



# *In Context*

The Newsletter of **The Nature Institute**

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#44

*Fall 2020*



## The Nature Institute

Dear Friends,

When we consider the contents of this issue of our newsletter, we realize how strongly we are woven into a large community. It becomes clear that we are the beneficiaries of a rich connectedness that makes our work possible.

Take, for example, the Notes on pages 3–5 regarding Jochen Bockemühl and Michael Wilson. Bockemühl, who passed away in May of this year, and Wilson, who died in 1985, were both extraordinarily devoted and faithful observers of the natural world — Bockemühl being especially known for his studies of plant life, and Wilson for his engagement with light and color phenomena. The two of them stand among the host of individuals whose undertakings during their lifetimes provide an immensely valuable foundation for the ongoing efforts of ourselves and many others to develop the skills for a vital understanding of the phenomenal world.

Then there are all the researchers contributing to the voluminous technical literature in all the sciences. Both Steve's work on genetics, epigenetics, and evolution (see his feature article on p. 18) and Gopi's work in physics (p. 8) are thoroughly dependent on this literature. We do add different perspectives, but the entire venture would be wholly impossible if the ongoing efforts by thousands of researchers were not continually being published for others to draw upon. This can vividly remind us that we are engaged in an intensely *social* enterprise.

Craig, with his strong orientation toward the living beings of nature, certainly draws on the technical literature as well. But, happily, he need only step outside his door to find himself in some of the natural environments he loves most. Going out into nature and patiently observing an animal, or a flower such as bloodroot (p. 11), one is always “in company” — some of the most profoundly instructive company available to us.

There is also, importantly, that vital sphere in which we meet and converse with colleagues (pp. 8-9), or interact with participants in courses and workshops. We think of all the students who were important for Henrike as she developed the teaching methods leading to her workbook in projective geometry (p. 9). Engaging with people who share our interests and concerns and contribute their own points of view and experiences, enriches our work.

And, of course, there is the essential supportive connection with the readers of our publications, and all the donors and foundations that financially support the Institute each year. It is impossible to imagine how our work could be effective and beneficial without this web of interconnections. We are grateful for them all.

Warm greetings,

Craig Holdrege

Steve Talbott

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## Jochen Bockemühl: A Remembrance

JOCHEN BOCKEMÜHL (1928 – 2020) was a pioneering Goethean scientist and an influential teacher for many students who — during the past decades and around the globe — have worked with this holistic approach to science. I had the great fortune to be one of those students and then to collaborate with him on different projects.

Soon after finishing his PhD, Jochen began working at the Research Institute at the Goetheanum in Dornach, Switzerland. From 1971 to 1996 he was the head of the Institute and of the Goetheanum's natural science section. In addition to research, Jochen traveled to many different countries. He gave courses for lay people and also special trainings for farmers, pharmacists, and doctors. The weeklong seminar he gave at Emerson College (UK) in 1976 made a deep impression on me — especially his love for concrete phenomena and his commitment to explore what the sense world, rightly observed, could reveal about the deeper nature of reality.

Jochen's research up through the 1970s was on metamorphosis in plants. He carried out extensive investigations into the transformation of plants through time and included the study of changing root morphology. His special focus was the transformation of leaves. It would be a mistake to think of Jochen as “only” observing and ordering outer phenomena. It was his special strength to attend in a subtle way to how we participate in what we observe through our thinking and how the way we think affects what the phenomena can reveal. For him the transformations in the plant were not only an object of study, but also a partner in a dialogue that can help the researcher learn to think in more dynamic and transformational ways.

Though a quiet and reserved person, Jochen was at his best in seminars, exploring a particular concrete phenomenon, and observing and commenting on thought processes. I had many “aha” moments in such situations.

In late winter 1979, I was a new student at the natural science study year at the Goetheanum, which Jochen and his colleague Georg Maier led. It was a real immersion in the practice of Goethean science, and each of the 18 students carried out a research project. Jochen was my mentor and he suggested a project connected with the question of heredity, building on extensive work that he had done with the

groundsel (*Senecio vulgaris*). I was not particularly interested in heredity, but the prospect of observing how different morphological types of the plant vary under different conditions and over three generations in a year was intriguing. So I took up the project — little knowing that the topic of heredity would become a major focus of my own research over the next 30 years!



In the 1980s, Jochen began to focus more on landscapes. In the desire to meet and then articulate the holistic character of a landscape, Jochen would attend to both the details and the overall impression of a particular place or scene. He began drawing (with pastels), from memory, scenes from his experiences (see pictures on the following page). One time I was with him on a field trip in the Swiss Alps. We were

walking down a forested mountain with many larch trees. We stopped for a few minutes and looked, then continued our way down the mountain. A few days later I entered his office and to my surprise saw a finished drawing of a larch tree within the larger landscape. I realized that Jochen had the ability to really be with the things when observing; they became part of him, and in the process of drawing from memory, qualities became clear to him that he otherwise wouldn't have noticed.

After I returned to the US in 1992, I had little direct contact with Jochen. But my experiences with him and the work of the Research Institute in Dornach were a major source of inspiration for The Nature Institute. Jochen was always pushing boundaries, where something new and fresh can arise; he wanted to go deeper and tap into what is alive in the world. This entails giving careful attention to lived experience and reining in the tendency to form general, abstract conclusions. In this sense, his efforts live on at The Nature Institute. CH

\* \* \*

Books by Bockemühl that have been translated into English are:  
*In Partnership with Nature* (with contributions by students; 1980)  
*Toward a Phenomenology of the Etheric World* (ed. volume; 1985)  
*Awakening to Landscape* (1992)  
*The Metamorphosis of Plants* (with Andreas Suchantke; 1995)  
*Extraordinary Plant Qualities* (with Kari Järvinen; 2006)

# Awakening to Landscape

A short excerpt and four drawings from *Awakening to Landscape*

BY JOCHEN BOCKEMÜHL

When we appreciate the beauty of a landscape today and want to protect it, our idea of beauty is usually based on images relating to earlier conditions of life to which we long to return.

However, beauty “preserved” in the old image does not normally fit in with present-day life styles. Something comes into the picture that is not in accord with the times and we realize that it has been artificially imposed.

It would be quite a different thing if we were to see beauty in the landscape where human goals are in harmony with naturally occurring processes. In this sense, awakening to landscape also means awakening to oneself and to personal responsibility. This is the starting point for a completely new way in which human beings relate to their environment: The decaying environment is perceived as our own inadequate human nature. The seeds for a new life, seeds we can help to develop, will then be found in any place where we become aware that something wants to come into existence that has the quality of wholeness.

How can we relate to the living environment of the landscape in such a way that new beauty may arise?



Spring



Summer



Autumn



Winter

The countenance of a Jura mountain landscape in Switzerland through the four seasons, drawn from memory.

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# A Commitment to the Phenomena of Color

“Michael Wilson felt that the major theme in his life had been the understanding of light and colour.” These words were written by Wilson’s colleague Ralph Brocklebank soon after Wilson’s death in 1985 (he was born in 1901). Brocklebank continues:

He had developed a remarkably keen eye for observing and recording the ever-changing patterns and effects of sky and cloud, sunbeam and shadow, dawn and dusk, and all the phenomena of the atmosphere.

Wilson was not only a close observer of color phenomena in nature. Over decades, building on Goethe’s work on color, he created and carried out numerous experiments that show the myriad lawful relations of color phenomena and the conditions under which they appear. I had the opportunity to hear him give a talk at the University of Sussex in the UK in the mid-1970s and recall his energetic and lively presentation — with the use of many slides — on color. The lecture was in the physics department and I remember him stating at one point late in the talk: “You see, color is more than wavelength!”

Over the course of more than 30 years Wilson wrote articles on color. Many of these articles were hard to come by, and we can be grateful that in 2018 a volume of 26 articles was published: *What is Colour? The Collected Works*, Michael Wilson (edited by Laura Liska and Troy Vine, Logos Verlag, Berlin, 2018). Anyone interested in a disciplined, phenomenological approach to color will gain much from the study of these essays. Here I present one short excerpt from the prelude to the main essay in the book. It gives an impression of the nuanced attention he gave to the appearances of the visual world:

The mountains have emerged from the night fresh and clean in their mantle of deep violet blue, and a liquid light pours across the land calling forth colour as it goes. As the sun climbs and warms the earth, the mountain slopes disclose their form in a play of pink light and purple shadow, while beyond them the distant ranges lie serene and still, cool blue beneath the pale transparent turquoise of the rain-washed sky — a colour changing with infinite smoothness to deep cobalt overhead. In front of us the wind-swept autumn grass and the dying bracken glow gold and orange-brown in the morning light and even the outcrops of cold grey rock have joined in the scheme of things and show their sunlit faces warm against shadows of

soft violet grey. Beyond this the blue of the lake lies back in vivid contrast—a blue embracing all the subtle transitions from clear emerald to deep violet.

We lose ourselves in wonder at the majesty of the perfectly ordered colours and must feel that beauty is not by chance in the world. And yet, we reflect, only yesterday the same landscape was grey—the sky, the mountains, the rocks, the water — all grey with but a hint of dull colour in the grass and bracken. The solid features of the landscape have not changed and the sun gives no more light than yesterday. Where then has the wealth of colour sprung from, whither will it vanish? What is the miracle of air and cloud? (p. 4) CH

## New Editions of Noteworthy Books

- This year the second edition of *The Heart and Circulation: An Integrative Model* by Branko Furst, M.D. was published by Springer Nature. We reviewed the first edition in *In Context* #31 (2014). The new edition has a whole new section encompassing 100 pages that focuses specifically on the heart and circulation in the human being. As Furst writes,

It is my hope that this expanded version of the text will inspire new avenues of thought and stimulate further exploration of ideas that will deepen our understanding of the heart and circulation and thus bring us a step closer to “what makes a human being human.”

Cardiac surgeon Roland Hetzer writes in a forward to the book: “the hallmark of his thesis is the renunciation of the cardio-centric view of the circulatory system, which regards the heart as the motor of blood flow, while providing a view of the importance of the peripheral circulatory system ... This book brings a significant gain of knowledge.”

- This fall the authorized edition of *Threefoldness in Humans and Mammals* by Wolfgang Schad will be published (available through [steinerbooks.org](http://steinerbooks.org)). We printed an excerpt of the previous edition in *In Context* #41 (2019). This in-depth (1300 pages in two volumes with color photos) treatment of dynamic morphology is a one-of-a-kind study. It shows the truly integrated nature of animal forms, and is a treasure trove of insight into the biology of animals.

## Events

We were obliged to postpone residencies this past summer for both our 2019-2020 cohort of **Foundation Year students in Goethean science** and a new cohort of participants enrolled in the 2020-21 Foundation Year. But in the meantime, we are engaging these groups of students—from six countries and nine different states—in remote learning, mentoring, and discussion. To make this possible, we invested in equipment that enables us to create podcasts, videos, and online group meetings with high audio-visual quality. Until classes resume at the institute next summer, our cohorts of Foundation Year students will carry out observation exercises and will read and discuss chosen texts related to Goethean science.

This extension of the program means that both groups will now receive an extra year of work with Goethean science (without additional fees)—a benefit they’ve gratefully welcomed. Their eagerness for more guidance from our staff revealed a strong motivation to deepen the practice of direct observation and living thinking. We look forward to assessing how this additional year will fructify our work together next summer when we meet (hopefully!) at the Institute.

\* \* \* \* \*

Throughout this year we have continued our collaboration with the **New Perennials Project of the Rockefeller Family Fund**. This involves research into the characteristics of annual and perennial plants and questions concerning the long-term sustainability of agriculture.

Craig has written an essay, “Annuality and Perenniality in Wild Plants: Developing Malleable Concepts” for *The Perennial Turn: Contemporary Essays from the Field*. Edited by Bill Vitek ([newperennialsublishing.org](http://newperennialsublishing.org)), the director of the New Perennials Project, this volume was published in October.

In local field research for this project, Judith Madey and Craig have been comparing the growth dynamics and morphology of corn, a major crop that is an annual, with the qualities of alfalfa, another major crop that is a perennial. In the process, they were dazzled by the corn stalk and flowers in all their sublime intricacy. Here Craig shares a few observations and some photos of their work.

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*Corn (maize) is unique among cereal plants (grains) for having separate flowers for stamens (pollen formation) and kernel formation (Figure 1). The stamen-bearing flowers in*



1

*numerous slim branches (called tassels) grow at the top of the plant (Figure 2), while the cobs with the kernels (Figure 3) develop in the axils of leaves in the middle of the plant. Early in their development these two very different organs of the plant look virtually the same (Figure 4). You could think that the germinal tassels would become a cob. This indicates an embryonic “sameness” that differentiates into polar forms over time. Sometimes a plant will reveal the kinship of these parts in the mature plant by forming part tassels, part cob where normally only the tassels or cobs would develop (Figure 5). Such anomalies — often considered malformations or monstrosities — are in fact revelatory of the underlying unity and wholeness of the plant.*



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This fall, Craig is again working with **farm apprentices at Hawthorne Valley Farm** to augment their practical work in the field and barn. Engaging the aspiring farmers with guided observational exercises and group discussion, he introduces them to Goethean inquiry with the aim of developing a deeper insight into the qualities and relations of nature. A primary focus of the workshop is to reveal organisms as dynamic and integrated beings within the larger web of life; resident cows at the farm, as well as local wild and cultivated plants, allow rich opportunities for observation.

Hawthorne Valley Farm intern, Brigid James, examines parts of goldenrod.



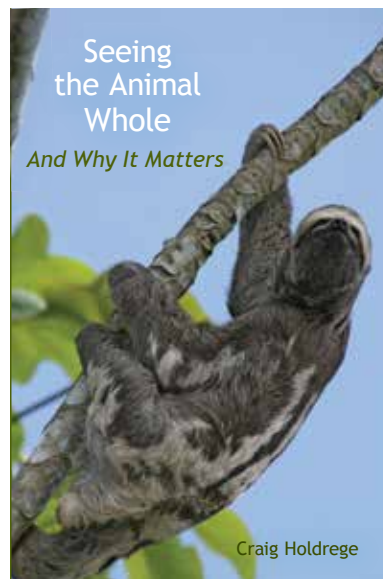
## Publications and Website

- Gopi Krishna Vijaya had an article, “**Colour, Wavelength and Turbidity in the Light of Goethe’s Colour Studies**,” published in the *Journal for General Philosophy of Science* (available online at: <https://link.springer.com/article/10.1007/s10838-020-09517-3>). In this technical paper, Gopi discusses the one-sided and often arbitrary conventional approaches to “explain” color (wave length, “light rays,” and so on) in physics. Drawing on Goethe’s experiments, he also shows how light and darkness can be seen as true polarities, even according to the current understanding of physics.

- Craig Holdrege’s latest book, *Seeing the Animal-Whole, And Why It Matters* (Lindisfarne Books) will be published early in 2021. The result of Craig’s close and deliberate encounters with various animals over many years, the book portrays nine different species, illuminating each animal’s specific way of being. Readers discover many fascinating details about these creatures, but this is no mere collection of facts. As Craig writes, “I want to show how an animal’s features are interconnected and are a revelation of the animal as a whole . . . how the animal is intimately interwoven with the larger context that supports its life, a context that it also actively influences.”

The book begins with Part I, *Portraits*, comprised of five in-depth animal profiles: The Flexible Giant (the elephant); In Praise of Slowness (the sloth); Where Does an Animal End (the American bison); How Does a Mole View the World?; and The Intertwined Worlds of Zebra and Lion. In Part II, *Rethinking Development and Evolution*, Craig challenges dominant explanatory frameworks in evolutionary biology and presents a broader perspective in three different chapters: Why Does a Zebra Have Stripes?; The Giraffe’s Long Neck; and Do Frogs Come From Tadpoles? The last section of the book, Part III, *Taking Responsibility*, highlights the life of The Dairy Cow in the context of our obligation to domesticated animals. It also includes a final chapter, A Biology of Beings, in which Craig describes the philosophy and methodology of his scientific inquiry, grounded in the view that an organism is fundamentally “an integrative, creative activity and not a thing.”

- **We’ve remodeled our website!** While Covid-19 compelled us to postpone some of our work at the institute, it brought other projects to the fore — such as the long-



discussed redesign of our website. Having more than 20 years and 700 pages worth of research articles, images, and teacher resources on [natureinstitute.org](http://natureinstitute.org), the task of transferring all its content to a new platform was a painstaking feat for our in-house team. Seven months in construction, the updated website now has a clean, uncluttered design that makes for easier reading and scanning, greater mobile compatibility, clear navigation, and optimization for search engines. The content itself has not changed — only your access to it. Let us know what you think!

A portion of the Nature Institute content, including particularly Steve’s “Biology Worthy of Life” project, is remaining on the original Internet hosting site, with some redesign of its own (and perhaps more to come). You will now find it at [BiologyWorthyofLife.org](http://BiologyWorthyofLife.org), or, rather less memorably (if also less unwieldy): [bwo.life](http://bwo.life).

- Since the spring, Craig and Henrike have had weekly colloquiums on potential study topics with Jon McAlice and Sergio Spalter, MD, both affiliate researchers of the institute. Their four-way dialogue often prompts a fresh way of seeing phenomena or a new path of attention, as it did for Craig, who was moved to write *Viruses in the Dynamics of Life*. Published in response to the dearth of balanced reporting in the media on the nature of viruses, including Covid-19, his in-depth article contextualizes the phenomena of viruses both culturally and biologically. Emailed to our readership, the article’s even-handed portrayal of the subject prompted many appreciative comments. “Thanks so



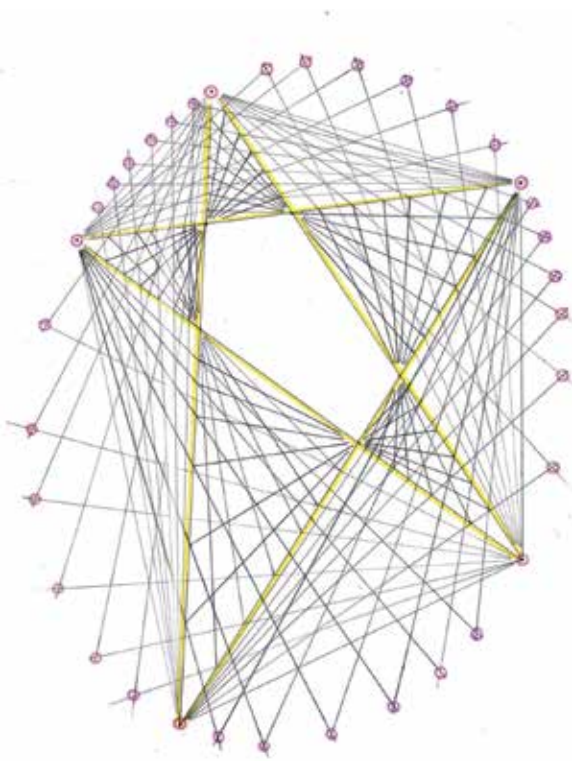
much for taking the time to explain, in clear, easily understood language,” one reader stated, “the history of the discovery of viruses and their role, as far as we understand that now.”

Likewise stimulated by the weekly meetings, Jon recently published an article on our website, *Extendedness and Permeability: Core Gestures of the Living Organism*, that depicts organismic life as transcending what we conventionally consider the boundaries of living beings. With fresh thinking, he succeeded, as one reader put it, “... in provoking so quietly such deep awarenesses and multiplicities of possible context.” Both articles can be found on our website.

- We're delighted to report that a **Chinese edition of Craig's book**, *Thinking Like A Plant*, has recently been published in China.

- And, finally, here is an update from Henrike about work on **her new book in projective geometry**:

*In collaboration with The Myrin Institute, we published Part 1 of my workbook in projective geometry, To the Infinite and Back Again, in 2019. This spring, we also made it available online for free. The book is written for high school and college students, and for adults with various professional backgrounds. We have heard from people in Australia,*



*Taiwan, South Africa, Hungary, Brazil, and the US that they have been working with the book, sometimes in schools or in study groups.*

*This year I am writing Part 2, again a workbook meant for schools, self-study and for the lay-person. Topics that I cherish most, and that I have taught in Nature Institute courses over two decades, are included in this book. While designing, writing, researching, and especially while executing the illustrations for the book, I myself experience the strengthening and wholesome effects that engaged work in mathematics can have. Projective geometry not only expands my mind — allowing me to grasp in thought what before was incomprehensible — it also allows me to strengthen my sense of “I know with certainty.” I cultivate my abilities of exact imagination and of thinking in transformations.*

*Part 2 builds on Part 1, but has a different focus: the principle of duality (polarity) in projective geometry. In working with geometric polarity we learn that what we usually call the “exterior” or “periphery” of a figure or form is as essential and formative as what we normally call the “interior” and “point-center.” We can shift perspective and see things from their “outside” as much as from their “inside.” Everything is embedded in a context that belongs to it. Work in this field can provide practice and a means to counterbalance the overly narrow, “centered” way of viewing things that is so dominant in our times.*

*I hope that the book will be in print early in the new year. It will offer a wealth of practices and exercises that readers can choose from to stimulate their own thinking and inner work.*

# Thank You!

*We are privileged to thank all who have contributed goods or services to The Nature Institute between April 1 and September 30, 2020. And special thanks go to those who helped make our Spring \$5,000 challenge grant a success. We ended up raising more than \$7,000 in support of our mission!*

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# Meeting Bloodroot

(*Sanguinaria canadensis*)

CRAIG HOLDREGE



Figure 1. Bloodroot (*Sanguinaria canadensis*) flowering in upstate New York in late April. (All photos in this article were taken by the author.)

IN EARLY APRIL, I begin my wanderings through the deciduous forests in upstate New York where I live. I want to participate in the budding forth of early spring plants. The trees are bare and the air cool. The forest floor is light brown with dead leaves covering the soil. You have to get down on your knees and look carefully to discover the first plants poking out of the soil and through the leaf litter.

There is no set date on which I can know that this or that plant will appear. Clearly, the plants are attuned to the lengthening of the days. But their time of emergence can vary by a number of weeks. If it remains cold and overcast, the plants emerge later, while a burst of unfolding will accompany a spell of warm, sunny days. Ensuing cold will slow all processes down again. It's a dynamic dance of sun, elements, and the plants. And yet I do know—I can trust—that some plant species will appear earlier than others.

One of the earliest wildflowers to emerge from the rich soil of bottomland woods is bloodroot (*Sanguinaria canadensis*). Its characteristic grayish-green buds are easy to discern once you get to know them (Figure 2). The scales

of the bud open and a little plant emerges. What I see is a tightly wrapped, not-yet-unfolded leaf. A tender whitish green cap begins to grow up from its center—the flower bud. The leaf encloses the flower and provides a protective mantle as the plant grows into the vicissitudes of the airy, light-filled world. Taken in its momentary appearance at this phase of its life, bloodroot is quite inconspicuous. But viewed as a process, the closed flower bud and the enwrapping leaf are powerful images of becoming. There is a palpable fullness and tension that speaks of life and development.

The upward elongation of the flower stalk continues so that it extends beyond the enwrapping leaf. If I am lucky I can see the two pale green sepals before they fall off, leaving the petals free to open (Figure 2, third image). Entering the woods on a warm and sunny mid- to late-April afternoon, my attention will quickly be drawn to the wide-open and white radiance of bloodroot's blossoms. Usually eight petals radiate out from a glowing center of golden stamens.



Figure 2. Development from bud to open flower in April; upstate New York.

The petals have an almost inexpressible soft and luminescent whiteness. Viewed from above, the flowers seem to hover several inches from the ground. The flowers open on sunny days and close toward dusk, only to open again the next morning—if it is sunny. On cloudy days the flowers remain closed or open only a little. Occasionally I catch a glimpse of a small native bee gathering pollen from the stamens.

This phase of flowering lasts only a few days to a week (or longer if the weather is cool). The petals fall off very easily—a typical characteristic of the poppy family, to which bloodroot belongs—and one hard rainstorm can remove them all. What’s left, when the petals and stamens have fallen off, is the pistil in the middle of the flower. It develops over time into a narrow and upright fruit capsule that bears seeds.

Remarkably, while bloodroot is flowering, its single leaf continues to enwrap the flower stalk and only gradually begins to open. In this phase of its development, bloodroot reveals a special two-fold gesture: open luminance in the flower above, and restrained enclosing in the protective leaf below. It is this contrasting gesture that struck me many years ago when I started to notice bloodroot, and each year it continues to speak strongly.

## Nature Speaking?

I just used the words “gesture” and “speak” in connection with a plant. Does nature gesture and speak? I think so, but only if we attend and are open to her utterances. Of course the gesturing and speaking are not of a human sort. They are of the earth. I can’t help but see the earth, with its ever-changing

garment of plants, as an activity that is expressing itself in all its utterances. The challenge is in understanding those utterances. When I attend to a plant and it strikes me in a way that I say, “Oh, isn’t that beautiful,” I have been touched by the plant. This being touched dwells in my life of feelings. I know I’ve met something real and important, but I may not be able to articulate it any further. However, the feeling remains strong and connects me with the earth and its plant life.

In my work with plants I strive to see whether I can learn to perceive the gesturing of nature more distinctly. Bloodroot is beautiful, but so is the dandelion that flowers later in lawns, or wild chicory that flowers in rich sky-blue along roadsides in the summer. What are the unique qualities of the different plants? What are they saying in their forms and colors, in the times and places in which they develop? How is the earth speaking through them?

My way of gently approaching these large questions—which are more guides for study than occasions for definite answers—is in a sense quite simple.<sup>1</sup> I attend carefully to the plant. I take the time and effort to notice its characteristics and to follow mindfully how it develops. By going out to the plant with this focused attention, I get to know it. This getting to know is enhanced by bringing the plant alive in my imagination, a practice that the scientist and poet Goethe called “exact sensorial imagination.”<sup>2</sup> I re-picture its features and development as vividly as possible—imagining how the parts unfold; beholding the processes of transformation as movement; inwardly sensing the changing textures, colors, and scents.

And I need to look at the plant in its context. Where and when is it growing, who are its neighbors, what other creatures

does it interact with? I compare it with other plants. This is key. The uniqueness of something often stands out and becomes clearer through contrasts, especially when I vividly picture what I am studying. Instead of theorizing and “thinking about” the plant in an intellectual way, I strive to observe and “think with” the plant, and thereby participate more fully in its life. All this work helps me get to know the plant as an active, transforming, and dynamic being. It opens the door, if I am fortunate, to a more intimate sense of the qualities of a particular plant species. It can—in its plant-like way—begin to speak.

## A Gesture of Early Spring

In the northeastern United States you wait a long time for spring to arrive. In February it can be bitter cold and yet the days rapidly become longer. The sun’s arc in the sky grows higher, and in a wind-shaded area the sun warms your cheeks. The birds that have overwintered begin to sing in the mornings, as though they are celebrating the return of the light. Nest building is still many weeks ahead.

From a planetary point of view, spring begins around March 21 in the northern hemisphere, when the days become longer than the nights. In upstate New York, snow can cover the ground well into March. Plant life appears dormant. And yet there are stirrings of life beneath the quiescent surfaces. When the nights are cold and the daytime temperatures rise above freezing, the sap begins to rise in the trunks of trees, traveling from the roots up into all the buds that later unfold. I can’t see this movement, but when the maple sap harvesters insert their taps into the tree trunks, the sap slowly drips out. Inner movement precedes visible development.

Bloodroot is one of the first wildflowers of the forest floor to show that visible development. What I witness is the springing forth of plant life in a particular habitat. It is showing me what early spring means from a plant perspective. I can say this because, as I have studied other wildflowers at other times of the year, the special character of bloodroot has become all the more potent. I think of greater celandine (*Chelidonium majus*), a relative of bloodroot in the poppy family and a species that has become naturalized in northeastern forests. I discover its first light green leaves emerging from the ground soon after bloodroot’s, but it does not begin to flower right away. It only flowers at the end of May into June. As the days get longer and warmer over a number of weeks, it develops many leaves in a rosette close to the ground. Subsequently, a leaf-bearing upright stem grows up from the rosette and then forms multiple branches with leaves—and at the ends, many rich-yellow flowers (see Figure 3). It comes to appearance more gradually with its multitude of leaves, above-ground branches,



Figure 3. Greater celandine (*Chelidonium majus*) flowering in early June.

and flowers. It has a growth form that you find in many wildflowers that develop over a longer period of time and flower later in the spring.

No plant that develops after early spring emerges from the ground with just one leaf and one flower. This is a quality of early spring. The earth initially sends forth plants that unfold quickly, close to the ground, and in a bold expression. In bloodroot’s case the leaf enwraps the flower as an upward growing bud, the one large flower then unfolds, and only later does the leaf—in concert with the greening of the rest of the forest—develop further. The flower is like a burst of light and form that passes quickly, ushering in spring.

In the same forests there are other plants that I can find that begin to flower a little after bloodroot (and keep their flowers longer), which have a similar growth gesture to bloodroot’s. Figure 4 shows trout lily (*Erythronium americanum*) and wake robin (*Trillium erectum*), both members of the lily family. Trout lily emerges with a spear-like bud formed of two leaves that enwrap a single flower, which then unfolds. Wake robin grows out of the soil with a whorl of three leaves enwrapping a single flower that then unfolds its deep maroon petals. These plants (and there are others) share a similar growth form that does not occur in plants later in the season. All issue forth in spring, staying close to the cool ground, bearing few leaves that at first serve as protective sheaths for the flower, and then flowering conspicuously with one large flower per shoot, before the greening of spring predominates.



Figure 4. Trout lily (*Erythronium americanum*) and wake robin (*Trillium erectum*), two woodland wildflowers that begin to flower soon after bloodroot.

## Completing Life's Cycle

Bloodroot's development does not, of course, stop with flowering. But it becomes less conspicuous, since once the petals drop, the single green leaf, flower stalk, and fruit capsule blend in with the greening surroundings of the forest floor. More and more wildflowers unfold and begin to bloom. A carpet of green forms on the forest floor. Every year I realize anew that the forest floor has its peak of illumination in May, before the trees are green. Even though the days continue to get longer, there is increasingly less illumination on the forest floor. The early flowering woodland wildflowers bring an array of colors and form into the forest before it moves into its shady summer. In mid-May the canopy of the forest begins to close overhead.

After flowering, bloodroot's single leaf unfolds fully and grows (Figure 5). Whereas the development from bud to flower progresses rapidly, with each day showing visible changes—the changes we human beings long for and are nourished by in spring—now everything slows down. I need to be more committed to stay with the slower, less eye-catching development that follows flowering. What I discover is that bloodroot's leaf blade continues to grow

slowly throughout the spring and early summer, in contrast to those of many small spring wildflowers that decay soon after flowering. At first the leaf stalk is about as long as the leaf surface itself (what botanists call the leaf blade). The leaf blade is initially fairly upright and fans out into an overall roundish form that most typically (in a mature plant) has five to seven lobes. The orientation then shifts from upright to horizontal; this occurs simultaneously with the greening and closing of the tree canopy. The leaf blade takes on a slightly concave bowl shape. The flower stalk does not elongate after the petals fall off, so that the leaf now forms a canopy above the fruit capsule, just as the unfolding leaves of the trees form a canopy for the forest floor—a beautiful instance of a part mirroring a process in the whole. Moreover, I witness how bloodroot's leaf slowly changes in relation to the flower, the flower stalk, and the fruit, and how it also transforms in concert with the seasonal greening and darkening of the forest as a whole.

Figure 5. Leaf development after flowering.





Figure 6. Seeds in the opened fruit capsule. The white structures on the seeds are the elaiosomes that ants eat (see text below).

By the end of June, the fruit capsule at the tip of the flower stalk has swollen and splits open, revealing numerous small, round, and shiny dark-brown seeds. It is always exciting to catch the seeds nestled in the capsule before they fall to the ground and disappear from sight (Figure 6). The flower stalk and capsule then dry up, shrivel, and decompose. Only the leaf is left above the ground. The leaf blade grows no more, but the leaf stalk continues to lengthen. When I go into the forest in late August or early September, the leaf blade has come to rest on the ground and the leaf begins to decay. Long before the tree foliage begins its fall transformation from green to brilliant yellows, oranges, and reds, bloodroot is no longer visible.

## Pathways of Development

After I studied bloodroot for a few seasons, it became clear to me that the plant has two pathways for continuing its life over the winter and into the next spring. One is through its rhizome and roots, which remain in the ground after the leaves have wilted. The rhizome is an orange-red underground stem that has many little roots growing from it. (If you gently scrape the rhizome with your fingernail, it emits a dark red watery sap—the origin of the name “bloodroot.” When the leaf stalk or flower stalk breaks, you can also see the red sap.) The rhizome grows and branches during the spring and summer, and near the end of the growing season it develops buds. Inside the buds a complete flower and a complete leaf pre-form in miniature. This most stunning development of undifferentiated tissue into a tightly compressed leaf and flower occurs completely hidden away in the protective sheaths of the bud. For me it is impossible

to imagine how a plant makes a flower, with its precise arrangement of two sepals, eight petals, multiple stamens, and a central pistil in miniature, surrounded by an enwrapping, folded leaf, and all of this in such a way that the later unfolding reveals coherent and organized structures. It is beyond comprehension, and provides a healthy dose of modesty in view of the wisdom at work in a plant.

These buds of nascent life remain dormant during the fall and winter. The plants become active again in the increasing light and warmth of the next spring, when leaves and flowers sprout forth. With leaves and flowers prepared the previous year, bloodroot can unfold quickly in the spring.

After discovering that bloodroot has an underground branching stem, I realized that when looking at two or three of its “plants”—each with its own leaf and flower—growing close to one another (as in Figure 1), I was probably looking at just one plant, the rhizome of which had formed buds out of which the above-ground flower and leaf pairs arose. So what I might designate as “one plant” with leaf and flower will often be a branch of a larger plant from which a number of leaves and flowers have grown. A mature bloodroot plant is therefore like a small bush that has its branches underground, and the extremities of the plant—flowers and leaves—only show themselves above the ground for a period of time.

The second way for bloodroot to continue its existence is through seeds. The seeds drop to the ground near the mother plant and may germinate there in the following spring. In this case you find little seedlings with a single small, unlobed leaf growing near mature plants (Figure 7). Such a plantlet develops a small rhizome that grows and overwinters. In the following year it will likely bring forth one or two leaves, but probably not flowers. These leaves often have three lobes and don’t grow as large as the leaves on mature plants. In the next year the plant is probably established enough to bring forth one or more flowers, and the leaves grow much larger and often have five to seven lobes.

Figure 8 shows a number of leaves from plants of different ages. The two small leaves (1 and 2 in the figure) stem from seeds that germinated in the current year. Leaves 3 and 4 may be from one plant (I didn’t want to



Figure 7. Small leaves (about 2 cm in diameter) of bloodroot seedlings.



Figure 8. Leaves from plants of different ages; see text.

dig around and disturb the plant or plants to find out), but there were no flowers growing with these leaves. Leaf 5, which was even bigger and more lobed, also had no flower. The large and seven-lobed leaf (#6) enwrapped a flower before it unfolded. So in this group of leaves you see the stages in the maturation of bloodroot plants made visible through the increasing size and degree of lobing of the leaves. You have spread out in space what any given mature plant has gone through over the course of a few years. How old a bloodroot plant can become is, to my knowledge, not known.

## Bloodroot and Ants

Many years ago I wrote a short description of bloodroot.<sup>3</sup> After reading the description, a biologist and former neighbor, Elliot Schneiderman, mentioned to me that ants are known to disperse the seeds of bloodroot. He briefly described this fascinating process and then remarked: you described bloodroot in its annual cycle, but don't the ants belong to the wholeness of bloodroot as well?

My immediate reaction was: of course! I had tried to show—as I have done here in greater detail—that we need to go beyond any one momentary state of the plant and begin to grasp it as a process in time. But I didn't go further, which Elliot pointed out. It is another step to view everything we call the “environmental interactions” of a plant as part of that plant, for without these interactions the organism wouldn't exist in the way it does.

Here's what I learned about bloodroot and ants: When bloodroot seeds fall to the ground, ants often arrive. They pick up the seeds and carry them to their nest. Each

bloodroot seed has a small white fleshy outgrowth called an elaiosome. The elaiosome grows outside the seed coat and is not part of the germ. The ants are attracted to this part of the seed—ant larvae feed on the elaiosomes, which are rich in fats and sugars. The fast-growing larvae thrive on this nutrient-rich food.

The seed itself, retaining its potential for germination, is discarded by the ants, usually with other organic waste from the nest. As one researcher put it, the seeds are placed on “private compost heaps” and out of these seed beds tiny plants can grow the next year.<sup>4</sup> By collecting the seeds, the ants spread bloodroot into a larger area of the forest, and they also provide the conditions for a new colony of bloodroot to develop. In this sense the ants belong to bloodroot, just as bloodroot—as food— becomes part of the ants. This is one example of how different beings in an environment interweave and participate in their mutual lives. There is no such thing as an organism that is separate from other organisms.<sup>5</sup>

## Being Itself Differently

So far I have painted a picture of bloodroot as a special expression and embodiment of early spring in a temperate deciduous forest environment of eastern North America. In my engagement with it, I begin to understand it as a specific activity bringing forth form and substance in ongoing transformation. Its appearing and disappearing, its becoming and wilting away, are deeply connected with larger rhythms.

Bloodroot is wholly embedded in the annual rhythm of the seasons—the changing relation between sun and a particular place on earth during a year. This is



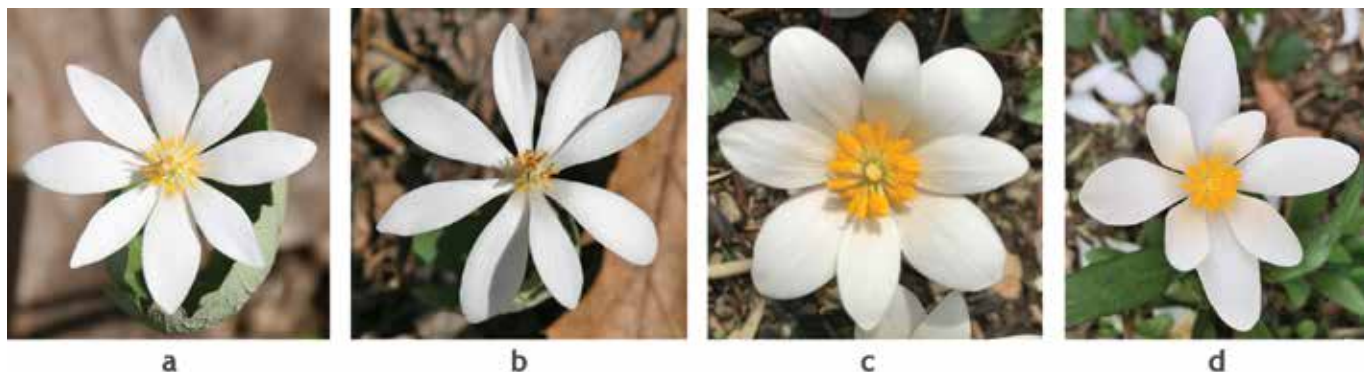


Figure 9. Variations in the shape and size of petals in flowers that have eight petals.

its encompassing context. At the other pole there are the very local conditions of a particular place such as topography and soil. A specific plant may grow in one place for a number of years, and each year the cosmic seasonal rhythm remains virtually the same, but the local conditions of weather and habitat may change radically from year to year. In this sense, each year brings new opportunities for the mutual interweaving of plant and environment.

When I am mindful of this dynamic interplay, it becomes clear that bloodroot does not develop according

to some strict set of rules. Rather, bloodroot becomes itself and maintains itself through the environment, and continually shifts

its activity in relation to changes in the environment. So, for example, when it is cloudy and cool for a number of days, I find the flowers closed; there is little transformation. When a few sunny warm days follow, the flowers unfold, pollen is offered up to the native bees, and fruit and seed formation begin. The plant relates to those specific circumstances in a way that accords with its way of being. At the same time, the ways in which bloodroot can grow differently in different circumstances are an expression of the vital plasticity that allows it be itself differently.

One of my favorite activities is to go out and look at various stands of bloodroot to see if—and how—they differ from each other. What surprises does bloodroot have in store? I'll start with what is typical: Bloodroot flowers usually have eight petals, the lower four being somewhat larger and rounder than the upper four. The petals are often regularly spaced so that you can discern a square formed by the lower petals and an offset square of the narrower petals, which grow in the space between the lower petals (see

Figure 9, flower on the left). Beautiful embodied geometry. Again and again I see this pattern. When I attend to the flowers on many different plants, the more I look the more I see that not only does the overall size of the petals on different plants vary, but the shape and arrangement of the petals as well, as Figure 9 illustrates.

Beyond that, if I look at enough different flowers, I notice that the number of petals occasionally varies. Figure 10 shows a few such variations that I have found in plants in a wooded area beside a creek that I often visit—flowers with nine, ten and twelve petals. Others have found plants

with as few as three and as many as twenty petals.<sup>6</sup>

Surprising variations such as these reveal a kind of playfulness, an abundance of

possibilities that a species can display. By being open to the surprises that a plant offers up, we experience another facet of its dynamic nature. I think that philosopher Susanne Langer rightly saw it: “Every discovery makes the living organism look less like a pre-designed object and more like an embodied drama of evolving acts, intricately prepared by the past, yet all improvising their moves to consummation.”<sup>7</sup>

Many habits of thought can get in the way of our seeing the drama of a plant's life. One is the tendency to pay most attention to “typical characteristics.” Then the norm in my mind overshadows the richness and variability that the plant shows in its development and forms. Another hindrance is the drive to want to “explain.” In our modern scientific age, this usually means discovering the spatial antecedents of any given phenomenon that contribute to its coming into appearance. What genes or hormones or environmental cues “cause” the plant to form a bud at a particular time? This kind of questioning can lead to

*It seems as if the day was not wholly profane,  
in which we have given heed to some natural object.*

~ RALPH WALDO EMERSON<sup>8</sup>



9 petals



10 petals



11 petals



12 petals



12 petals



12 petals

Figure 10. Variation in the number and shape of petals in different flowers.

interesting discoveries, but the discoveries cannot be taken as explanations. They simply expand our knowledge of the drama of life.

To see the drama, I need to literally come to my senses and immerse myself in the variety of phenomena. I inwardly participate in the dynamics of process and transformation, and weave the instances of surprising formations into a growing picture of the plant. In all its expressions, the plant can help me leave normative abstractions behind. With an open attentiveness and an active mind, I can begin to participate in the wisdom that informs the plant world. And, to paraphrase Emerson, nature shows herself as never profane when I have truly given heed to the concrete appearances of life, letting that life come to life within me.

#### NOTES

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6. See: Johnson, Roswell H. 1909. "Aberrant Societies of *Sanguinaria* and *Trillium*." *Torreya* vol. 9, no.1, pp. 5–6.  
Spencer, Warren P. 1944. "Variation in petal number in the bloodroot, *Sanguinaria canadensis*." *The American Naturalist* vol. 78, no. 774, pp. 85–89.
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# Natural Selection and the Purposes of Life

STEPHEN L. TALBOTT

*The following is half of a chapter in “Evolution As It Was Meant To Be — And the Living Narratives That Tell Its Story.” Already written parts of the book are available on the Nature Institute’s adjunctive website, [bwo.life](http://bwo.life) (also accessible as [BiologyWorthyofLife.org](http://BiologyWorthyofLife.org)). The full version of this chapter is at [bwo.life/bk/evotelos.htm](http://bwo.life/bk/evotelos.htm).*

BIOLOGISTS OFTEN THINK of purposiveness, or teleology, under the concept of function, as when they say that a trait is “for the sake of” this or that, or an organ exists “in order to” achieve a particular end. And so, as philosopher David Buller has summarized common usage, “the function of the heart is to pump blood, the function of the kidneys is to filter metabolic wastes from the blood, the function of the thymus is to manufacture lymphocytes, the function of cryptic coloration (as in chameleons) is to provide protection against predators.”

All this poses difficulties for a science that would honor its materialist commitments, since the concept of function, as Buller observes, “does not appear to be *wholly* explicable in terms of ordinary causation familiar from the physical sciences.”

Whereas kidneys may continually adjust their activities and their own structure *in order to* do a better job of filtering metabolic wastes from the blood, no physicist would say that falling objects adjust their activities and their own structure *in order to* reach, as best they can, the center of the earth. More generally, organisms may strive to live, but physical objects do not strive to maintain their own existence. Organisms, so it seems, have intentions of their own, whereas physical objects are simply moved from without according to universal law.

Biologists have long worried about how their language of purpose might be explained, or explained away, in a respectable, materialistic manner — that is, explained without having to acknowledge that organisms really are purposive beings.<sup>1</sup> But their problem has, in recent decades, been resolved — or so we are told. Buller, who was writing at the turn of the twenty-first century, was able to point to a “common core of agreement” representing “as great a consensus as has been achieved in philosophy” — an agreement that “the biological concept of function is to be analyzed in terms

of the theory of evolution by natural selection.” More particularly, “there is consensus that the theory of evolution by natural selection can provide an analysis of the teleological concept of function strictly in terms of processes involving only efficient causation” — the kind of “purposeless” causation physical scientists accept as applicable to the inanimate world (Buller 1999).

So we no longer need to think of organisms as having genuine intentions, purposes, or aims of their own — no longer need to struggle with the problem of teleology, or end-directed activity. Teleology, we must believe, has been tamed, leaving biologists safe in their world of lifeless thought.

To put the most common version of the idea very simply (and not many working biologists seem worried about the need for a more sophisticated formulation), organisms are said to possess teleological, or purposive, features *because those features are present by virtue of natural selection*. That is, they were selected for the very reason that they effectively serve the organism’s crucial ends of survival and reproduction. And since natural selection is a perfectly natural process — meaning that it involves nothing “mystical” like *real* purpose, intention, or thought — we can know that the functionally effective traits given us by natural selection are straightforward exemplars of physical lawfulness and nothing else, whatever they might *look* like.

If this feels as though it is cheating a bit, then you might want to trust your intuition — for more than one reason. I will briefly touch the issue from three different angles.

## (1) The Arrival of the Fittest

To say that natural selection preserves traits promoting the survival of organisms does nothing to explain how the teleological character of those traits might be compatible with materialist thought. The preservation of a trait is an entirely different matter from its nature and origin. The proposed explanation does not show how functional, or end-directed, traits could initially occur in organisms previously bereft of teleology. Claiming that teleological features or activities already existed at some time in the past and then were preserved by natural selection merely pushes the problem back to an earlier time, without solving it.

We heard about this in the chapter, “Let’s Not Begin With Natural Selection,” where prominent figures in evolutionary biology over the past century and more complained that natural selection — even if it explains the survival of the fittest — cannot explain the arrival of the fittest. The arrival of traits is simply assumed, with natural selection then playing a role in their preservation and their spread throughout a population. Yes, purposive features are “good” for the survival of organisms and therefore may be preserved. But how does this bare fact make these features, in Buller’s words, “explicable in terms of ordinary [physical] causation”?

Given the historical persistence of the complaint by leading biologists about natural selection and the arrival of the fittest, it is remarkable that the arguments today about how natural selection explains teleology generally proceed without so much as an acknowledgment of the problem.

## (2) Circular Reasoning

It is important to realize that purposiveness runs through *all* biological activity. It is reflected in the coordinating principles that account for the integral, interwoven unity of the organism’s life. The complexity theorist and philosopher of biology, Peter Corning — who appears to hold a conventional, materialist view of life — was nevertheless gesturing toward this purposive unity when he wrote that living systems “must actively seek to survive and reproduce over time, and this existential problem requires that they must also be goal directed in an immediate, proximate sense ... Every feature of a given organism can be viewed in terms of its relationship (for better or worse) to this fundamental, in-built, inescapable problem” (Corning 2019).

Rather than being just one more discrete trait that might have been neatly evolved at some particular point in evolution, the *telos*-realizing capacity of organisms reflects their fundamental nature. It is what “living” means. We are always looking at a live performance — a future-directed performance, improvised in the moment in the light of present conditions and ongoing needs — not a mere “rolling forward” of some blind physical mechanism set in motion eons previously.

Here we encounter a staggeringly obvious problem. You will recall from the chapter, “Let’s Not Begin With Natural Selection,” that selection is supposed to occur when three conditions are met: there is variation among organisms; particular variations are to a sufficient degree inherited by offspring; and there is a “struggle for survival” that puts the existing variants to the test. But — and this is the

crucial point — *all* the endlessly elaborate means for the production of variation, the assembly and transmission of inheritances, and the struggle for survival just *are* the well-regulated, end-directed activities whose teleological character biologists need to explain. So the basic conditions enabling natural selection to occur could hardly be more thoroughly teleological.

In other words, the purposive performance of an organism is a pre-condition for anything that looks at all alive and capable of being caught up in evolutionary processes of trait selection. So the common form of the argument that natural selection explains the apparent purposiveness of all biological activity appears to assume the very thing it is supposed to explain. This is argument in a circle. It would be truer to say that teleology explains natural selection than that selection explains teleology.

Although this problem in the explanation of teleology has been almost universally ignored among biologists, it has not been entirely overlooked. Georg Toepfer, a philosopher of biology at the Leibniz Center for Cultural Research in Berlin, has stated the matter with perfect directness:

With the acceptance of evolutionary theory, one popular strategy for accommodating teleological reasoning was to explain it by reference to selection in the past: functions were reconstructed as ‘selected effects’. But the theory of evolution obviously presupposes the existence of organisms as organized and regulated, i.e. functional systems. Therefore, evolutionary theory cannot provide the foundation for teleology. (Toepfer 2012)

## (3) The Lure of the Machine

Those convinced that natural selection explains teleological traits (rather than the other way around) do occasionally make at least passing reference to the problem of the origin of the traits. For example, Buller writes that “natural selection explains the presence of a trait by explaining how it was preserved after being randomly generated.” Organisms, he says, “are built by genes,” and genes undergo random mutation, whereby new traits arise.

Of course, random activity does not by itself explain anything at all. So we can be sure that this activity is assumed to take place against a (perhaps largely unspoken) background that contributes essentially to the supposed explanation of teleology. A foundational feature of this background is the assumption that an organism is no more than a kind of material structure — preferably a machine, or mechanism, that we can imagine is controlled by a genetic program.

Evolution then “works” by tinkering<sup>2</sup> with at least some part of this physical structure until, over geological time, entirely new sorts of structure take form. The tinkering works mainly upon randomly occurring variations — usually, it is said, *genetic* variations, or mutations. And, despite the word itself, *tinkering* is not admitted to be something the organism or any other agent *does*. Nor does it reflect any sort of wisdom playing through living beings. Rather, the contriving of complex, sophisticated new features is something that blindly *happens* to the organism.

But finding things that blindly happen to the organism is hard to do.

**The nonrandomness of mutation.** To demonstrate that last point, we need only consider the unexpected reality of those genetic mutations upon which natural selection is supposed to work. The crucial observation was made by Oxford University biophysicist Norman Cook in 1977: far from being random, these mutations are actively managed by the organism. “Biological intervention through enzymes and enzyme systems is the principal mechanism of *in vivo* mutation,” he wrote. He went on to point out that if changes in the genetic material are indeed mediated by other cellular molecules, then the idea of randomness loses its meaning (Cook 1977).

Furthermore, as British radiologist B. A. Bridges remarked: even studies of radiation-induced mutation in bacteria have shown that cellular repair systems are “necessary for nearly all of the mutagenic effect of ultra-violet and around ninety percent of that of ionizing radiation” (Bridges 1969).

That is, outcomes depend at least in part on what the organism does with the influences impinging upon it. You might think that radiation mostly causes very local alterations in DNA, corresponding to the immediate location of damage. Yet the great majority of radiation-induced mutations involve large regions of DNA, often encompassing many thousands of nucleotide base pairs, or “letters,” of the genetic sequence. This is greater than the length of many genes (Elespuru and Sankaranarayanan 2006). The organism making such changes is apparently prepared to respond as best it can and in its own way when it engages the potentially harmful, mutagenic effects of its environment.

All this raises fundamental questions about the idea of an evolutionary process rooted in chance mutations. Where do we ever see random, wholly undirected change as opposed to an organism’s *response* to its external and internal environment?

**Activity precedes structure.** However, the decisive issue goes far beyond responses to mutation. There remains the larger truth that every organism, in its entire being, is first of all an activity — a truth we have seen amplified

throughout the first half of this book. When we look at an elaborately choreographed molecular activity such as RNA splicing (see the chapter on “The Mystery of an Unexpected Coherence”), the explanatory challenge lies in the fact that, unlike in a silicon chip, there are no precisely incised channels in the watery medium of the cell’s plasm. Likewise, there are no finely machined gears, switches, levers, springs, or hinges<sup>3</sup> to forcibly shape the carefully sequenced and well-aimed activity of the hundreds of molecules engaged in the extended task of splicing. The fluid realm of the cell is one where a kind of freedom reigns. There is also a continual exchange and transformation of substances, which means there is little in the way of a stable and rigidly fixed structure of any sort.

Where, then, do we even glimpse in the organism a machine-like object to begin tinkering with? Can one tinker with a power of activity?

So one way to pose the problem of natural selection and teleology is to ask: How can we relate natural selection to the evident teleological constraints upon all the molecules involved in RNA splicing, DNA replication and repair, or gene expression? What keeps these intricate processes — and countless others like them — “teleologically on track” to perform intricate and extended tasks despite what would be, in strictly physical terms, an overwhelming invitation to disorder? Can we possibly imagine that the cell’s living activity is controlled, step-by-step, by mechanistically enforced instructions issuing from the genome?

It’s not just that no one even pretends to have discovered genetically encoded instructions specifying what each of the molecules involved in RNA splicing should do, moment by moment. Even if there were such instructions, and even if they were so surpassingly complex and subtle that they could manage every moment’s need in perhaps trillions of differently contextualized cells throughout an organism’s unpredictable lifetime — still, these instructions would have no way of being continuously conveyed to the virtual infinitude of molecules needing them.

So the first thing we require is not some way to explain teleological activity based on evolutionarily tuned structures. Rather, we need a way to understand how all the heritable molecular structures in a reproductive cell are teleologically formed and elaborated in the first place.

In sum, we do not even know what “tinkered with” could mean, given that tinkerable structures must first be derived — and continually derived again — through teleological activity. There is a well-known “central dogma of molecular biology” (articulated by Francis Crick in 1958 and re-articulated in 1970) that concerns the one-way passage of information from DNA to protein. For all its fame (and infamy), it is much less cited today than it was in the past, perhaps

because its relevance to the actual life of organisms is so limited. In any case, a much more profound principle would read something like this:

All material structure in an organism derives from, and must be maintained by, the organism's activity. The structure, once originated, is put into the service of this activity — and in this sense becomes a constraining shaper of activity. But *activity always precedes both structure and constraint.*

## An Aversion to Meaning

The theory of natural selection gives us no argument against the self-evident purposiveness of organisms. To the contrary, it confirms the theorist's largely unacknowledged recognition of this purposiveness. For we can make sense of natural selection only after we have thoroughly internalized, from childhood on, a vivid awareness of the lively agency, whether of cats and dogs, birds and squirrels, worms and fish, or of the animals in our laboratories. The scientist can take this agency for granted without having to mention or describe it, since everyone else also takes it for granted. And so one speaks ever so casually of individual "development," or the "struggle for life," or the "production of variation," or "reproduction and inheritance" — all in order silently to import into theory the full range of the living powers that made biology a distinct science in the first place, but that few are willing to acknowledge explicitly in their theorizing. In this way, amid contradiction, circular reasoning, and what I have called the biologist's "blindsight" (see the chapter entitled "The Keys to This Book"), the materialist preserves his preferred picture of a meaningless existence. All he needs to do is appeal to natural selection, that "universal acid" (Dennett 1995) capable of dissolving all objections to what one wants to believe.

Several decades ago the British biologists Gerry Webster and Brian Goodwin had already noticed that "the organism as a real entity, existing in its own right, has virtually no place in contemporary biological theory" (Webster and Goodwin 1982). Goodwin later elaborated the point in his book, *How the Leopard Changed Its Spots*:

A striking paradox that has emerged from Darwin's way of approaching biological questions is that organisms, which he took to be primary examples of living nature, have faded away to the point where they no longer exist as fundamental and irreducible units of life. Organisms have been replaced by genes and their products as the basic elements of biological reality. (Goodwin 1994, p. vii)

The banishing of organisms from evolutionary theory was also an obscuring of biological purposiveness. It may even be that the banishing happened, in part, *for the sake of* this obscuring. Yet who can doubt that, if we ever do take the organism's purposiveness into account at anything like face value, the results could be of explosive significance for all of evolutionary theory?

It is difficult to pinpoint whatever lies behind the extraordinary animus the biological community as a whole holds, not only toward teleology, but indeed toward any meaningful dimension of life or the world. But the animus seems as deeply rooted as it could possibly be. Michael Ruse, who might be regarded as a dean of contemporary philosophers of biology, once briefly referred to an article by the highly respected chemist and philosopher, Michael Polanyi, in this manner:

Polanyi speaks approvingly, almost lovingly, of "an integrative power ... which guides the growth of embryonic fragments to form the morphological features to which they embryologically belong."

And what was Ruse's response?

One suspects, indeed fears, that for all their sweet reasonableness the Polanyis of this world are cryptovitalists at heart, with the consequent deep antipathy to seeing organisms as being as essentially physico-chemical as anything else ... Shades of entelechies here! (Ruse 1979)

The real antipathy appears to be on Ruse's part. One wonders exactly what violation of observable truth he saw in Polanyi's reference to "an integrative power" that "guides" embryological growth. No biologist would dare deny that embryological development is *somehow* integrated and guided toward a mature state. And it is difficult to understand how any actual integrating and guiding could be less than the expression of an effective "power," however we might end up understanding that term. Just think how much less justification there is for all the conventional references to the "power," "force," and "guidance" of natural selection! (On that, see the chapter, "Let's Not Begin with Natural Selection.")

As for Ruse's shuddering at the term "entelechy" (sometimes rendered as "soul"), the scholar who is perhaps the foremost interpreter of Aristotle today translates the Greek *entelecheia* as "being-at-work-staying-itself" (Sachs 1995, p. 245). What better characterization of an organism and its distinctiveness relative to inanimate matter could there possibly be? Every biologist who uses the conventional term "homeostasis" (a system's maintenance of its own

stability) or, better, “homeorhesis” (a system’s maintenance of its characteristic activity) is already saying something similar to “being-at-work-staying-itself.” It’s the way of being of any organism. The Aristotelian term is useful for reminding us that an organism is first of all an activity, and its activity is that of a centered agency possessing a remarkable coordinating and integrative power in the service of its own life and interests.

On our part, we will now do our best to read the organism and its activity back into evolutionary theory. In doing so, we will ignore the strange taboo against accepting living powers and purposiveness as relevant to the theory.

*The full (and much longer) version of this book chapter is available at <https://bwo.life/bk/evotelos.htm>.*

## NOTES

1. Part of the worry about purposive activity has to do with the fact that it is future-oriented, and therefore seems to involve something like conscious human planning, which we can hardly attribute to an earthworm. Nor do we need to. I deal with this issue in another chapter (not available at this writing). The present chapter deals only with the relation between teleology and natural selection.
2. The idea of tinkering — that evolution is a tinkerer rather than an engineer — traces back to an influential article by the French biologist, François Jacob (1977). “Tinkering” is now one of the tropes of evolutionary theory.
3. I am, with more than a touch of irony, echoing a statement by the Harvard cognitive psychologist and evolutionist, Steven Pinker, where he says:

The stuff of life turned out to be not a quivering, glowing, wondrous gel but a contraption of tiny jigs, springs, hinges, rods, sheets, magnets, zippers, and trapdoors, assembled by a data tape whose information is copied, downloaded, and scanned. (Pinker 1997, p. 22)

We might hope that by now Pinker has awakened from his culturally induced trance and has realized that, as far as our current, rapidly expanding knowledge goes, the “quivering, glowing, wondrous gel” (if we discount the hyperbolic ridicule intended by the phrase) is actually closer to the truth than is the picture of all those wonderfully familiar, but terribly unbiological, machine parts.

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Evolutionary biologists act certain that they know *how* new life forms originate and complexify. But they don't... Many biologists claim they know for sure that *random mutation* (purposeless chance) is the source of inherited variation that generates new species of life and that life evolved in the single-common-trunk, dichotomously branching-phylogenetically-tree pattern! 'No!' I say ... Our zealous research, ever faithful to the god who dwells in the details, openly challenges such dogmatic certainty. This is science.

LYNN MARGULIS, editorial in *The American Scientist* (2006)