the pump model is not sufficient to understand the circulation of the blood or the sensitivity of the heart to the emotions and the circadian rhythms of the hormonal and nervous systems.

- Structure and function of the heart, veins, arteries and capillaries
- The embryology of the heart and circulation
- Structure and function of the pulmonary and systemic circulation
- Composition and function of blood
- Structure and function of respiratory organs
- Lung disease—smoking, industrial disease, air pollution

This could lead on to consider many ethical / rights issue, such as:

- The change of attitudes to the protection of worker over the last century
- Our personal involvement in buying products from other countries where safety and health standards are well below what we now expect
- Present laws about the age at which people can buy cigarettes
- ‘Passive’ smoking
- The predicament of young children whose parents smoke
- The rights of non-smokers in any house community.
- Air pollution and the fact that air recognizes no national boundaries.
- Blood transfusions. heart, lung and other transplants: the reality that foreign proteins are rejected by the immune system leads to the topic of blood groups, “rhesus” babies, vaccination, AIDS and the whole nature of disease
- Illness and health; the limitations of the “germ” theory, which omits the part played by the immune system and the degree to which this is strengthened by exposure to illness. Can some illnesses (e.g. childhood illnesses, common colds) actually be necessary’? What should the role of medicine be—to ‘knock out the invader’ or to strengthen the immune system? Is health the same as the absence of illness?

Class 10

Content suggestions:

The rationale is elaborated with some examples out of the wide range of topics that could be chosen for a particular class.

The increased maturity of Class 10 goes hand-in-hand with a new stability in their thinking. They can follow more complex and abstract processes such as those in the digestive tract, where different food substances are subject to a sequence of breakdowns through the action of different enzymes. A study of the metabolic system is an appropriate challenge for them. The anatomy and physiology of the skeletal and muscle systems have received some attention in Class 8, and it may be better to leave this topic to Class 10. Although the teaching approach is different a Class 9 that has just entered the high school may not be keen on material that seems to take them back to their previous year's work. This is not necessarily so but leaving the skeleton until Class 10 also allows comparative studies with animals, which raise evolutionary considerations which can be handled in more depth at that age.

STUDY OF THE METABOLIC SYSTEM

- Food and nutrition - including cultural and philosophical values (e.g. macrobiotic / vegan)
- Organs and biochemistry of digestion– nourishment as an active process, not a passive filtering of lists of chemicals
- Liver, gall bladder, pancreas, spleen: diabetes, medically and socially
- Kidneys - no passive filtering but active, selective re-absorption

STUDY OF THE SKELETAL. SYSTEM

- Anatomy and physiology of the skeleton and muscles - polarities of form and function; those features that allow uprightness and freedom of the arms
- Comparative study of human and mammal skulls
- Joints and levers
- Bone formation and growth—aging and bone disease
- Personal health in posture (e.g. sitting and lifting)

STUDY OF THE NERVOUS AND HORMONAL SYSTEMS

This is another topic where it is hard for most adolescents to grasp more than a crude 'electric cable / computer' model until Class 10. Similarly, the endocrine system, where crude 'chemical switch' models can prevent any real appreciation of the subtle and powerful interactions of glands and organs can now be appreciated.

- Structure of brain / central nervous system cerebro-spinal fluid
- Nerve function—inadequacy of telephone / electric cable model; limitation of the motor / sensory model
- Latest research on brain function—inadequacy of the 'mapping' approach and the computer analogy
- The open questions: memory, thinking and consciousness
- The endocrine glands—sensitivity of the body to hormones (e.g. growth, excretion); special influence of the pituitary; ovulation and menstruation

STUDY OF EMBRYOLOGY

Hormone influence leads naturally into a study of human embryology, a rich area for Class 10, and again one which demands the emotional and intellectual maturity that has been achieved by most pupils by the end of Class 10. The ability to follow the development of several features at the same time, to appreciate the transformations of shape and size, to relate to the responsibilities and the issues involved in sexual relationships and parenthood, demands that the young people have emerged from a general phase of sexual knowledge and interest. A number of young people in Class 10 will have entered a serious relationship, and for those who have not, the prevailing mood of a Class 10 is usually one in which both sexes can feel comfortable in asking questions and stating their opinions, without fear of the crudities that are more prevalent in Class 9. While it is assumed that all young people of this age are fully conversant with 'the facts,' it can also be surprising to find there are confusion and misunderstandings, too. If the mood of the main lesson is one of genuine respect for the developing body of a unique individuality, deep questions can stir in the young person, along with the sense of wonder for the way in which conception, gestation and birth take place so smoothly.

Child development and the idea that we continue to grow inwardly our whole lives, with new crises and new opportunities, can help to balance the picture young people can have that 'growing up' is all about getting to be 18 or 2 1. The knowledge that their mother and father may be going through the physical and psychological passage of menopause and mid-life could contribute to their finding a new relationship with their parents. It would also help to change their perception of old people, whose inner needs are not so easily perceived as their more obvious outer ones.

- Pregnancy and birth—physical and emotional changes for mother arid father.
- Implantation and the development of the embryo from conception to term along with the surrounding membranes.
- Conception, abortion, embryo research, surrogacy and similar topics.
- First three years of physical and emotional development standing, speaking, memory
- Child development, personality, temperaments
- Adulthood—what is it?
- Old age

Class 11

Content suggestions:

Some examples out of the wide range of topics that could be chosen for any one particular class:

HISTORY OF THE MICROSCOPE

From the early Dutch lens makers (e.g. Lievenhoek) to the electron microscope. The scanning electron microscope reveals the richness of form, even at a magnification of 50,000. Experience in the preparation of slides allows pupils a more critical appreciation of the magnification, clarity and the color of the images and diagrams seen in books, etc.

THE PLANT CELL

- A detailed study of its main features
- The importance of the cytoplasm in relation to the nucleus
- Mitosis and meiosis
- Sexual and asexual reproduction
- Boundaries of plant / animal (e.g. Euglena, Chlamydomonas)

GENETICS

- Mendel's experiments and their modern interpretation in breeding
- Chromosomes, genes, DNA: the essential features of genetic engineering

CLASSIFICATION

- Features of some of the major phyla: algae, fungi, lichens, ferns, mosses, grasses, conifers, flowering plants

ECOLOGY

- The role of plants in photosynthesis, decomposition, and nitrogenation within the carbon and nitrogen cycles and in the hydrosphere
- Relationship to animals (e.g. seeds / herbivores / pollination)

PLANT / INSECT RELATIONSHIPS
• Examples of unique interdependent relationship.

PLANT AND LANDSCAPE
• The precious nature of soil structure and its community of organisms
• Trees, grasses, and soil erosion on a small and large scale
• Diversity in forests and animal habitats
• Monoculture and overgrazing

EARTH AS BIOSPHERE
• Consideration of the whole earth provides a balance to the microscope and genetic details.

GOETHE'S BOTANICAL STUDIES
• An historical and practical introduction to a Goethean approach to plant and landscape observation. Current research along the same line.

AGRICULTURE AND FORESTRY
• A consideration of the degree to which cultivation of the plant world has been distorted by other values, (e.g. consumerism) and how the distribution of plant resources (e.g., food, timber) over the world is subject to commercial and political factors (e.g. the patenting of genes and terminator technology).

Class 12

Content suggestions:

Some examples out of the wide range of topics that could be chosen for any one particular class.

Some of the Botany could be carried over from Class 11, but the main focus for Class 12 is Zoology, with an introduction to the main phyla and their diversity.

The opportunity should also be taken to select detailed features which touch key issues in biological theory and raise fundamental questions about the relationship of human beings to the animal world.

Some examples below:

- *monifera* (sponges)—the sieving of a sponge through a nylon mesh and its ability to regenerate as a colony with form and function
- *coelenterata* (hydra)—the ability of the sea slug to ingest hydra without triggering the nematocysts, then to use those nematocysts within their own skins as a defensive mechanism
- *mollusca* —the unexpected complexity of the eye of the squid, which anticipates the mammalian eye well before the evolution of mammals
- *arthropods* —the complex structure of hives and colonies; metamorphosis and the re-constitution of living organisms
- Echinodermata—the embryonic development of the starfish shows that lateral symmetry (fundamental to the architecture of higher animals) develops first before radial symmetry overwhelms it.
- Vertebrate development from the point of view of an increasing independence from the environment, e.g. regulation of warmth and the internalization of organs such as the lung.
- Evolution, including a historical appreciation of the development of a Darwinian interpretation of evolution, the fossil record, and such anomalies as the Burgess Shale.

- Comparative embryological development and the polarity of precocial and altricial development
- Ethical questions of biological and medical intervention in human, animal and plant life
- Conservation and human responsibility for stewardship of the earth's biological resources - philosophical, economic, political, social aspects of environmental degradation. The task of education and the urgency of changing attitudes. The role of tourism and consumerism on world habitats.

Field Trip Questions

Observations you might ask the students to take notes on during a field trip to an aquarium.

First, select two separate fish and observe them for as long as possible noting:

- How does the fish initiate movement?
- How does the fish maintain position in the water?
- What are the color and position of the eyes? Describe their movement.
- Describe the number and position of the fins. What is each used for?
- Can you identify the lateral line?
- Describe the scales.
- What are the color patterns in the dorsal and ventral fins?
- How does the fish you are observing interact with other organisms?
- Describe the mouth. Do you notice special adaptations or shapes? Are teeth visible?
- Do you notice nostrils?
- Do you notice an operculum or gill slits? Are gills visible?
- Are there any special shapes or special organs such as photoluminescent structures or lures?

Books

Recommended as reading material by David Mitchell and Andy Dill

Grade 9 Physiology

Many (8) one-page scientific sheets about the body and health are distributed.
The students are asked to summarize each page into two sentences.

Many handouts on current findings about the body.

Grade 9 Chemistry

Many biographies of men and women scientists.

Grade 10 Embryology

A booklet entitled *The Gene* , a Hawkhill Learning Power Book

Human Hormones by Claude Villee, Jr, put out as a Carolina Biology Reader.

The Man Who Mistook His Wife for a Hat by Oliver Sachs

"Mechanism of Pancreatic Secretion" by Bayliss and Starling

"Internal Secretion of the Pancreas" by Bating and Best

A large assortment of Carolina Biology Readers are made available.
The students must write a summary of one.

Several folders of current clippings (from magazines and newspapers) are made available. They choose one topic to study in more depth to write a report and give an oral presentation.

Many handouts on current findings about embryology.

Grade 11 Cytology/Botany

The Lives of a Cell by Lewis Thomas

Selections from Darcy Thompson's *On Growth and Form*

"Faith in a Seed" by Henry David Thoreau

Great Experiments in Biology, Prentice Hall. 1955. Readings of Hooke and Schwann

Letters by Antoine von Leeuwenhoek

Many handouts.

Grade 12 Zoology

Under the Sea Wind by Rachel Carson

The Edge of the Sea by Rachel Carson

The Sea Around Us by Rachel Carson

The House of Life: Rachel Carson at Work by Paul Brooks

"Four Legs Good, Two Legs Bad" by Matt Cartmill,*Natural History,* 11/83

"The Evolution of Life on Earth" by Stephen Jay Gould, *Scientific American*,
October 1994.

"How Did Life Start" by Peter Radetsky, *Discover,* November 1992.

The Magic Mountain by Thomas Mann—extract chapter "What is Life?"

A Sand County Almanac by Aldo Leopold

"Darwin's Mistake" by Tom Bethell

"Darwin's Untimely Burial" by Stephen J. Gould

Many handouts on current findings about animals and comparative anatomy.

Reading List of Recommended Books from Keith Badger

Bushcraft by Mors Kochanski
Roots of Survival by Joseph Bruchac
Jungle Lore by Jim Corbett
Camping and Woodcraft by H. Kephart
Bird Track and Sign by Mark Elbroch
Tracking and the Art of Seeing by Paul Rezendez
The Wild Within by Paul Rezendez
Reading the Forested Landscape by Tom Wessels
Book of Woodcraft by E.T. Seton
Education of Little Tree by Forest Carter
Earth In Mind by David Orr
Trees in My Forest by Bernd Heinrich
The Keepers of the Earth by M.J. Caduto and Joseph Bruchac
The Keepers of Life by M.J. Caduto and Joseph Bruchac
The Keepers of the Animals by M.J. Caduto and Joseph Bruchac
The Book of Buckskinning by Rebel Publishing Co.
*The Traditional Bowyers Bibl*e by Bois d'Arc Press

Everything by Henry David Thoreau and John Muir

By Tom Brown: *The Tracker*
The Quest
The Journey
The Vision
The Science and Art of Tracking
The Field Guide Series (7 volumes)

Periodicals:
Wild Earth
Journal of Primitive Technology
Wilderness Way
Primitive Archer
Orion
Orion Afield
Northern Woodlands

Some other books recommended by other colloquium participants

Eastern Tidepool and Reef–North Atlantic Marine Life by Dr. C. Harvey Clark, ISBN #0-88839-406-3 available from Hancock House Publishers, 1431 vHarrison Ave, Blaine, WA 98230-5005 Note: There is also a West Coast version.
The Wholeness of Nature by Henri Bortoft
Genetics and the Manipulation of Life by Craig Holdrege
How the Leopard Changed its Skin by Brian Goodwin
Guide for the Perplexed by Schumacher
The Vessel in the Fire by M.C. Richards
Origin of Species (abridged) by Charles Darwin

Hartmut Döbel adjusting a stereoscopic microscope.

Andy Dill focusing in on a Storksbeak seed.

Kenneth Melia providing equisitum spores for microscopic observation to Jim Henderson and Keith Badger.

Translated by Timothy Cox from "Die Vorgeburtlichkeitdes Menschen—Der Entwicklungsgedanke in der Embryologie" (Human Prenatality -—The Idea of Evolution in Embryology, Verlag Urachhaus, 1982), Chapter 2

Basic Gestures of Human Embryological Development

by

Wolfgang Schad

In the beginning, there is the union of the egg cell with a sperm cell. Already in this statement, there is not only an observation which was first made for humanity under a microscope in 1944, but also a sweeping principle: the concept of the cell. In this view, a great variety of different structures have come to be considered as cells, since 1839 when Theodor Schwann proclaimed that all plants and animals are made up of them. A cell is any structure which has cytoplasm, a nucleus, and a membrane which demarcates the whole. The *general cell theory* (i.e. that all organisms are comprised of cells), which was proposed by Schwann and which is still advocated in textbooks to this very day, is untenable in the cases of plants, animals, and the human being. Very commonly, tissues consist of multi-nucleate structures whose individual nuclearcytoplasmic regions are not bounded by membranes. Such "plasmodia" comprise, for example, the fibers of the entire transverse voluntary musculature of the human body, and that is a significant volume. There exist very highly developed sea algae, for example, the siphon algae *(Caulerpaceae)*, which are comprised entirely of a single conterminous plasmodium with several hundred thousand nuclei. Upon closer inspection, it is not the case that there is a complete separation between the cells in even normal so-called cellular tissue, or otherwise their close cooperation would be impossible. Between them, there are countless cytoplasmic bridges (plasmodesmata—see fig. 2), which in fact not only functionally, but also morphologically, spring beyond the defined cell principle. A sheer aggregate of independent cells living next to each other would not yield an organism, but only a "colony."

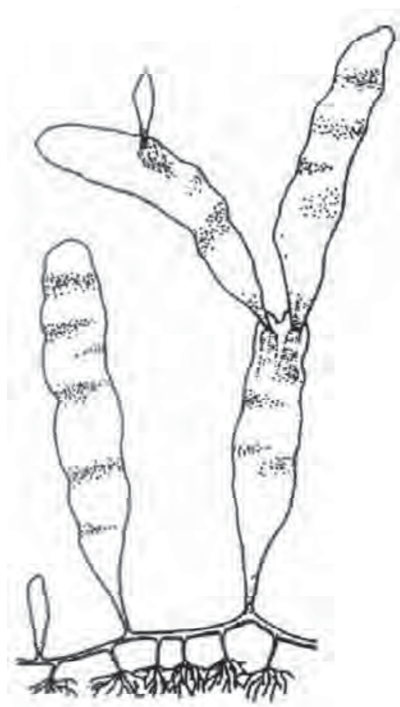


Fig. 1. The siphon algae Caulerpaceae becomes as big as a hand and despite all branching consists of a single contiguous cytoplasm with countless nuclei (After Schenk.)

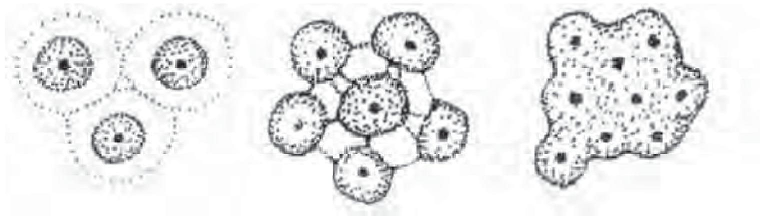


Fig. 2. Multi-nucleate structures. Left: Colony of single cells, living independently of each other, which are here externally held together by dead, excreted gelatinous substance. Middle: Tissue of "cells" which stay connected through cytoplasmic bridges (plasmodesmata). Right: Plasmodium (formerly also called syncytium) consisting of a single common cytoplasm with multiple nuclei.

Only the inclination toward atomic thinking, which would like to build life up additively out of individual building stones, gives the cell theory any right to survive, not the reality. An unconsidered, unconscious wish not only to understand the biological world additively, but also to create it in this way and so to be able to manipulate it artificially was the father of this thought. However, observation shows that all organisms which are composed of true tissues organize these tissues in a state between that of sheer cell colonies and of contiguous plasmodia, a state which allows the cytoplasm associated with a particular nucleus not only to collect around it but also to maintain a connection to neighboring nuclear-cytoplasmic regions. This thoroughly rhythmical, intricate construction can end, on the one hand, toward the extreme of plasmodium (e.g. most of our musculature), or on the other hand toward the extreme of single cells (e.g. gametes). In the first case, after nuclear division, no cytoplasmic division takes place, but in the second case, the complete separation of cytoplasm occurs.

Therefore, a general cell theory of organisms is untenable, unless we take "cell" to mean what the astute botanist Julius Sachs described as the "energide" in 1892: the functionally close connection between a nucleus and its directly adjacent cytoplasm, regardless of whether this is morphologically wholly, partly, or completely divided off from the neighboring energide. In fact, cells are spoken about today in the sense of energides, inexact as that may be. Here we must again learn to link the living connections which nature reveals, in order to get away from "thinking with bricks."

A further important observation was made by Richard Hertwig in 1884. He noticed that in most living tissues the size of the cell nucleus remains in constant proportion to its associated cytoplasm, this constant varying only according to the species. A larger cytoplasm will have a larger nucleus; a smaller cytoplasm a smaller nucleus (law of the species-specific ratio of cytoplasmic to nuclear volume). Now at the formation of the sex gametes, where the organism always, without exception, reproduces the unicellular state, the constancy of the nuclear-cytoplasmic relation conspicuously fails. The ovum becomes an ovum through the very process of forming so much cytoplasm that it cannot maintain the normal relation with the (actually relatively large) ovule nucleus (polar body). The sperm cells on the other hand reduce their share of cytoplasm so much that it comes to surround the cell nucleus only as an extremely thin hull and braids itself together to form the flagellum.

In the case of the female cell, the nuclear-cytoplasmic proportion polarizes toward the cytoplasmic; while the spermatozoa polarize toward the nuclear. In 1841, this characteristic of the sperm was first noticed by Kölliker, and of the ovum by Remak. When Lothar Vogel, therefore, sees the loss of cell nature in mature sex gametes, it is an overstatement, since all constitutional parts of a cell remain present. And yet, the harmonic co-ordination of organelles inherent in normal living tissue has been lost in both types of cell.

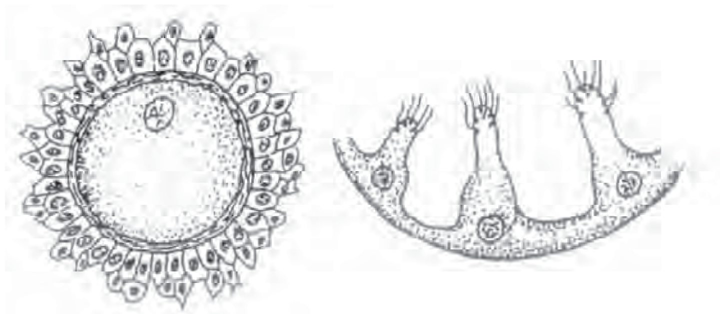


Fig. 3. Left: Ripe human egg cell after ovulation, surrounded by the narrow zona pellucida (a transparent gelatinous envelope) and many low-cytoplasm nurse cells, together forming the corona radiata which had taken part in the maturation of the egg cell. Right: Sertoli plasmodium from the lining of the seminiferous tubules, in whose cytoplasmic projections the sperm cells reach maturity,

It is even more telling to note how the organism can form such polarization in the first place. Namely, the sperm cells can only ripen in plasmodium, in the so-called Sertoli "cells," which meanwhile become conspicuously rich in cytoplasm, while helping the many sperm cells reach maturity in a cytoplasmic process. The egg cell, on the other hand, develops with the help of the cells surrounding it, the "corona radiata," which is made up of large numbers of nuclei with little cytoplasm. The nurse cells corresponding to each type of germ cell complement what the ripening sex cells themselves are lacking! But in this way, the human gametes can polarize themselves so extremely that a sperm cell represents only $^{1}/_{100\,000}$ of the volume of the egg cell.

At conception, a biologically exceptional process occurs. Every higher organism (as is generally known from the difficulties involved with organ transplantation) rejects and destroys every kind of foreign protein through immune reactions. Yet even if they originate in different individuals, the living chemistry between egg and sperm cells do not mutually exclude each other. This means that the individualized albumin structure appropriate to the mature organism does not yet exist: it has actually been suspended with the breakdown of the ratio of cytoplasmic to nuclear volume. Rudolf Steiner often spoke of a "chaotification" of the germ cell albumen (GA 205, 226) The direct expression of this is the possibility of foreign insemination.

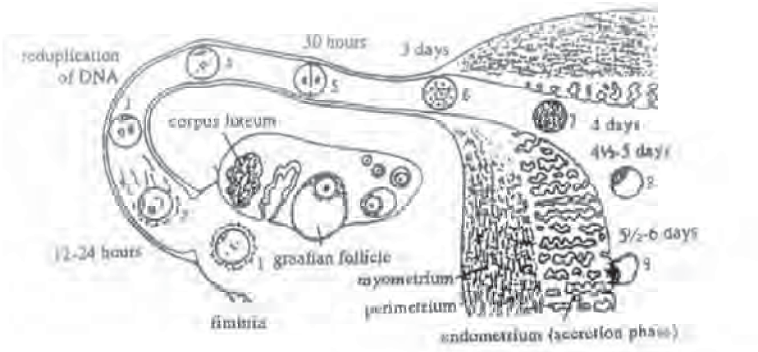


Fig. 4. Early development and path of the human germ cell in the first week from ovulation (1) until implantation (9). (From Langman)

At the moment of conception, the reception of the sperm nucleus mitigates the relatively short supply of nuclear substance in the ovum. In the process of cell division which commences immediately, the cytoplasm, still by far the greatest proportion, now becomes distributed among the quickly multiplying nuclei, but the volume of cytoplasm does not increase. This so-called cleavage process has the effect of re-establishing the normal ratio of cytoplasmic to nuclear volume. By experimentally changing the quantity of cytoplasm in fertilized animal eggs (e.g. of sea urchins) through the removal of egg fragments, fewer nuclei and thereby fewer cells form: the cell count is related to the ultimate quantity of egg cytoplasm (Seidel 1953). After restoration of the ratio of cytoplasmic to nuclear volume, the further development proceeds according to the tight interplay of both active polarities. From now on, it is possible to speak of ectodermic tissue capable of organization. The cytoplasm lives in a temporal rhythm and becomes the space in which the etheric can intervene. The nuclei convey the supertemporal species-specific order and all astral access, presuming it is already allowed to bring in the anthroposophical terminology.

The first cellular structuring of the developing organism is, therefore, and this must be pointed out with all its consequences, not an accretive *addition of* cells, but rather a *division,* beginning with the unity of the fertilized ovum and leading to the multiplicity of twelve or sixteen individual blastomeres which constantly remain in contact with each other. This uniformly large mulberry, the morula, passes along the uterine tube to the uterus, moving forwards by means of the beating of the ciliated epithelium of the inner lining of the uterine tube. Thereby, through the release of transmitters, there is already a fully fledged mutual contact with the maternal organism along the humoral pathway. Thus, the travelling zygote is affected by the ovarian corpus luteum hormones, and the corpus luteum is conversely influenced by secretions of tinorula (Seidel 1968).

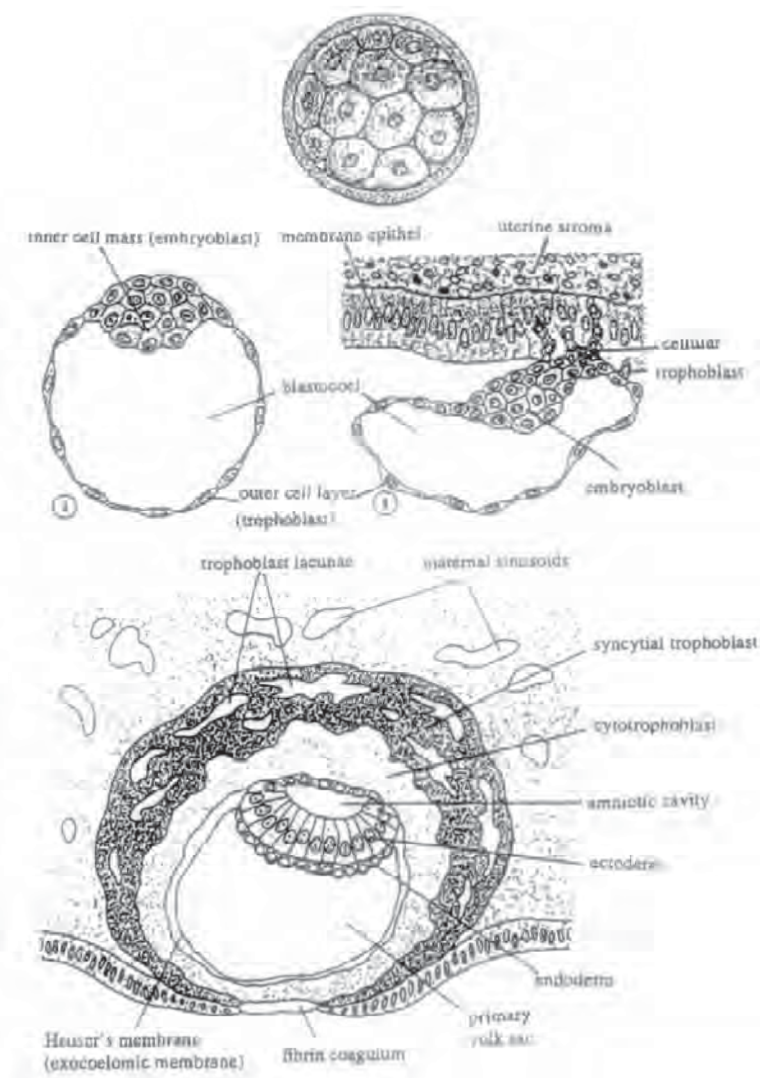


Fig. 5. Early embryonic stages.
Top: Human morula on the fourth day, still surrounded by the zona pellucida, which later disappears. Middle: A human blastula (blastocyst), about 4 – 4 1/2 days old; B. Beginning of the implantation of the blastula of a rhesus monkey. Bottom: Human blastula, (about nine days old, after successful implantation in the uterine mucous membrane. The embryoblast has differentiated into ectoderm (with first amniotic cavity) and endoderm. (From Langman).

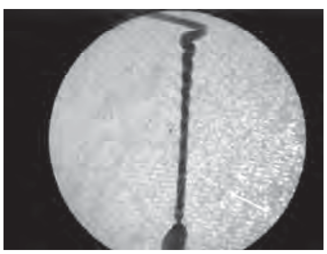
With the loss of the zona pellucida on approximately the fifth day of development, a second structuring occurs: the fluid-filled spaces between the blastomeres flow together to form a cell-free cavity, turning the morula into a blastula. Thus, nearly all the blastomeres collect together into a strong, enlarged surface, the trophoblast (ectodermic nutrient layer), and the embryo begins to expand. Simultaneously, however, it keeps a small portion of cells, the embryoblast (inner cell mass), compactly together. But in fact this does not transform into the actual embryo, but for the time being merely into further inner cavities: the amnion and the yolk sac. Research on mammalian embryos has shown that the trophoblast and the embryoblast cannot continue to develop independently of each other; they mutually depend on one another for their existence (Petzoldt).

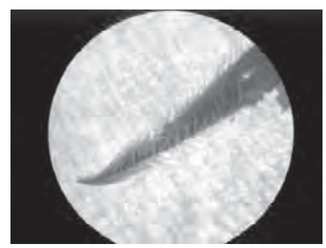
Toward the end of the first week, on the sixth day, the blastula affixes itself to the upper inner lining of the uterus and becomes covered by a mucous membrane. With implantation (nidation), an intensified contact with the maternal organism begins through direct tissue adjacency. Theoretically, due to the genetic make-up of the sperm cell, the mother's body should reject this foreign embryo through a violent immune reaction, just like with every other foreign protein. This actually does occur in rare cases such as immunologically instigated sterility. But in general, the immunological defence system of the maternal organism is obviously inhibited, or otherwise the development and functioning of the placenta, which binds mother and child over a period of many months, would be impossible. Furthermore, it is important that the implantation normally succeed in the upper part of the uterus, not according to gravity. If it were to implant lower at the cervix, the placenta previa would develop blocking the birth canal, located so as to be mortally dangerous at birth if not surgically ameliorated.

As already mentioned, after implantation further cavities form in the embryoblast of the blastula: the amniotic cavity (amnion), in which the future embryo and foetus will float weightlessly in the amniotic fluid, and the yolk sac which will function as the first location of blood formation, and also as an embryonic hormonal gland. The decision about whether the embryo will become identical twins, triplets, etc., is made by about the twelfth day, depending on whether the dividing blastomeres of the embryo form multiple embryoblasts or yolk sacs For human beings, it is known that up to monozygotic quintuplets can develop (Starck). Today increasingly more nonidentical (fraternal) twins, triplets, etc., are being born, where treatments with ovulation stimulating hormones are undertaken or when polyovulation occurs in compensation for residues left by ovulation inhibitors. The frequency of twins is about 1% of all births, and of these only 20% are identical.

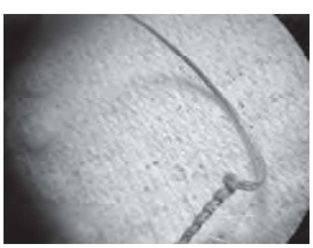
Up to the twelfth day, it is not only decided whether the embryo will develop into a single individual or into multiple individuals, but also whether the actual physical development occurs at all. If not, the embryo remains as a blastocyst, which shortly dies; the substantiated estimations of embryologists seem to indicate that about half of all embryos atrophy in the early stages of their development and are expelled unnoticed with menstruation (Langman). However, if multiple yolk sac complexes do form at the amnion, identical twins, etc., will develop. Toward the end of the second week, the embryo finally becomes determined as an independently living organization.

But now, from where does the physical development actually proceed? Precisely at the still extremely tiny surface of contact between the amnion and the yolk sac. The amnion portion will become the initial outer skin (the ectoderm), and the upper skin, nervous system, and part of the sense organs will arise from it. The yolk sac will become the "inner skin" (the endoderm), which will develop into the entire digestive tract with all its auxiliary organs (liver, gallbladder, pancreas). During the first half of the third week, the middle germ layer, the mesoderm, works its way from the outer epiblast of the embryo (from the trophoblast), over the body stalk, to form a layer between the ectoderm and the endoderm. At the same time, however, the cells of the middle layer ingress from the posterior ectoderm (out of the primitive streak) and later out of the anterior ectoderm (mesectoderm of the neural crest) into the mesoderm. This layer will become the most important organ of the rhythmical system: blood circulation, heart, musculature, bone system, kidneys, and genital organization. The lungs likewise arise as an “intermediate” formation out of the transitional region between the pharyngeal ectoderm and the upper esophageal endoderm.










Various microscopic views of the Storksbeak seed. Notice the tip (upper right) which drills into hard soil aided by the rotation of the spiral coil which spins as the wind fans the top.

A poem by Pablo Neruda

Maremoto

Los relojes del mar,
]as alcachofas,
las alcancías con sus Ilamaraclas,
los bolsillos del mar
a manos Ilenas,
las lámparas del agua,
los zapatos, las botas
del océano,
los cefalópodos, las holoturias
los recalcitrantes cangrejos,
ciertos peces que nadan y suspiran,
los erizos que salen
de los castaños del profundo mar,
los paraguas azules del océano,
los telegramas rotos,
el vals sobre las olas,
todo me lo regala el maremoto.

Seaquake

The clocks of the sea:
the artichokes,
the blazing money boxes,
the pockets of the sea
full of hands,
the lamps of water,
the shoes and boots
of the ocean,
the mollusks, the sea cucumbers,
the recalcitrant crabs,
certain fish that swim and sigh,
the sea urchins that leave
the deep sea's chestnuts,
the ocean's azure umbrellas,
the broken telegrams,
the waltz over waves,
the seaquake gives all of this to me.

The following rough translation is provided for colleagues to work with. We would be happy to provide revisions as people send us corrections. Please contact me if you would like a copy of the German text.

— DSM

Charles Darwin

by

Wolfgang Schad

Charles Darwin first studied medicine at Edinburgh and then, on the advice of his father, he studied theology at Cambridge. The works of William Herschel and Alexander von Humboldt came into his hands there and, by his own admission, caused him to decide to become neither a doctor nor a minister but rather to strive for a career in science (Schweber 1978, 323). The most important empirical prerequisite for that choice brought about his participation on the five-year voyage around the world from December 27, 1831 until October 2, 1836. After his return, crucial questions arose from the observation material. His future theory that later made him so famous had not yet occurred to him during his travels. Many have puzzled over the matter and much has been written on the subject of if and to what extent the basic ideas of his theory of evolution Darwin discovered on his own or took over from others. There is much that speaks for the assertion that the central ideas developed within him, but that he was only certain of those ideas once he had discovered them by others and could then become more specific.

At that time England's natural science did not offer a well-prepared soil in which to receive Darwin's theory. H. Hauff (1840, 202) wrote:

> Only in England do a portion of the natural scientists still stubbornly cling to the letter of the law, which probably stems from the fact that so many of the teachers of natural history are ministers of the Episcopalian Church.

The naturalists Buckland, Sedgewick, Concybeare, Whewell, and Henslow, etc., were priests in the Anglican Church. The latter was Darwin's botany teacher at Cambridge and became his most important mentor, who also conveyed the offer of the world voyage to Darwin. In Germany the materialism controversy beginning in 1840 surrounding Feuerbach, C. Vogt, Buechner, and Moleschott, etc., prepared the way for the rapid acceptance of Darwinism after 1860. Even most of the physicists in England, with the exception of John Tyndall (1820–1893), long rejected his major work (Pulte 1995, 113). The new opinions, already at that time, of Charles Lyell (1797-1875), founder of actualization in geology, met with much public refusal.

> Uniformitarianism and Plutonism were looked upon with aversion and horror as subversive of religion and morality. (Judd 1911, 25).

After the long voyage, the following two years of 1837 and 1838 were decisive for the development of Darwin's ideas. Schweber (1977, 1978) emphasized that for the strengthening and clarifying of these ideas, as is known, Thomas Robert Malthus played a role but also the Scot Adam Smith (1723 – 1790), and the Frenchman Auguste Comte (1798 – 1857) had a substantial part. It was a review of works by Pierre Simon de Laplace (1825) and Auguste Comte (1838) in August of 1838 by David Brewster that informed Darwin of Leplace's cosmology and Comte's discussion of planetary movements. With that, Darwin's theological conception of the world was finally replaced.

In September of 1838 he came upon the book by Malthus (1826) which contained a mathematical model of population dynamics: human population increases in geometric progression (doubles every 25 years), but the increase in food supply progresses mathematically. Through that, the fight for resources and survival is automatically programmed. The basic idea that everywhere in nature the number of offspring is more than what can grow to maturity was made known to Darwin already as a student in Cambridge through a book by William Paley (1743 – 1805), *The Natural Theology*, and also during his travels in Buenos Aires from the writings of Alexander von Humboldt (1769 – 1790), *Political Essay on the Kingdom of New Spain* (1833). Benjamin Franklin ((1706 – 1790) had also already spoken of Malthus (Timiriazev 1939 / 1940, 118). However, the theoretical relevance of this idea to his questions of evolution, especially through the mathematical form offered by Malthus, only sparked for Darwin after his return. Malthus concluded from it a pessimistic picture of society, while, as is known, already in 1776 Adam Smith (1723 – 1790) conversely saw a positive possibility of improvement in economic life. Darwin was obviously subscribing to Smith when he attributed automatic progress in nature to natural selection (Schweber 1978, 325). What the market was to Smith, natural selection was to Darwin. From his view, it takes hold at the individual level rather than at the species level (Darwin 1859, Chap. 3; see also Ruse 1980). It remains unclear whether the "individual" of Darwin's evolution was meant to be somatic or in the sense of genetic makeup, since he did not yet know of Weismann's distinction. The discussion of whether Darwin's selection takes hold of single hereditary factors, genetic properties of individuals or the entire gene pool of a species, has never ceased since Darwin's works contain arguments for all three viewpoints. In his Lamarck-like hypothesis of heredity (1868), the "gemmules" represent a kind of hereditary factor. As an empirical macro biologist, he stayed with the visible individual and, taking over the thoughts of Malthus, he thought in terms of dynamic populations. Dawkins (1978, 1988) recognizes only the active, self-replicating "Keimbahn-Replikatoren" (Trans. germ course replicators), because only they are genetically and therefore evolutionarily relevant.

Darwin's concept consists of five different theory complexes that don't have to be accepted or rejected all together as is clarified by Rudolf Schmidt (1876), Ernst Haeckel (1878), Theodor Pinter (1910), and recently, Ernst Mayr (1985).

1. Evolution theory as such (species mutation).

2. The theory that all organisms come from common ancestors (Realgenese trans. real genesis).

3. The inheritability of changes in small increments (gradualism).

4. The theory of new species splitting off from old (divergence).

5. Natural selection.

All five theorems could already be proved before Darwin's "Origin" of 1859—so also natural selection as a factor of evolution from Alfred Russel Wallace (1858), Edward Blyth (1835) and Patrick Matthew (1831) (see Bowler 1988), and, as we have already seen, with Maupertuis (1756) and La Mettrie (1750).

Darwin was not the original creator of these concepts, but was rather the one who first bundled them together as well-thought-out ideas, supported by material facts and indications of a never before realized proportion and so brought them into the scientific discussion once and for all.

Darwin's original intention was to write a much more detailed presentation with the title "Natural Selection." However, after A.R. Wallace returned from his trip to the Malaysian tropics with the same theory of selection, Darwin decided upon a one-volume edited version: "*On the Origin of Species by Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life" (1859).* The more detailed original version was first made available in 1975 by Stauffer.

The epic-making work quickly found the widest circulation, not only in England, but in all of Europe and beyond, in part because it finally presented a clear concept for the question of cause and also because it became a provocation for the creationists. Darwin followed a purposeful strategy of circulation in that he directed his publisher to send 90 free copies to leading scientists at home and abroad. But still, even his closest fellow combatants had various reservations, the working through of which occupied Darwin's remaining years of life.

1. Charles Lyell (1863) accepted the theory of evolution, but required from sources outside of Darwin's influence, he produced experimental evidence proving species mutation through variation and selection (not through hybridization). The same from Huxley (1860, see 1893, II, 22 – 79) and Quatrefages (1877, 73).

2. Thomas Henry Huxley accepted the fact of natural selection only as one among others (Bowler 1988, 76).

3. Alfred Russel Wallace (1864, 1870) in contrast, never even went along with the Lamarck-like components of Darwin, but rather maintained that the theory of selection was strictly only applicable to nature and just as strictly rejected the use of biological selection as an explanation of the cultural evolution of humankind.

4. Joseph Dalton Hooker (1859 / 1860) and Wallace (1870) took exception to the all too anthropomorphic terms that, without an explanation of those terms, was carried over to nature; such as "breed choice," "the struggle," and "higher development" (see also Todes 1995 and Young 1985). Who is it then that "chooses?" (Flourens 1864).

5. The botanists criticized the fact that almost all the supporting evidence in "Origin" was taken from zoology.

6. Scientific methodists like John Frederick Herschel, John Stuart Mill, and William Whewell, complained that the premises of induction in the sense of Bacon's scientific method were not adhered to, so that the basis of induction was too small for such an all-inclusive generalization as the whole of evolution.

7. The coincidental appearance of variations within the offspring of every generation is no useful foundation for a sure theory (Pulte 1995, 117).

How did Darwin react to these objections?

1. Darwin agreed there was a lack of experimental evidence. However, he pointed out the needed time span for such an experiment was far and above what was available and could not, in principal, be delivered.

2. Darwin later distanced himself from declaring that only his concepts were valid:

   > Hence if I have erred in giving to natural selection great power, which I am far from admitting, or in having exaggerated its power, which is in itself probable, I have at least, as I hope, done good service in aiding to overthrow the dogma of separate creations. (1871, I, 153)

3. In spite of personal conversations with Darwin, Wallace did not change his mind. (Harvey 1995, 241). "Social Darwinism" is therefore a valid description, even if it contains elements of social Lamarckism, since Darwin himself in *The Descent of Man*

often uses Lamarckist procedures of reasoning. To another point, Darwin regretted the medical assistance afforded to the weaker ones, considering the evolution of humankind, without wanting to prevent it. (1871; 1992, 148)

4. Darwin pointed out the metaphoric in the commonly used man ner of speech that the comprehending reader would take into consideration (1859, Chap. 3).

5. From then on, much of his research was dedicated to botanical themes, such as the flowering ecology of orchids, the growth and stimulated movement of climbing plants, the trapping abilities of carnivorous plants, as well as cross-breeding experiments with plants.

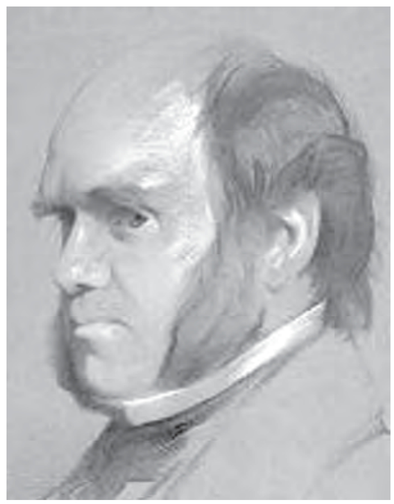
6. Even the extreme inductionist Bacon acknowledged the value of deduction when he spoke of "*stepping down to experimental applications*" (see Hull 1995, 76).

7. Darwin willingly admitted that he didn't know the cause of variation but only the fact of it. "Coincidence" means here only the uncertainty of the knowledge of the cause of variation. What now still appears to us to be coincidence must not necessarily be so in itself (1992, 153).

With that, suggestions for research after Darwin were cast, so that we must now differentiate between old and neo-Darwinism. On the one hand, conclusions of Darwin from his later experiments and theoretical explanations that are outdated, such as his pangenesis theory of heredity in which Lamarck as well as Darwin assume heredity of somatically acquired qualities, had to be eliminated. On the other hand, categorical ambiguities had to be eliminated. Darwin's views contain holistic, probable, plausible and descriptive features (Pulte 1995, 121). With the first German recipients, with Carl Gegenbauer and Ernst Haeckel, a mixture of evolutionary and typological thought patterns are present, which is why they described Mario di Gregorio (1995, 50–51) as a semi-Darwinist. Thomas Huxley, Darwin's great defender, stood for the assumption of evolution even without himself ever accepting the theory of natural selection and is therefore named by Bowler (1988, 76) a pseudo-Darwinist.

The word "Darwinism" was first used in Germany in 1861 by Rudolf Wagner. What we understand today as Darwinism is something devoid of all Lamarckism that is presented in order to have a foundation to address questions of interest to us and help satisfy our need for explanations.

More than ever the question remains, why did Darwin's theory of natural selection have an immediate and epochal effect? Its success is certainly founded on many layers of circumstances. For one, it fell at a time of appropriate expectation among the scientific community. Theoretical and practical economic liberalism had given up their sociological cover (Nordenskioeld 1926, 469, Rieckmann 1938, 62). Through natural science, Darwin was able to convince by the dissolution of teleology through a long-awaited (for the question of evolution) linear causality and thanks to his wealth of factual material gathered over a period of decades.



CharlesDarwin

The Development of Neo-Darwinism

by

Wolfgang Shad

In the following pages we will be considering seven desiderata in the light of further research.

1. The question of being able to experimentally show species mutation depends upon the view of what identifies a species as such. Micro species could be seen as members of a macro species, if fertile hybrids are produced in cross-breeding experiments. With all the morphed species in paleontology as well as with parthenogenesis, i.e. apogamic and non-sexual reproduction (especially prokaryotes, for example) a physiological species identification of a potential reproductive community cannot be secured. What is sure is that genuine, experimental, new formation into generics, families or still higher levels (if these hazy categories even allow for passable definitions), cannot be produced to this day. Darwin's concept has proven itself extremely fruitful for infra-specific "microevolution." Below the level of species, established characteristics are, in observable time frames, hereditarily capable of mutation. For the trans-specifically valid "macroevolution," however, the concept is missing experimental evidence. Also, the recently added discussion of the *Antp (antennapedia)* mutation of drosophila (Scheuwly et al. 1987), in which, after heat shock, antennae production was switched over to the development of extremities, in no way effects a change in the construction plan; comparative anatomy of the 19th century already knew that the antennae of all anthropoids are extremity homologous (Gegenbaur 1874, 251–252). Such a mutation only realizes the phonotypical development of an archaically inclined and continuously available power that has already often come under observation in nature (Balazuc 1948, Wagner 1915, Wohlbold 1941). Likewise, the reverse transformation of the holder of the back wings of the drosophila through mutation *bx (bithorax) and pbx (postbithorax)* (Lewis 1978) does not demonstrate a change in the construction plan, but rather experimentally confirms the existing homology.

Equally, the gene *Pax-6*, which is responsible for the formation of the eyes in all Metazoans, demonstrates that while it affects the eye formation, it has no specific effect on the construction plan. Under the effect of this gene, the drosophila (genetically *eyeless*) develops complex eyes, the mouse (genetically *small eye*) and humans (genetically *aniridia*) develop vertebrate eyes (Halder 1995 a; b). Structural plan specificity as a result of macro-evolutionary divergences remains experimentally open.

Peters' criticism of projecting intra-specific evolution onto trans-specific evolution remains (Peters 1972, 349–350): The complex of internal system conditions for evolution must still be deciphered. In addition, it is necessary, on the one hand, to accept the lack of experimental empiricism, for today's standards, in macro-evolutionary processes and, on the other hand, not to side-step into psychomorphe models. In the meantime, there exists an incontestable psychosomatic, however only a deep psychological reaction to the Soma—and only with the higher animals and humans. Nowhere, however, does there exist empiricism over hereditary psycho-genetic effects on the passage of germs. Every attempt to put this problem in the realm of psychology (psycho Lamarckism) does not help further here.

The experimental proof of species evolution remains bound to the question of definition, that is what can apply as species characteristic, whereby new combinations through hybridization are only seen as being within large or macro species.

2. The rationale for atele characteristics cannot be provided using the theory of selection, because the suitability of it cannot be exhibited. Therefore, only that which has turned out to be expedient but was not expediently planned, can be interpreted. Teleology is therewith not evident a priori, but only posteriori. So, the question arises if it's even about expediency at all or much more, only fitness for survival? Teleology (Pittendrigh 1958) is, however, also overtaxed when atele characteristics appear. Think of the quite general increase of repetitive non-coding DNA in macro-evolution (Alberts 1990, Voet 1992).

3. The historical justification for the term "social Darwinism" is debated. Whether it is drawn from the common Darwinism of Ernst Haeckel and his successors or from the pre-Darwin evolutionists (Sandmann 1995), one still can't get around the fact that Darwin was willing to selectively, and therefore biologically, derivate the level of culture of humankind.

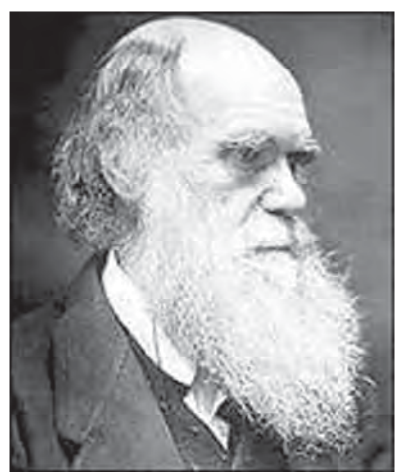
   There is reason to assume that the immunization that thousands received saved those who would have, in earlier times, succumbed to smallpox because of their weak constitution. Here it happens that also the weaker members of civilized society reproduce their kind. No one who has given their attention to the breeding of domestic animals will doubt that this must be harmful to the human race in the highest degree (1871; 1992 b, 148).

It was clear to Darwin what kind of socio-political consequences such a scientific, for him, statement could have: the organized refusal of help for all the weak and ill. So, he was also moved by the question of how that could be avoided:

> The help which we feel driven to give to the helpless is mainly the result of an instinct for sympathy which was originally attained as a part of the social instinct but later, in the above described way, became tenderer and more widespread. We can also not check our sympathy, even though it is hard pressed by our intellect, without degrading the noblest part of our nature . . . We must therefore, completely without doubt, tolerate the effect of the weak staying alive and reproducing.

He calls upon an innate sympathy which as the "noblest part of our nature," that, nevertheless, need not be pressed upon by the intellect, but rather tolerates the "effect of the weak staying alive and reproducing." The reason why an instinct against severe natural selection was bred into us by natural selection itself remains unaddressed. With that, later social Darwinism had an unanticipated argumentation placed at its disposal. The translator of Darwin's main work into French, Clemence Royer, touted naturalistic ethics for human society, not reconciled to Christian humanity, in her forward of 1862. After reading the book, Darwin declared her "the most remarkable and clever woman in Europe." Darwin said she explained "that natural selection and the struggle for life will explain all morality, nature of man, politics, etc." (see Harvey 1995, 231).

Among Darwin's personal circle, Herbert Spencer represented an unbroken validity of the natural selection oriented view of evolution for nature as well as human society, while Wallace and Mill spoke out just as strictly against equality of the two from an ethical perspective. Huxley held the view of a sliding transition. In the early stages of evolution between animals and humans, natural selection was still considerable, but then was more and more suppressed by human cultural development in support of humanitarian ethics, which strives to protect the individual in every respect. Darwin's attitude to these questions should be viewed in light of this contemporary background. Within his scientific form of thought he represented natural selection even for humans, but as a sympathetic member of society, he neutralized the same in his publications. Darwin wavered between the two positions of Spencer and Wallace. He didn't want to see his theory of natural selection, including the cultural realm, diminished, nor did he want the knowledge of the elimination of humanitarianism that he himself had experienced.



Charles Darwin

Bowler (1995) tried to protect Darwin from the reproach of social Darwinism in that he exposed Spencer's stronger position in this respect as social Lamarckism. Now, as Bowler himself stated, one can only speak of acquired and inherited qualities after Weismann's distinction between soma and keimbahn (trans. germ course) (1885) which is why Darwin often debated with a Lamarck-like slant. According to his pangenesis theory all somatically characterized genes should migrate to the propagation cells. Old Darwinism is a mixture of arguments between natural selection and Lamarckism. Each application of the evolutionary concept to humans contains the assumption of high and less highly developed human beings. To describe this assumption as social Lamarckism or social Darwinism cannot be done unequivocally before Weismann. Without question, Darwin had the larger effect on human society's sense of identify after 1859.

4. The first translators of the work *Origin* stood before the immediate semantic problem of adequately translating the central metaphors "*natural selection, struggle for existence* or *survival of the fittest*" for other languages and cultures. These metaphors originated out of human civilization (Glick 1974, Junker 1995, Todes 1995). "*Natural selection*" was a transformation of "*artificial selection*" used by plant breeders. Who now selects when there are in nature no intentional, choosing subjects? Pierre Flourens (1864) immediately questioned. "*The struggle for existence*" was a metaphor borrowed from Herbert Spencer (1852) out of the context of ecumenical liberalism which he called "*progress through struggle.* " Who actively struggles here for their existence when the words "in order to" don't even exist? *Survival of the Fittest":* This formulation also comes from Herbert Spencer within the framework of his philosophical substantiation of mercantile liberalism. It cannot be meant as anticipatory planning in nature, but rather fitness for life based on the rate of reproduction. Then why doesn't evolution stop at the stage of prokaryote and the Protisten stage of the later Praekambriums? Today they have not only the largest reproduction rate within a time period, but also the longest survival rate in evolution. The "increasing individualization" that has recently been brought into the debate would, on the other hand, favors the development of those creatures that increasingly discard extrinsic factors. This has, at least in humans, contributed to an individualized development of teleological powers, but which plays no role in inheritance through the germ line.

The word choice brought the represented concept into unnecessary acceptance difficulties, because it perceives itself as being causal-mechanistic. Darwin immediately defended himself against semantic misunderstandings and referenced the mere metaphor (1859, Chap.4). On the other side, he later realized that it would have been better to have never introduced the all too anthropomorphically biased terms since once they were there, it was very difficult to retract them: "Talking of 'natural selection'; if I had to commence *de novo*, I would have used 'natural preservation' (see Young 1985, 95). Until today this point of criticism has not been erased, but rather unintentionally strengthened through a further increase in the militarization of language usage in evolutionary biology, because words such as *strategies*, *tactics*, *competition*, and *cleverness* were widely spoken in lieu of *selfish, ultra selfish* or also *intelligent* and *altruistic genes*, etc. And this happened not only in popularizing portrayals, but also as the accepted norm in the relevant specialist literature (i.e. Wade 1981). Paradoxically, the elimination of teleology caused an inflation of Psychismen. Even bacteria and viruses *"develop attack strategies," "use intelligent tactics,"* and *"invent advantageous weapons."* In endocytobiose the plastids are "enslaved" cyanellen. Symbiosis is a *"fighting balance"* because "*shining self interest*" lies on both sides. Such words are regarded by everyone as teleology, but one obviously can hardly get along without them.

This point of criticism would have been cleared up if, for instance, the premises of mechanistic evolution would have been helped using the vocabulary of physics and chemistry. Chemistry has long gotten away from the still much used in the 19th century metaphor "*elective affinity,*" which Darwin still used.

One finds oneself here with language in a similar situation as having a half-full glass of water. For one person, it's half-full, for the other, half-empty. The perspective of attitude determines the interchangeable garb of language. What for the one is a brutal suppression of the weak is for the other a selfless deferral to the fit. Todes (1995) recently brought out the reason that for a long time in the Russian cultural sphere it was socially justified to interpret Darwin's evidence in a diametrically opposed fashion as mutual assistance. In the 19th century the overpopulation which ruled the British Isles was eased by escaping to overseas colonies. In sparsely populated areas of Russia, on the other hand, mutual assistance was a social custom. Among many other Russian authors, it was K.F. Kessler (1880) and P.A. Kropotkin (1908) who especially emphasized mutual assistance in the animal kingdom. Recent authors like Magnus Schwantje (1952), John Wiens (1983), Martin Lindauer (1991), and Martin Novak (1995) tried to bring altruism back into the biological view. However, both the militaristic as well as the pacifistic use of language cannot be justified out of pure natural science. Here more reductionism would be in order because, on the one hand, it could de-emotionalize the debate and on the other hand, because the use of conscious or, more widespread, unconscious backward transference as an apology for human behavior is shaky on both sides. Ethics cannot be biologically justified, or if at all, then only "*morally analogous*" behavior from the animal kingdom, for example, should be spoken of in those terms (Lorenz 1956).

If we don't want to charge the 19th century alone with the state of the anthropomorphist metaphors (no matter which way they are presented) of today's biology, then it behooves us to make the, now widely established, specialty language, which stems sociologically from the political East-West tensions (especially in the second half of the 20th century), comprehendible. In spite of often opposing agendas, at closer inspection, it can be seen that science does not take place in a social vacuum. We don't need to address the subject of adequate language semantics in too detailed a manner here, but only name the desiderata that were declared immediately after 1859 and mark their position as of today.

5. In botany Darwin's reception was much more hesitant than in zoology, but it was especially successful in the areas of flower ecology and plant geography (Junker 1989, 1995).

6. David Hull (1995) rightly exposed that the strict induction method of Darwin's concept inaugurated by Bacon and demanded by Herrschel, Mill, and Whewell did not transport it into the unscientific. Scientific results depend, methodically, mostly upon a balanced use of inductive as well as deductive procedures. Every experiment is based upon deductive hypotheses, without which the conclusions of the experiments could not, inductively, be extensively evaluated.

7. Darwin called hereditary variations coincidental, because he did not yet know their cause. Carl Wilhelm Naegeli (1817 – 1881) began in 1884 to strictly differentiate between hereditary variations and non-hereditary modifications. In 1885 August Weismann (1834 – 1914), in his germ plasma theory, pointed out the fundamental difference between the germ line and soma. Only the germ line and not soma is the carrier of super-individual (trans. over or supra individual) inheritance. Experimental research thoroughly confirms Weismann's postulation. With that, Lamarck's and Darwin's assumption of the inheritability of somatically acquired characteristics was refuted. From then on one could speak of a revision of the Darwinist concept called Neo-Darwinism, a description that shaped the work of Georges John Romanes (1895, 7). Hugo de Vries (1848 – 1935) discovered an Oenothera, an inheritable variation which was first named by him mutation that positively did not occur through smooth, gliding changes, but rather in a short, sudden manner (1901). It turned out that his "new species" was either a hybrid split or stemmed from polyploidization (Renner 1917), but in spite of that, the de Vries formulation verified itself with other objects inside inheritable variations (Baur 1925). In 1927 Hermann Joseph Muller (1890 – 1967) discovered the ability of x-rays to produce mutations in *drosophila*. Further highly charged (trans. high energy?) rays (UV, *Y*) along with chemical poisons also proved to be mutagenic. With that the physical and chemical causes of inheritable variability were found, then unknown for Darwin.

A further development of classic Darwinism over and above the desiderata of the 19th century that have been dealt with was the specification of the question of what the object of selection is, exactly. As has been said, Darwin could not yet differentiate between the inheritable and the non-inheritable factors of the organism and contained himself primarily to the individual (that is, two individuals required for sexual reproduction) as the creator of its offspring. The genetic diversity that can be newly formed with every meioses and fertilization through recombinations and new combinations is, however, greater than only the two individuals, that is to say, all the individuals of the species or at least the respective population. Accordingly, the gene pool of a population is the reflex standard (trans. standard of reaction or reaction norm?) met by natural selection (Fischer 1958). If one adds to that the principles of *co-evolution* and *cooperation*, then the object of selection is *every* biotic system (genes, cells, individuals, populations, Bio-zones) as long as it's capable of information exchange (Wieser 1994, 9).

In the meantime, the formed disciplines of mutation genetics and population genetics that stood critically opposed to one another in the 1950's as "mutationists" and "selectionists" came together with the "synthetic theory" (Huxley 1942, Mayr 1963). It integrated the up and coming molecular genetics with the evolutionary concept of ecology. The germ line dynamic on the one side and extrinsic factors that affected the soma on the other side then completed and complimented each other with the appearance of mutability and natural selection of all natural organisms.

Since 1968 a new supplementation to Neo-Darwinism is in discussion through the Japanese genetic theorist Motoo Kimura. It turns out that in most instances, molecular changes to the genome must in no way change the pheno-typical character design, and that is, neutral or very close to neutral, in respect to natural selection. Therefore, often after many mutations, it comes to a selection-neutral accumulation of new inheritance patterns, until they are converted into pheno-typical changes of characteristics. With that the following facts should be made more understandable:

- the emergence of non-expressive pseudo-genes as well as all accumulation of "garbage DNA,"

- the accumulation of molecular mutations with long-term, stable phenotype, i.e. "living fossils,"

- the quickened phases of evolution in "punctuated equilibrium" by Gould and Eldrege (1977),

- the genetic basis for macro evolutionary processes of development.

Kimura summarizes:

"I place high value upon clarifying that the laws which determine molecular evolution are completely different from the laws that steer pheno-typical evolution (Kimura 1987, 268)."

With that the complex of internal systems as opposed to natural selection is given a greater authority than the synthetic theory promised it, and extrinsic as well as intrinsic factors are seen in equal interaction. The considerations that took place at that time between "selectionists" and "neutralists" are dependent upon the further opening up and clarification of the cascading effects between molecular basis and phenotypes before Kimura's suggestions can lead to a further synthesis with the "synthetic theory."

Despite increasing refinement of methodic instrumentation, the process of evolution remains conceptually unsolved. Is a respective living creature genetically independent and capable of self-reproduction in any form, or is it a complex arrangement of outside factors? In the first case one can speak of stringent survival up to an extreme interpretation of egoistical genes (Dawkins 1976). In the second case, it is as senseless to speak of fitness and survival as in the physical world. A dualism remains that is only fictively monistic. Otherwise, the teleonom-indicated-psychistically-powered metaphors would still have been easily removed.

The conflict of language can be highlighted by the following example. The mechanistic concept of life had always to deal with the conceptual difficulty presented by the word "survival," as opposed to the biotical predetermined niches, and conversely, the difficulty of describing the autonomous destructive processes which have today returned to the attention of research (i.e. apoptosis) using a neutral nomenclature.

In so far as the genetically arranged cell death in advance is understood not only as pre-programmed but even as purposeful, then one seems justified, in a legal sense, to speak of "murder," "execution," and "suicide" (Martin 1993, Scott et. al. 1996). Correspondingly, true zytotoxic T-cells of the immune system get their biologic "individuality" through "hostility to foreigners," etc. The cell is then not only given a psychological quality, but also an anthropomorphic one. Similar to social Darwinism, the first step introduced will be to make the biological anthropomorphic, and the next step will be to make the human into biological. This is not the place to politicize the problem, but rather it is our duty to inject science into it. Because of blurred premises, clarification of terms are being replaced by unclear linguistic forms. Again we come upon the smearing of the irreconcilability of causality and finality. As has already been pointed out, since both ways of thinking differ considerably in their temporal orientation regarding the need for an explanation, then the above named difficulty requires empirical and conceptual investigation into biological sequences of time.

Project #5

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