In Context

The Newsletter of **The Nature Institute**

#40

Fall 2018

Dear Friends,

In the inaugural issue of *In Context* twenty years ago, we wrote about the difficulties in describing the kind of science our new Institute intended to pursue. Among the descriptive phrases we considered were these:

- Holistic science
- Goethean science
- Phenomena-centered science
- Qualitative science
- Participative science
- Contextual science

There is no one "right" choice, and we have tended to employ many different descriptive terms, despite the fact that almost any description will seem problematic in an environment so thoroughly shaped by the reigning abstract and quantitatively biased science of today. But perhaps no term has occurred more frequently in this publication than the especially problematic "Goethean science" — problematic if only because it is so foreign both to the general public and the scientific community. But at least its unfamiliarity may open a space of receptivity in the hearer, allowing a new understanding to arise that is not already prejudiced by the abuses that have colored, or miscolored, a phrase such as "holistic science."

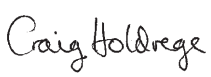
In this issue of *In Context* we might be seen as coming full circle to address the questions about "Goethean science" raised twenty years ago. Actually, we suspect that many issues of the newsletter might be seen that way. Questions about the nature of the unconventional science we try to explore are, after all, always needing to be addressed in our work precisely because the work is so unconventional. But it is true that in this current newsletter the matter of scientific method looms especially large. It becomes fully explicit in our Notes and Reviews article, "A Fresh Take on the Goethean Approach." The central observations in this note (which are the basis for a few reflections by Craig) came from a thoughtful scientific colleague residing in Europe.

Then there is the feature article, "Goal-Directed Activity in Life," which we have taken from a 1945 book by E. S. Russell. Russell was a Scottish biologist who spent a lifetime reflecting upon the distinctive character of living beings, and whose own work illustrated so wonderfully how one's scientific method can sketch this character. He would hardly have called himself a "Goethean scientist," given the absence of that phrase in his day, but his work was nothing if not holistic, context-centered, qualitative, and phenomena-based. The key thing for Russell was to observe the actual behavior of organisms, and then refuse to ignore the "purposive" and "goal-directed" (he often said "directive") nature of that activity.

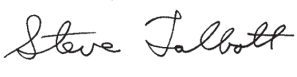
Starting with, and staying close to, phenomena in one's scientific work — including in one's theorizing — is, of course, at the heart of a phenomena-based science. This is why Steve, in preparing a new book about the nature of organisms and about the implications of this nature for evolution, begins the book with a chapter containing vignettes drawn from the life of various organisms. That chapter ("Scenes of Life") is included here alongside the piece by Russell.

We hope, then, that this issue of *In Context* provides interested readers with rich opportunities for noticing the special features of living creatures, and also for working toward an ever more systematic, disciplined, qualitative (and Goethean!) understanding of living phenomena.

Craig Holdrege



Steve Talbott



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Animals in Their World

Craig Holdrege

Photos: C. Holdrege

WHEN YOU VISIT the northern area of Yellowstone National Park in June, you encounter an island of wildlife that provides a glimpse into the wealth of animal life that once spread over vast areas of the continent. Henrike and I spent eight days there, hiking and observing plants and animals. We saw bison, elk, moose, deer, pronghorn, bighorn sheep, bears, and coyotes. We didn't see any of the wolf packs, although some avid nature lovers were observing them at great distances through their spotting scopes. We encountered nests of peregrine falcons, bald eagles, and golden eagles. We even came face to face with a badger as we hiked down a trail — it emerged from its den, looking at us with a piercing gaze.

I share here only our experiences of the bighorn sheep. We were at an overlook that lets you peer down into the gorge of the Yellowstone River, which was rushing along, full with spring meltwater. On the opposite side you look onto a nearly vertical wall of basalt and the gradually eroding, but very steep incline of ancient lava. Some trees grow on these steep canyon walls, but very little herbaceous vegetation.

After a while, we noticed that there were animals on those cliff sides. They were female bighorn sheep (ewes) and their young lambs. Do not picture domestic sheep. The ewes were sleek and fairly short-haired, and resemble domestic goats more than sheep. The lambs were grey and had long, spindly legs. In coloration the sheep blend well with their rocky ground. The ewes moved slowly among the rock-strewn walls — walls on which, as a human being, I would certainly want to be roped in and secured — and they fed occasionally on the sparse vegetation. They often paid little attention to their lambs, which were frolicking around on the inclines as though there were no deadly chasm to plunge into. The lambs jumped from rock to rock, ran after one another, sometimes kicked up rocks that bounded down into the river far below.

These bighorn sheep inhabit a remarkably inhospitable environment — and yet, it is their home, their place. Inhospitable means inhospitable for us human beings. It was so vividly clear that they live in a different world, not only in terms of the outer environment, but also in the way they are part of that environment. They are not worrying about falling; the ewes are not agonizing over the wild behavior of their lambs; they are not concerned at how sparse the vegetation is; they are not planning ahead to decide where to spend the night. They live embedded in this "harsh" environment as an extension of their being. They are at home.

On this trip, while observing so many different animals, such different ways of being and ways of relating to the surroundings, I had the growing sense that I don't really fathom what it is to be animal — to be so integrally entwined with one's world. We have kinship as ensouled beings, but I'm the one observing them and thinking about their characteristics. I can appreciate their existence and, in fact, I'm in awe of them. This connects me with them and at the same time makes me realize how different I am.

Our Encounter with Institutionalized Dogmatism in Biology

LAST YEAR we wanted to place an advertisement in the journal *The American Biology Teacher*, which is published nine times a year by the National Association of Biology Teachers (NABT). The ad would have highlighted our new kit on "Diversity in Human Evolution" and my recent monograph, *Do Frogs Come From Tadpoles?* We soon realized, however, that placing the ad was not a straightforward task.

We contacted the Association and described the ad. The executive director replied that "NABT has a policy that all materials from new advertisers be reviewed for consistency with the association's policies on scientific integrity and other formal positions … In addition to the title 'Do Frogs Come from Tadpoles?', I see the Nature Institute also has some resources about evolution, and specifically on hominid evolution, that will also need to be reviewed."

This happened in August 2017, and we were told that it was not possible to say how long the review process would take.

Nine months later, in May 2018, we received the following notification that our request to submit an ad had been rejected:

> The Association has completed reviewing and have concluded that [the frog monograph's] contents are

inconsistent with NABT's policy on promoting scientific integrity as well as its current position on teaching evolution [nabt.org/Position-Statements-NABT-Position-Statement-on-Teaching-Evolution].
As a result, the Association will not allow the advertisement or promotion of your monograph through NABT products or events.

I wasn't terribly surprised at the rejection, since NABT's position statement on evolution suggests that it does not want to promote any perspectives that might call into question or even expand what its leaders apparently believe to be the standard mechanistic view of evolution. In effect, the organization promotes a kind of dogma that fortifies it against any challenges coming from intelligent design theory or other positions. It appears that NABT wants to protect its readers from heresies.

I decided to respond to the decision — as calmly as I could, given that their position reflects a kind of dogmatism and censorship, which flies in the face of the spirit of open scientific inquiry. Below is the text of my May 2018 email letter to the organization. I received no response to the concerns I expressed in this letter.

Dear —

Colleen passed on to me your email informing us that you will not accept our request — submitted in August 2017 — to advertise in your journal.

I wholeheartedly agree with Dobzhansky's statement that "nothing in biology makes sense except in the light of evolution," which you cite in your position statement on teaching evolution. But since our understanding of evolution is continually evolving, theories and proposed mechanisms change over time. Thirty years ago, Lamarckianism was heretical and considered unscientific. Now it has become one additional way of understanding certain evolutionary processes. Articles that discuss Lamarckian-type processes appear in *Nature, Science,* and other respected journals; witness the whole surge in research on the importance of epigenetic inheritance. The search for truth in science will always lead beyond existing paradigms.

Your policy statement emphasizes the bedrock acceptance of evolution — with which we at The Nature Institute fully agree — and also the discussion of mechanisms. If you review the scientific literature, there is no consensus about these mechanisms. Therefore students need to learn both existing theories and mechanisms, and learn that we don't have all the answers. Otherwise, instead of promoting open-ended scientific inquiry, teachers will be promulgating a doctrine. That is my concern about your policy.

Many teachers (secondary and post-secondary) have profited from our educational resources, so that is why we have a hard time understanding why you would want to prohibit your readers from exposure to them. We do critique theories and proposed mechanisms (nothing special in science), but as part of the work to gain greater insight that enhances and expands knowledge. Is that "dangerous" for your readers?

You write that the resources we wanted to make known through the ad not only do not conform with your evolution policy, but are also "inconsistent with NABT's policy on promoting scientific integrity." What is your concept of "scientific integrity" and how do we transgress it?
I do not write in hopes that you will change your mind about your decision. But I do feel the need to express my disappointment that — as an organization that wants to support and encourage good biology education — your policy treats your readers as followers of a doctrine who need to uphold some imagined status quo. Couldn't you rather assume that your readers are mature, discerning human beings, who can make their own choices about what they find stimulating and relevant in the search for a deeper understanding of evolution and the origin of species — that "mystery of mysteries" Darwin spoke of?

Sincerely,
Craig Holdrege

A Fresh Take on the Goethean Approach

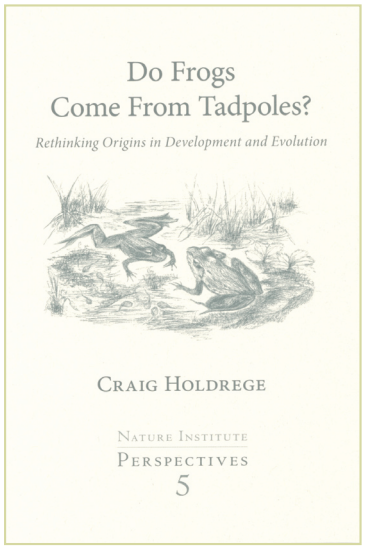
SOME TIME AGO I was contacted by a colleague who had heard me speak at a conference and had read my monograph, *Do Frogs Come From Tadpoles?* In his email he offered a succinct formulation of the Goethean way of science that we here at the Institute found both original and illuminating. We'd like to share his thoughts — in my words (he wrote in German). I'll add a little commentary afterwards.

He wrote that in reading the monograph he discerned three capacities that are essential to the Goethean approach. In his view, research is inadequate if you only exercise one or two of them. He characterized the capacities this way:

> (1) You must be a good observer in order to take seriously the manifoldness of appearances in nature. You need to love the phenomena so much that you persist in attending to them and resist sacrificing them to "beautiful thoughts."
>
> (2) You need to be able to think clearly in a philosophical way. Such thinking is more than logical. It needs a feeling for where a thought carries you when you think it through to an end. That is, you need a compass within the world of ideas. This is the quintessence of philosophical thinking. And here as well, you must love the consequences of the orientation in the world of ideas enough so that you don't sacrifice them to something else.
>
> (3) Finally, it is also necessary that you bring the two sides together. That is, you shouldn't observe something in a careful way and then philosophize about something else. Rather, you need to stay with precisely those ideas that come to you through the observation — ideas that were stimulated by the observation.

In the English-speaking world, people often use the term "Goethean observation." I'm not always sure what they mean by this term, but in the best case it conforms to the first capacity —working to perceive and stay true to the phenomena in their manifoldness.

What people often do not see so readily is how essential the second and third capacities are for the process of inquiry. Just as we need to be keenly aware of what the encounter with the sense world brings us, so also do we need to be



aware of our thinking processes and where a given thought or train of thought leads. To take an example from the frog monograph: What do I mean and what do I *not* mean when, after carefully considering the rich phenomena of development, I say "a frog comes from a tadpole"? In that monograph I described how everything in a tadpole is broken down and transformed as the adult frog comes to appearance. Therefore, in a very real sense, a frog does *not* come from a tadpole. In considering such matters, I strive to express the fresh meaning that reveals itself in the particular phenomena I am focusing on. I make every effort to hold habits of thought at bay so that they do not occlude this encounter with the world.

When we can keep the intensity of sensory observation and clear, self-aware thinking together, then we are creating fertile soil for moments of insight — the third capacity. In moments of grace, a new insight may spring to us — out of the process itself. In the case of my frog studies, a moment came when my understanding was revolutionized by realizing that there is good reason to say: frogs do not come from tadpoles!

We cannot make such insights happen. They come to us. But we can prepare for such insight in the sense that we are patient, can wait, and remain open. We free ourselves from the compulsion to get hold of the truth once and for all. We are prepared to let knowledge grow.

CH

New Foundation Course in Goethean Science

2018 Summer Intensive

In July we began, for the first time, a year-long, low-residency course. Called "Encountering Nature and the Nature of Things," it offers a foundation in the science of phenomena. This is an approach that is contextual, qualitative, and holistic — what we often call "Goethean science." We accepted twenty-two applicants into the program. The participants come from diverse professional backgrounds — high school and university education, science, farming, and others. Most are from the U.S., but others reside in Canada, Brazil, Argentina, Switzerland, and Australia.

The course began with a two-week intensive at The Nature Institute and continues now that the participants have returned home. There they are carrying out individual research projects, studying texts from a reader we created for the course, and engaging in correspondence and conversation with mentors and classmates. Participants will then return in July 2019 to conclude the course with another two-week intensive.

Each day of this first intensive followed more or less the same rhythm. When participants arrived at 8:30 a.m., we met briefly and then went to our "places." Each of us had found a spot on the grounds of the Institute where we would spend about half an hour. One of the program's facilitators, Jon McAlice, a Waldorf educator and consultant with an interest in the psychology of learning, provided guidelines for ways of experiencing the place differently each day over the course of the two weeks. One day we attended to what was close by and then shifted to the larger environs; on another we paid attention to sounds or smells. All this helped us to live in our senses and dwell in what the world revealed.

After the place observations we worked for an hour with short texts by Goethe, Rudolf Steiner, and the late Henri Bortoft, a leading interpreter of Goethean science. These texts addressed fundamental characteristics of the consciousness we need in order to develop a participatory relation to the world.

In two sessions each day we explored a specific phenomenal domain and considered the associated methodologies. For example, Henrike led us into the world of light, darkness, and color. She encouraged us in the practice of careful and ordered observation of the visual world, together with concrete thinking that does not draw heavily on models

and theoretical constructs. In this way the phenomenal experiences themselves gained greater meaning and depth. Craig led plant studies, with a focus on the phenomena of metamorphosis. We spent many hours observing different plants. Gradually the living qualities of plants, and especially the transition from vegetative growth and transformation in the green leaves to the radically new formation of the flower, came into clearer focus.

In the afternoon, between these two sessions, we worked artistically. During the first week we modeled with clay to immerse ourselves in the realm of form and forming, and the second week we deepened our experience of color through watercolor painting exercises. Each day concluded with a gathering of questions that were alive in the group, and then a communal cleaning of the Institute.

The course facilitators, in addition to Jon, Henrike, and Craig, included John Gouldthorpe, who studies the relationship between perception, conception, imagination, and identity. All the facilitators commented on the high degree of commitment, openness, and enthusiasm the participants showed in all the activities. At the end of the course, participants were asked to reflect on the two weeks. One question was, "What has changed for you?" Here are some responses:

This course opened a door for me on how to see this world. I was wondering how I lived these years without noticing so many amazing phenomena. This course also refreshed me and inspired me for my teaching.

My understanding about nature and science has changed. The approach to nature that I had before was far from nature itself.

Consciously discovering the playfulness of nature/life and realizing how much is overlooked when I am not acting/engaging as part of the life process around me. Now I am not taking things for granted and saying "oh yes, I know that field." Instead I say "What can be revealed today? What processes are here?" I feel more sensitive to that which comes toward me, a new interest in the world and my participation in/with/among it.

Due to our positive experience of this first intensive, and the fact that more people applied than we could accept, we have decided to offer a new class in 2019 that will start with a first intensive from June 24 to July 6. For more information, please see our website.

At Home and Abroad

- In April, ten students from the first-year class at the Alkion Center for Adult Education, which is an initiative of our neighbor, the Hawthorne Valley Association, came to The Nature Institute for three Saturday afternoons. Henrike worked with them on a training of thinking through projective geometry, while Craig dealt with plants and plant metamorphosis.
- At The Nature Institute this past June, Craig and Henrike led a group of twelve participants — many of them teachers — in a week-long intensive in sustainability education called "Let the Phenomena Speak!" During this time the group immersed itself in the natural world and explored questions around how to deepen their own perceptive capacities and help to guide others along this path.
- This August, Henrike led two mornings of professional development work with the faculty and staff at Green Meadow Waldorf School in Chestnut Ridge, New York. They focused on the challenges and potentials of science teaching in the middle school: igniting interest in the natural world; opening and closing windows of understanding; the effects of media consumption; and where a successful phenomenological science can lead.
- In September Craig taught for one week in the Masters in Holistic Science Program at Schumacher College in England. He introduced the students to Goethean methodology and focused on the study of plants.
- On September 21, The Nature Institute celebrated the twentieth anniversary of its founding in 1998 with an evening talk and day-long workshop. Craig's talk was on

Studying examples of leaf metamorphosis during the June sustainability education intensive.

"Where Does an Animal End? The American Bison" preceded by an introduction from Henrike.

- Craig went to Middlebury College in Vermont this October to talk to students in an innovative course focused on "perennial thinking," taught by Middlebury instructors Marc Lapin, Nadine Barnicle, and William Vitek. Their course is exploring how to transcend the mind-set of agricultural monoculture and extend the research and vision of polyculture to other domains of human activity. As the course description explains, this involves "an emerging story of thinking more like a prairie than a plow." So it's fitting that Craig's book, *Thinking Like a Plant*, is a text for the class. In his talk Craig spoke about the phenomena-based approach to understanding plants and the relevance of that understanding for enlivening the qualities of our human thinking.

Still Ahead

- This November Craig and Henrike will travel to Brazil, where they have been asked once again to offer a course on "Seeing Nature Whole — Foundations of Goethean Science." Hosted by the Associação Sagres, a center for adult education in the city of Florianopolis, the program includes two two-week modules, one in November, 2018, and one in November, 2019.
- In December Craig will participate in a four-day conference in Kassel, Germany, for Waldorf high school students. It will offer engaged students the possibility of dealing with important current issues in the sciences and humanities. Craig will give four keynote talks on contextual approaches to understanding life. He will also co-teach a course on evolution for those students with a special interest in biology.
- Information about our 2019 Winter Course is now available. We will also begin a new Foundation Course in 2019. See announcements on the back cover.

Publications and Resources

Our first podcast. Last year we shared a number of Craig's talks as videos on our website's "Other Media" page. Now we've added our first podcast — a recording of a talk that Craig gave this spring entitled "Cultivating the Roots of Earth Stewardship." Speaking with an audience consisting mostly of educators, Craig took up the question, "How can we help our children grow up to become caring and responsible stewards of the earth?" You can listen to it online at http://natureinstitute.org/media.

In process: A new book from our *Biology Worthy of Life* project. Steve is working on a new book tentatively called *Whole Organisms and Their Evolutionary Intentions*. It represents the culmination of his efforts to date in our *Biology Worthy of Life* initiative. An introductory chapter providing some glimpses into the wonders of life is a feature article in this issue of *In Context*. Steve has also posted an article on our website summarizing some of the themes he will be exploring. While his perspective departs radically from conventional thinking, he suggests that it might also be considered mere common sense. Stay tuned for other individual chapters, which will appear on our website as they are written.

And praise for a previous book. Steve found himself in good company recently, sharing favorable recognition from the journal *Plough Quarterly*. In its Winter 2018 issue, which focused on "Staying Human" in a technological world, the quarterly recommended five books that its editors consider of "enduring" value for understanding technology. The five included Mathew Crawford's *Shop Craft as Soul Craft: An Inquiry into the Value of Work*, Aldous Huxley's *Brave New World*, C.S. Lewis' *The Abolition of Man*, Neil Postman's *Technopoly: The Surrender of Culture to Technology*, and Steve's 2007 book, *Devices of the Soul: Battling for Our Selves in the Age of Machines*.

Celebrating Two Decades

In 1998, on Sept 20, The Nature Institute's founding celebration took place in our community. Craig Holdrege, Steve Talbott, and Henrike Holdrege, backed by a Board of Directors, an Advisory Board, and the office assistance of Penelope Lord, started on a journey. The journey's destination was, and continues to be, the practice of Goethean science in North America through research, publications, and adult education offerings.

Today, twenty years later, Craig, Steve, and Henrike continue their collaborative efforts, and the work is supported by an able staff — currently Linda Bolluyt, Colleen Cordes, Seth Jordan, and Veronica Madey. We have had colleagues who joined the work at the Institute for a period of time, and more colleagues located throughout the world who bring the same impulse to life in their own work.

The work has intensified and developed. We at The Nature Institute have learned and continue to learn, as do the participants in our courses and workshops, and also our readers (so we hope!).

At this point we want to say "Thank you." We are grateful for the widespread community of people who recognize, value, and support our work. We are grateful that the Institute's work finds an echo in the work of many others.

Looking back, we can say that our journey has brought us to places near and far, and that the work is fruitful and necessary — even more so today than twenty years ago.

At the founding celebration in 1998, I cited the philosopher Friedrich Hegel: "Thinking inflicts the wound, but also heals it." The wound — modern civilization's estrangement from the natural world and its riches and teachings — is inflicted by modern abstract, intellectual, and purely materialistic thought. We at The Nature Institute hope to continue working toward healing the wound. *HH*

As part of the celebration of The Nature Institute's twentieth anniversary on September 21, 2018, Craig gave a talk on the American bison. Over seventy people attended the festive evening, which was framed by music improvisations by Peter Alexanian.

Thank You!

We would like to give special thanks to a Nature Institute supporter who offered a $5,000 challenge grant in the spring, and to all who responded — your gifts totaled $10,200! Also, our deepest gratitude to everyone who contributed between April 1 and September 30, 2018.

PLEDGES

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Scenes of Life

Stephen L. Talbott

This is the introductory chapter of a book-length project I am now undertaking, tentatively entitled "Whole Organisms and Their Evolutionary Intentions." A kind of extended abstract, or overview, of the project is available at RediscoveringLife.org/ar/2018/thesis_34.htm.

We in the twenty-first century have inherited an extensive library of descriptive literature about living things, their habitats, and their mutual relations, bequeathed to us over the centuries by dedicated naturalists. Unfortunately, in this age of molecular biology and genetic preoccupation, the community of naturalists has largely died out. It is a shame that biologists today can easily pass through their schooling and into a pristine laboratory without ever having read descriptions such as the following, let alone having observed and investigated these phenomena for themselves.

The narratives below, culled from various sources, afford only fragmentary glimpses of the larger panorama of life on earth. But they are enough to remind us of the "miracle" that life can so easily appear to be. The reminder is a useful one, so far as it spurs us toward efforts of understanding that are not cramped by prevailing dogmas.

(1)

The obscure wisdom of the potter wasp

From biologist, novelist, and science philosopher, E.L. Grant Watson:[1]

"Among the fascinating stories of animal life told by the French naturalist Henri Fabre is that of the sand wasp *Eumenes* [often referred to as the "potter wasp"]. The fertilized female builds a little domed house of sand spicules on some stone or rock foundation. The foundation ring is traced in minute pebbles. On this she builds a series of concentric rings, each diminishing in circumference, so as to enclose a domed space. At the top she leaves a hole. She then begins collecting certain species of small caterpillars. She stings these into a partial paralysis, but does not kill them, for they will be needed as fresh meat for the young she will never see.

"When the wasp has collected either five or ten caterpillars, she prepares to close the dome, reducing the size of the hole. She now goes through a complicated process which would seem to indicate foresight on her part. Yet she has no foresight, only a highly developed instinct. From her ovipositor she excretes a juicy substance, working it with her legs into a narrow, inverted cone. With a thread of the same substance, she stitches the cone to the top of her domed building. Into the inverted cone, she lays an egg. She then seals up the hole, leaving the egg safe within the cone, suspended on a thread. This done, she goes off and builds another dome to repeat the same cycle of events.

"In a short time the egg hatches into a tiny, white grub, so helpless and delicate that if placed among the still-living caterpillars on the floor of the dome, it would inevitably be injured. In its cradle it is safe. When hungry it spins a thin thread of its own, on which it descends and takes a bite of caterpillar. If the wriggling caterpillars appear threatening, it can retreat up the thread, and wait. In this way the grub spends its infancy; but, as it grows stronger, it risks a final descent, and devours, at its leisure, the still living food that mother has so satisfactorily provided.

"From the domes that contain five caterpillars male wasps emerge; from where there are ten caterpillars, the larger female wasps. This raises an interesting question: Does the amount of food determine the sex? The mother wasp, who appears throughout her lifetime as a highly nervous and brilliantly alive creature, has built just the right sort of houses for the offspring she will never see; and has provided just the right amount of food. She is singularly well-adapted for her life; she stings the caterpillars just enough to keep them quiet, but not enough to kill them; she packs each dome with the right amount of food for male or female grub. The suspended cradle protects the tender infant from the rough reactions of the caterpillars while being eaten. Everything is in order, and as the emerging sand wasp dries her wings in the summer sunshine, she must surely feel that God is in his heaven, and all is well with the world. The caterpillars might harbour different sentiments ..."

(2)

The nesting cycle of the chaffinch

From British naturalist and ornithologist, Edward Max Nicholson:[2]

"The male must leave the flock, if he has belonged to one, and establish himself in a territory which may at the time be incapable of sustaining him alone, but must later in the season supply a satisfactory food-supply for himself, his mate and family, and for as many birds of other species as overlap his sphere of influence. He must then sing loudly and incessantly for several months, since, however soon he secures a mate, trespassers must be warned off the territory, or, if they ignore his warning, driven out.

"His mate must help with the defence of the territory when she is needed; pairing must be accomplished; a suitable site must be found for the nest; materials must be collected and put together securely enough to hold five bulky young birds; eggs must be laid in the nest and continuously brooded for a fortnight till they hatch, often in very adverse weather; the young are at first so delicate that they have to be brooded and encouraged to sleep a great part of the time, yet they must have their own weight of food in a day, and in proportion as the need of brooding them decreases, their appetites grow, until in the end the parents are feeding four or five helpless birds equal to themselves in size and appetite but incapable of digesting nearly such a wide diet.

"Enemies must be watched for and the nest defended and kept clean. When the young scatter, often before they can fly properly, they need even greater vigilance, but within a few days of the fledging of the first brood a second nest will (in many cases) be ready and the process in full swing over again. All this has to be done in face of great practical difficulties by two creatures, with little strength and not much intelligence, both of whom may have been hatched only the season before."

(3)

On migration

The **arctic tern** migrates every year between its residences at opposite poles of the earth. The meandering and partly improvised course of its annual round trip, shaped to take advantage of prevailing winds, amounts to as much as 56,000 miles (90,000 km)[3] — well more than twice the entire circumference of the earth, and mostly over the "pathless" sea. For mating, the tern usually returns time and again to the same northern colony. The slender bird accomplishing these feats, armored against the elements with nothing but delicate feathers, weighs about 4 ounces (110 g).

Many factors have been proposed to explain bird migration in general: navigation is variously said to be guided by sun and stars, earth's magnetic field, environmental cues such as odors and visual landmarks, and "mental maps" constructed from experience. It's commonly thought that, with any given migrating species, a number of such factors may play a role.

Photo C. Holdrege

Monarch butterfly (*Danaus plexippus*)

When a Pacific Ocean **Chinook salmon** is prompted by some deep urge to migrate from the open ocean to its natal stream — there to lay its eggs and die — several years may have passed since it left that stream as a juvenile. Supposing it hatched in a central Idaho waterway — and leaving aside thousands of miles of ocean travel so as to reckon only from the mouth of the Columbia River — its return journey could well extend over 900 miles. Struggling against stiff currents and strong rapids, the fish must gain several thousand feet in elevation. Upon reaching its birth stream, the male "knows" to pair up with a female, the female "knows" to dig a depression in the stream bottom in order to lay her eggs, and the male "knows" to fertilize the eggs. Both fish "know" to protect the eggs from predators — and both will very likely die before the eggs actually hatch.

Huge numbers of migrating **monarch butterflies**, starting from as far away as the northern midwest and eastern Canada, home in on a single wintering location in central Mexico with the precision of an intercontinental ballistic missile — except that the trajectories followed by the butter-

flies are hardly missile-like. Different groups follow separate paths, and these paths vary depending on conditions. Migration routes may also evolve historically: apparently there are no mentions of monarch butterflies in American colonial times, and it's been argued that the insects moved northward to take advantage of the luxuriance of larval host plants following the deforestation of northeastern America.[4]

In any case, none of the butterflies traveling from Canada or the northern United States to Mexico has had any previous life experience of that journey. The return trip northward in the spring occurs only over several generations, so there are no experienced "guide butterflies" to lead the way in either direction.

(4)

A fatal spitting accuracy

You may have heard about the **archerfish**, found in warmer waters of the Far East. This fish "spits" a forceful stream of water sufficient to dislodge an insect from its sticky attachment to a stem or leaf up to at least two meters away. Of course, when looking from the water into the air, the fish must correctly compensate for the same refraction of light that, in our own experience, makes a stick look "bent" at the point where it enters the water.

That itself is mystifying enough. But researchers recently showed that the archerfish's achievement is even more startling. This cunning hunter emits its lethal jet in such a way that the last water released (the trailing part of the stream) eventually catches up with the water released earlier — and does so right at the distance where the insect is located, making for maximum force of impact. Moreover, the way to do this changes a great deal, depending on whether the insect is 10 cm away or, say, 100 cm.

The gathering of water in the fish's mouth, its dynamic shaping, and the force of propulsion imparted to the stream in order to achieve the proper result at each distance, are extraordinarily complex — and not fully understood. But researchers, in testing the fish with targets at 20 cm, 40 cm, and 60 cm, reported that "jet tips recorded just before impact were equally well focused, and their shapes bore no information on how long they had traveled before."[5] That is, the fish adjusted the dynamics and timing elements of its water jet in order to have it "come together" in just the right way at whatever distance the target resided.

(5)

A surgical "battlefield"

The challenges an organism faces can demand fiendishly complex responses. These may require an almost infinite number of molecular interactions that neither this organism nor its ancestors have ever before carried out in the same, highly coordinated pattern. Wound healing offers endless examples. Here is a description offered by English biologist Brian Ford:[6]

"Surgery is war. It is impossible to envisage the sheer complexity of what happens within a surgical wound. It is a microscopical scene of devastation. Muscle cells have been crudely crushed, nerves ripped asunder; the scalpel blade has slashed and separated close communities of tissues, rupturing long-established networks of blood vessels. After the operation, broken and cut tissues are crushed together by the surgeon's crude clamps. There is no circulation of blood or lymph across the suture.

"Yet within seconds of the assault, the single cells are stirred into action. They use unimaginable senses to detect what has happened and start to respond. Stem cells specialize to become the spiky-looking cells of the stratum spinosum [one of the lower layers of the epidermis]; the shattered capillaries are meticulously repaired, new cells form layers of smooth muscle in the blood-vessel walls and neat endothelium; nerve fibres extend towards the site of the suture to restore the tactile senses … These phenomena require individual cells to work out what they need to do. And the ingenious restoration of the blood-vessel network reveals that there is an over-arching sense of the structure of the whole area in which this remarkable repair takes place. So too does the restoration of the skin. Cells that carry out the repair are subtly coordinated so that the skin surface, the contour of which they cannot surely detect, is restored in a form that is close to perfect."

Of course, we cannot even begin to picture the specific movements of the countless molecules and millions of cells in the damaged area. So we analyze the situation in terms of its general principles. The body, on the other hand, must be master of the actual material activities, in all their details. It must in some sense — although not at all in an obvious one — *know* what it is doing. All these details must "hold together" as they lead toward a future state of health.

(6)

On metamorphosis

Millions of species, from innumerable marine organisms to frogs to butterflies, undergo one or another sort of metamorphosis during their development. Here I draw from a description of the goliath beetle offered by British physician and evolutionary scientist, Frank Ryan:[7]

"Rather than a den of repose, we see now that the enclosed chamber of the goliath's pupa really is a crucible tantamount to the mythic pyre of the phoenix, where the organic being is broken down into its primordial elements before being created anew. The immolation is not through flame but a voracious chemical digestion, yet the end result is much the same, with the emergence of the new being, equipped with

Photos: Frantisek Bacovsky

Goliath beetle larva and adult (*Goliathus goliatus*)

complex wings, multifaceted compound eyes, and the many other changes necessary for its very different lifestyle and purpose.

"The emerging adult needs an elaborate musculature to drive the wings. These muscles must be created anew since they are unlike any seen in the larva, and they demand a new respiratory system — in effect new lungs — to oxygenate them, with new breathing tubes, or tracheae, to feed their massive oxygen needs. The same high energy needs are supplied by changes in the structure of the heart, with a new nervous supply to drive the adult circulation and a new blood to make that circulation work. We only have to consider the dramatic difference between a feeding grub or caterpillar and a flying butterfly or a beetle to grasp that the old mouth is rendered useless and must be replaced with new mouthparts, new salivary glands, new gut, new rectum. New legs must replace the creepy-crawly locomotion of the grub or caterpillar, and all must be clothed in a complex new skin, which in turn will manufacture the tough new external skeleton of the adult. Nowhere is the challenge of the new more demanding than in the nervous system — where a new brain is born. And no change is more practical to the new life-form than the newly constructed genitals essential for the most important new role of the adult form — the sexual reproduction of a new generation. The overwhelming destruction and reconstruction extends to the very cells that make up the individual tissues, where the larval tissues and organs are broken up and dissolved into an autodigested mush … To all intents and purposes, life has returned to the embryonic state with the constituent cells in an undifferentiated form."

Looking at the pupal case of a fly, the developmental biologist and evolutionary theorist, Wallace Arthur, asked: "What on earth is going on in there to turn one animal into another? If we didn't know better, we might venture 'magic' as our best attempt at an answer."[8] Arthur's wonder is justified. And he surely expects, as we must, that a more satisfactory answer than "magic" will be forthcoming — although whether that answer can be framed in terms of the science we now have is another matter.

(7)

A deceptive fragility

From Walter B. Cannon, an American physiologist who worked during the first half of the twentieth century:[9]

"Our bodies are made of extraordinarily unstable material. Pulses of energy, so minute that very delicate methods are required to measure them, course along our nerves. On reaching muscles they find there a substance so delicately sensitive to slight disturbance that, like an explosive touched off by a fuse, it may discharge in a powerful movement. Our sense organs are responsive to almost incredibly minute stimulations. The sensory surface in the nose is affected by vanillin, 1 part by weight in 10,000,000 parts of air. And as for sight, there is evidence that the eye is sensitive to 5/1,000,000,000,000 erg, an amount of energy which is 1/3,000 that required to affect the most rapid photograph plate.

"The instability of bodily structure is shown also by its quick change when conditions are altered. For example, we are all aware of the sudden stoppage of action in parts of the brain, accompanied by fainting and loss of consciousness, that occurs when there is a momentary check in the blood flow. Indeed, the high degree of instability of the matter of which we are composed explains why drowning, gas poisoning, or electric shock promptly brings on death. Examination of the body after such an accident may reveal no perceptible injury that would adequately explain the total disappearance of all the usual activities. But there are subtle changes in the readily mutable stuff of the human organism which prevent, in these conditions any return of vital processes.

"When we consider the extreme instability of our bodily structure, its readiness for disturbance by the slightest application of external forces and the rapid onset of its decomposition as soon as favoring circumstances are withdrawn, its persistence through many decades seems almost miraculous. The wonder is increased when we realize that the system is open, engaging in free exchange with the outer world, and that the structure itself is not permanent but is continuously broken down by the wear and tear of action, and as continuously built up again by processes of repair …

"There is also resistance to disturbances from within. For example, the heat produced in maximal muscular effort, continued for twenty minutes, would be so great that, if it were not promptly dissipated, it would cause some of the albuminous substances of the body to become stiff, like a hard-boiled egg. Again, continuous and extreme muscular exertion is accompanied by the production of so much lactic acid in the working muscles that within a short period it would neutralize all the alkali contained in the blood, if other agencies did not appear and prevent that disaster. In short, well-equipped organisms — for instance, mammalian forms — may be confronted by dangerous conditions in the outer world and by equally dangerous possibilities within the body, and yet they continue to live and carry on their functions with relatively little disturbance."

(8)

Immobile wisdom

The coyote tobacco plant (*Nicotiana attenuata*) of the western United States and Canada and northern Mexico implements a strategy with its insect predators no less sophisticated than that of any mammal dealing with a wolf or lion — except that the tobacco plant cannot scurry away on four legs or retreat into a burrow.

"The plant senses the amino acid compounds in a caterpillar's saliva and responds with an alarm signal — a hydraulic or electrical pulse through its stems and leaves. Within minutes, the plant's cells rev up their production of nicotine, a poison that interferes with an animal's muscle function. When attacked, a single wild tobacco leaf can pack in a half a cigarette carton's worth of nicotine. But some caterpillars, such as hawkmoths, have evolved a way to pass that poison through their gut instead of absorbing it, forcing wild tobacco to unearth new countermeasures. The plant produces compounds that inhibit digestion and make the caterpillar sluggish [and therefore more susceptible to attack by predators], as well as abrasives that wear down the attacker's mouthparts."[10] But there is more, for when hornworm larvae eat the tobacco leaves, the plant produces various volatile compounds that can attract *Geocoris* species ("big-eyed bugs") that prey on the larvae. And when the volatile compounds come in contact with the saliva of a larva, they go through a change that makes the larva even more attractive to the bugs, so that the modified compounds become, in effect, "signposts" directing the bugs to the larva's exact location. Further, even in the absence of direct attack, the tobacco plant may ready its defenses as a result of chemical signals emitted from neighboring plants whose leaves are already being eaten.

Finally, when eaten by certain night-feeding larvae, the tobacco plant goes through physiological changes that can, in as little as eight days, shift its flower-opening and pollination time from night to day, when it benefits from different pollinators. At the same time, the flowers reduce their production of a chemical that is attractive to predators.

All this is accomplished without anything like an animal brain. Nevertheless, the coyote tobacco plant clearly "knows" how to coordinate its resources in a meaningful and effective dialogue with its neighbors and its predators.

Photo: Dcrjsr (Wikimedia Commons)

Coyote tobacco plant (*Nicotiana attenuata*)

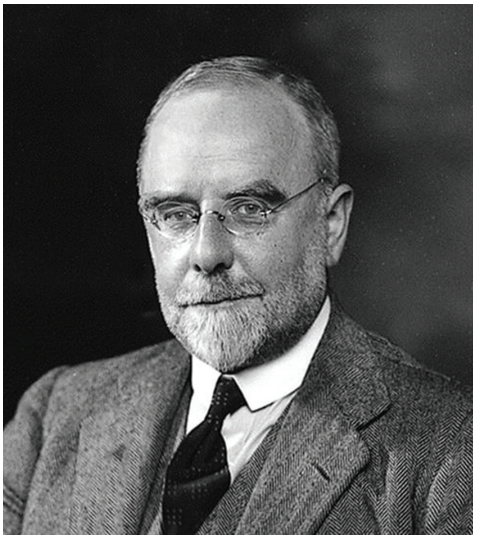
NOTES AND REFERENCES

1. Watson, E. L. Grant (1964). *The Physical Mystery of Life*, Hudson NY: Lindisfarne Press. Originally published in 1943.
2. Quoted in E. S. Russell (1938). *The Behaviour of Animals*. London: Edward Arnold, pp. 7-8. I have added paragraph breaks. The book by Nicholson is entitled *How Birds Live: A Brief Account of Bird-Life in the Light of Modern Observation*, and was published in London by Williams and Norgate, Ltd., in 1927.
3. Fijn, Ruben C., Derick Hiemstra, Richard A. Phillips and Jan van der Winden (2013). "Arctic Terns *Sterna paradisaea* from the Netherlands Migrate Record Distances Across Three Oceans to Wilkes Land, East Antarctica," *Ardea* vol. 101, no. 1, pp. 3-12. doi:10.5253/078.101.0102
4. Also, some butterflies today follow routes down the eastern coast to overwintering sites in Florida, and others end up along the Gulf Coast. In the west, there are populations that migrate between the Rocky Mountains and the coast of California.
5. Gerullis, Peggy and Stefan Schuster (2014). "Archerfish Actively Control the Hydrodynamics of Their Jets." *Current Biology* vol. 24 (Sep. 22), pp. 2156-60. doi:10.1016/j.cub.2014.07.059
6. Ford, Brian J. (2009). "On Intelligence in Cells: The Case for Whole Cell Biology," *Interdisciplinary Science Reviews* vol. 34, no. 4 (Dec.), pp. 350-65. doi:10.1179/030801809X12529269201282
7. Ryan, Frank (2011). *The Mystery of Metamorphosis: A Scientific Detective Story*. Foreword by Dorion Sagan and Lynn Margulis. White River Junction VT: Chelsea Green Publishing, pp. 104-5.
8. Arthur, Wallace (2004). *Biased Embryos and Evolution*. Cambridge UK: Cambridge University Press, p. 45.
9. Cannon, Walter B. (1939). *The Wisdom of the Body*. New York: W. W. Norton, pp. 19-23. The original text has been slightly condensed.
10. Pennisi, Elizabeth (2018). "Nature's Strategies: A Plant That Stands and Fights — The Wild Tobacco Plant Sounds Off When It's Under Attack," *Science* vol. 359 no. 6379 (Mar. 2), p. 985. doi:10.1126/science.359.6379.985

Goal-Directed Activity in Life

E. S. Russell

Editor's Note: *E. S. Russell was a Scottish marine biologist with a strong interest in the history and philosophy of biology. His 1916 history of morphological thought,* Form and Function, *remains a standard reference work today. We present here an abridged and slightly edited version of chapter 5 from his 1945 book,* The Directiveness of Organic Activities. *The chapter is entitled "Characteristics of Goal-Directed Activity" in the original.*



Perhaps nothing about the life of organisms is more obvious to biologists than the future-oriented and end-directed character of development, physiology, and behavior. In Russell's terminology, we observe a "goal-directed," "purposive," and "directive" aspect in all organic activity. At every level of their functioning, organisms carry out tasks, satisfy needs, and pursue their own interests. Biologists unavoidably define their subdisciplines and research projects in task-oriented terms: How is DNA replicated? How and why do cells divide? By what means is food converted into useful energy? What strategy enables the predator to capture its prey?

The future- and task-oriented activity of living beings radically distinguishes them from rocks, waterfalls, and clouds. The odd thing is that, despite their unavoidable recognition of this fact, biologists commonly exclude it from their theoretical understanding of organisms. They talk about organisms (and their evolution) as if they were merely physical systems, even though such systems are incapable of directing their activity toward the future fulfillment of their own ends. It is, for example, more or less anathema to speak of evolution as an end-directed process. (On this latter point, see "Whole Organisms and Their Evolutionary Intentions" (Talbott 2018).

It was a major part of Russell's life-long work to try to keep the directiveness of organic activity in mind, whether he was discussing heredity and genetics, animal behavior, or evolution. And therefore he brought disciplined and systematic attention to his observation of this directiveness. In today's environment, that kind of attention may usefully remind us of the missing element in so much of our own biological science.

British spellings and usage have been retained here. Editorial interpolations are in brackets. We have prefaced the chapter with a brief excerpt from the concluding chapter of The Directiveness of Organic Activities. *(For more about Russell, see* In Context #22. *And for further writing by Russell, see* In Context #30.*)*

Preface: An Introduction to Some Key Terms

[*Russell here refers to the overall content of the book:*]
We have reached the conclusion that directiveness and creativeness are fundamental characteristics of life, shared by no inorganic system; that they are not to be explained in terms of mechanism or of [human] purpose; that human directiveness and purposiveness in thought and action are a specialised development of the directiveness and creativeness inherent in life.

We recognise the fact that organic activities, as manifested by organised unities such as cells and organisms, show characteristics, especially their directiveness, persistency and adaptability, which are shown also in the instinctive and intelligent behaviour of ourselves and other animals. But we shall not fall into the error of interpreting organic activities in general in terms of conscious purpose or 'mind'.

The organism strives to persist in its own being, and to reach its normal completion or actualisation. This striving is not as a rule a conscious one, nor is there often any foresight of the end, but it exists all the same, as the very core of the organism's being. Confusion is apt to arise because to characterise [this drive] we have no other words than those which carry a psychological meaning, words such as 'effort', 'perseverance' and 'urge', which are primarily applicable to human behaviour. [Botanist Agnes] Arber has called attention

to this difficulty, but holds, quite rightly, that the use of such words is unavoidable, 'because we have no other set of terms in which to express that compulsiveness by which the plant works towards a certain end, which, if we were concerned with a self-conscious organism knowingly pursuing a train of activity, would be recognized as a goal' (1941, p. 87). We really require new terms to characterise the goal-directed and biologically purposive activities of living organisms, of which only some reach the level of conscious purposiveness.

Characteristics of Goal-Directed Activity

There are certain general or normal characteristics of all goal-directed activity (whatever its biological end) which may be summarised as follows:

1. When the goal is reached, action ceases; the goal is normally a terminus of action.
2. If the goal is not reached, action usually persists.
3. Such action may be varied:
   (a) if the goal is not reached by one method, other methods may be employed;
   (b) where the goal is normally reached by a combination of methods, deficiency of one method may be compensated for by increased use of other methods.
4. The same goal may be reached in different ways, and from different beginnings; the end-state is more constant than the method of reaching it.
5. Goal-directed activity is limited by conditions, but is not determined by them.

I shall now proceed to illustrate and exemplify these rules, which are normally, though not invariably, valid for directive activity, whether behavioural, physiological or morphogenetic.

The Goal is a Terminus of Action

When a rat has satisfied its appetite for a specific food substance it takes no more of it, until the need arises again; a full-fed animal normally ceases to feed. When a wound is healed over and the normal density of cells restored, the cellular activities directive towards these goals come to an end. When *Molanna* [a genus of insects known as "hood casemakers"] has repaired its case to something like normal, it ceases its efforts at restoration. When an animal's normal body temperature is restored by physiological or behavioural action, these regulatory activities are reduced to the minimal level required for the continued maintenance of normality.

When a motor nerve is severed, the fibres that run from the cut to the muscle degenerate and die, but the cut-end at once starts growing out to re-establish connection with the muscle.

> The fibre, so to say, tries to grow out to reach to its old far-distant muscle. There are difficulties in its way. A multitude of non-nervous repair cells growing in the wound spin scar tissue across the new fibre's path. Between these alien cells the new nerve-fibre threads a tortuous way, avoiding and never joining any of them. This obstruction it may take many days to traverse. Then it reaches a region where the sheath-cells of the old dead nerve-fibres lie altered beyond ordinary recognition. But the growing fibre recognises them. Tunnelling through endless chains of them, it arrives finally, after weeks or months, at the wasted muscle-fibres which seem to have been its goal, for it connects with them at once. It pierces their covering membranes and re-forms with their substance junctions [interface between distinct tissues] of characteristic pattern resembling the original that had died weeks or months before. Then its growth ceases, abruptly, as it began, and the wasted muscle recovers and the lost function is restored (Sherrington, 1922, p. 6).

This is an excellent case of persistent directive action, surmounting difficulties, and coming to an end when the goal is reached. It is, of course, typical of regenerative processes that they stop when normal structure is restored. If a newt's leg or arm is truncated, the wound is healed and a regeneration bud formed under the new skin. This grows and differentiates, reforming the missing part of the limb, in normal shape. 'When we are dealing with the regeneration of an adult organ such as a newt's limb', writes Waddington (1934, p. 339), 'the equilibrium towards which the regeneration takes place is a stable one; once the whole limb is regenerated, the change stops, except perhaps for growth changes.'

Growth and development in general move towards a definite or end-state, and cease when this is reached. A water-lily leaf grows up towards the surface of the water, and there expands to its full shape; growth persists till this end-state is achieved, and then stops.

In animal behaviour cessation of action when the goal is reached is so common a phenomenon as to require no elaborate demonstration. When a starfish or a beetle is turned on its back, the righting behaviour which follows ceases as soon as the normal position is regained.

It is interesting and significant to observe that if the goal or end-state is supplied by external agency, and not by the animal's own efforts, the restorative action will likewise come to an end. If, when the beetle is struggling to right itself, you present it with something to which it can cling, it will cease its efforts, which have now become unnecessary.

The same is true of the starfish (see, for instance, Russell, 1919).

Here is a more complex but very instructive example, which I take from Boycott (1929). The number of erythrocytes in the mammalian blood — which Boycott calls collectively 'the erythron' — is kept at a normal level (which is relative to the pressure of the atmospheric oxygen). If the erythron is reduced by severe haemorrhage, the loss is ultimately made good by the production of new erythrocytes from the bone-marrow, a process which goes on till the goal or end-state of a normal concentration is reached. The erythron can also be increased by transfusing an extra quantity of blood into the circulation; when this happens the excess quantity is actively destroyed by phagocytosis and normality again restored. The end-state or goal of these processes is quite definite — the restoration of the normal amount of red cells. Both processes, by the way, are accelerated by practice. Now if, in a bled rabbit, the amount of blood removed is quickly restored by transfusion, and the normal end-state thus artificially restored, then neither the process of destruction of the introduced erythrocytes takes place, nor the production of new erythrocytes from the marrow, for the goal aimed at has already been reached.

Editorial Comment: Regarding the "bled rabbit" just referred to, and, even more, a number of experiments discussed below, we find ourselves experiencing an all-too-familiar discomfort. The assaultive animal research we occasionally find ourselves reporting on has at times been difficult to stomach, and certainly contravenes our own values. On the other hand, (1) we feel that E. S. Russell's understanding of organisms holds great importance for biologists today, and we're not sure anything would be gained by using his references to contemporary research as a reason for discouraging access to his writing; and (2) given the fact that the massive abuse of animals in research today is largely hidden from public view (and therefore from the public consciousness), the "jolting" feeling one has at reading some of the descriptions about this research may at least have the beneficial effect of bringing the reality to public attention. Beyond that, we still never feel completely at ease when presenting the results of this sort of research, and have never found a way of handling the issue that is wholly comfortable for us. Maybe the discomfort is, for now, unavoidable.

Persistency of Action

It is characteristic of animal behaviour that if the goal is not reached at once, directive action continues with or without variation of effort. The salmon encountering a waterfall on its upstream migration tries time and again to surmount it, until its leaps are successful or it falls back exhausted; there is active, persistent, long-continued effort. Here there is an element of active striving, closely similar to what we ourselves experience when trying to do a difficult job. But persistence in action need not imply conscious effort, and it may be quite stereotyped and unintelligent — that is, inadaptable to circumstances. A pair of sparrows one summer built a nest in the roof-gutter of my house, and when this was cleared away built another in the same place; several times the nest was swept away and rebuilt by the persistent birds. Nor is persistence of action limited to behaviour; it is shown also in physiological and morphogenetic activities. A good example of this is afforded by persistent egg-laying in birds, when they are prevented from accumulating a clutch of normal size in the nest.

According to Bickerton (1927, p. 21), a great tit (*Parus major*) has been known to lay 25 eggs, instead of the normal 6-11, when she was left each day with only one egg in the nest; a starling (*Sturnus vulgaris*) in similar circumstances produced 40 eggs consecutively, and a moorhen (*Gallinula chloropus*) 49 eggs in 57 days. According to Herrick (1935, pp. 256-7), 'The northern flicker (*Colaptes auratus luteus*) commonly lays from five to nine eggs, but when it is systematically robbed from the time it lays its second egg, one being taken each day and one left as a nest-egg, the number it will sometimes produce is surprisingly great. The record of seventy-one eggs in seventy-three days made by a bird at Taunton, Massachusetts, beginning May 6, 1883, and reported by Charles L. Phillips, I believe has never been surpassed'.

Persistence of growth activity until a goal is reached is, of course, a common phenomenon in plants; the potato sprouting in a dark cellar sends out long white shoots, as it were in search of light; the prairie plant grows enormously long roots in its search for deep-lying water. The wood-rot fungi extend their rhizomorphs over brick, stone or metal in their apparent search for distant woodwork.

Variation of Action

(a) *Persistency with varied effort*. It often happens that the animal has several instinctive modes of action available for dealing with a particular situation, and if one fails it brings the others successively into play until the end-state or goal is attained. Take, for instance, the responses of the protozoon *Stentor* to nocuous stimuli (Jennings, 1906, pp. 170-9). If a stream of fine particles, say of Indian ink or carmine, is directed upon the disc of an actively functioning *Stentor*, no avoiding reaction is at first obtained; the *Stentor* ingests some of the particles. But soon it bends away, thus avoiding to some extent the irritating stream. If this reaction is not successful at first, it is repeated.

> If the repeated turning toward one side does not relieve the animal, so that the particles of carmine continue to come in a dense cloud, another reaction is tried. The ciliary movement is suddenly reversed in direction, so that the particles against the disc and in the pouch are thrown off. The water current is driven away from the disc instead of toward it. This lasts but an instant, then the current is continued in the usual way. If the particles continue to come, the reversal is repeated two or three times in rapid succession. If this fails to relieve the organism, the next reaction — contraction — usually supervenes (p. 174).

It is important to note that the order of events is not stereotyped, for sometimes the reversal of current may be tried before the turning-away response.

The third method of avoiding the nocuous stream, contraction into the tube, may last about half a minute, when the *Stentor* expands again. It does not then repeat the previous reactions, of turning away and reversing the current, but if the nocuous stimulus is still present it contracts again, repeating this response many times, during a period of 10-15 minutes, staying in the tube a little longer each time. Finally, it ceases to expand, contracts violently and repeatedly in the tube, and breaks away its attachment to the substratum. It then leaves the tube and swims away, to form a new tube elsewhere. If, on coming out of its tube forwards, it encounters the cloud of particles, it may swim backwards and force a passage through the substance of the tube.

That is a typical example of what Jennings calls 'Trial and error' behaviour. It is directive, in that it aims at a definite end-state or goal, relief from the irritating stimulus; it shows persistency with varied effort, for if one response fails to give relief others are tried until success is achieved. It does *not* imply learning, in the sense of bettering performance through experience and repetition, but it does imply the power of varying behaviour according to the result of previous action, a power which is essentially a psychological one, a power of relating events, and acting in accordance with the situation; what one may call a practical judgment seems to be involved.

Many investigators, following Bethe, have called attention to the fact that if an animal is deprived of one or more of its legs, it immediately regulates its locomotory movements so as to compensate for the loss. The ordinary rhythm of progression is radically altered, but unity of action is preserved. Thus the shore crab (*Carcinus maenas*) with all legs intact moves these in a regular order when crawling forward; amputate one or more, and progression is still carried out effectively, though the order of movement of the remaining legs is changed. Progression is a function

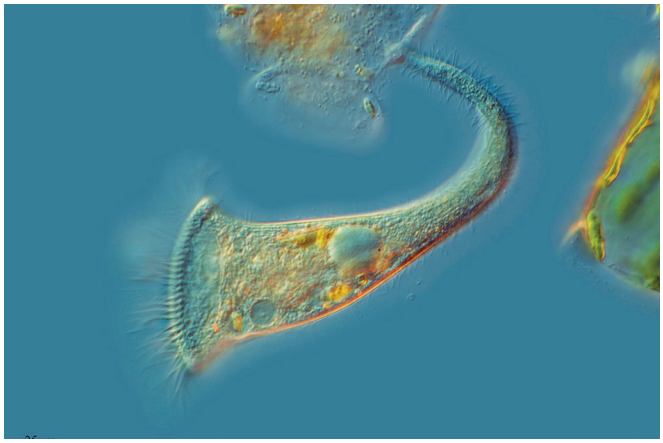


Photo: Proyecto Agua (CC)

The protozoan *Stentor igneus*

of the neuro-muscular system as a whole, not a summation of separate limb reflexes. So, too, 'an insect which has lost a leg will at once change its style of walking to make up for the loss. This may involve a complete alteration of the normal method, limbs which were advanced alternately being now advanced simultaneously. The activities of the nervous system are directed to a definite end, [namely] the forward movement of the animal — it uses whatever means are at its disposal and is not limited to particular pathways' (Adrian, 1933, p. 468).

In these cases we have to do with an immediate physiological regulation of movements, and not, strictly speaking, with an adaptative regulation of directive behaviour, for locomotion is not by itself behaviour.

But we find a similar principle exemplified in behaviour. If the organ normally employed in a particular job is missing, [an adjustment] is often made with a substitute organ, or organs, so that the normal end is attained by unusual means. The long hind-legs of the dung beetle are well adapted for impelling the ball backwards over the ground by alternating strokes, and they play the major role in this activity. But if one or both are amputated, the beetle can still push the ball along; if one only has been removed, the ball tends to move towards that side and this obliquity has to be corrected by extra efforts on the part of the stump and the middle leg of the same side; if both hind-legs are cut off, the beetle manages quite well with its middle legs and the stumps of the hind ones. With the loss of both hind-legs and both middle legs it still persists in its efforts to roll the ball along, using the end of the abdomen as well as the stumps of the legs. It even succeeds in digging the usual burrow in which to bury the ball. But if the fore legs only are removed, the beetle is helpless; it cannot replace the powerful thrusting movements of these limbs by any other organic means.

Behaviour is essentially a striving towards an end or end-state; the effort is persistent and, usually, varied. It may be blindly persistent along one line, without material variation of effort, especially in the case of highly specialised and stereotyped instinctive behaviour; but usually the effort is varied if success is not achieved at once.

(b) *Compensatory activity.* Where there are two or more functionally equivalent methods normally concerned in reaching a particular goal, if one is put out of action or deficient, the goal is often attained through enhanced activity of the remaining method or methods. We have seen several examples of this [under "Persistency of Action" above], and we may here recall and add to them.

In the healing of wounds in the higher vertebrates three processes are involved: (1) the active contraction of the tissues underlying the wound, whereby the exposed surface is reduced in size; (2) the migration of epithelial cells over the wound; and (3) their multiplication to supply the necessary number for epithelisation. In large wounds, where the need for cells is great, multiplication is more marked and goes on simultaneously with migration. Now if either contraction or epithelisation is prevented from taking place, the wound will nevertheless heal in normal time. Here is what Carrel tells us on this point. The wound scar

> is due to the collaboration of two types of tissue, the connective tissue filling the wound, and the epithelial cells, which advance over its surface from the borders. Connective tissue is responsible for the contraction of the wound, epithelial tissue for the membrane that ultimately covers it. The progressive decrease of the wounded area in the course of repair is expressed by an exponential curve. However, if one prevents either the epithelial tissue or the connective tissue from accomplishing its respective task, the curve does not change. It does not change because the deficiency of one of the factors of repair is compensated by the acceleration of the other. Obviously, the progress of the phenomenon depends on the end to be attained. If one of the regenerating mechanisms fails, it is replaced by the other. The result alone is invariable (1936, p. 202).

To compensate for loss of blood in severe haemorrhage, the body disposes of various converging methods, which are thus described by Carrel:

> First, all the vessels contract. The relative volume of the remaining blood automatically increases. Thus, arterial pressure is sufficiently restored for blood circulation to continue, the fluids of the tissues and the muscles pass through the wall of the capillary vessels and invade the circulatory system. The patient feels intense thirst. The blood immediately absorbs the fluids that enter the stomach and re-establishes its normal volume. The reserves of red cells escape from the organs where they were stored. Finally, the bone marrow begins manufacturing red corpuscles, which will complete the regeneration of the blood (ibid. p. 198).

For bringing about the first step in the process, the restoration of arterial pressure and blood volume, there are two converging mechanisms — contraction of the vessels and the taking up of water from the tissues and the alimentary canal. According to Carrel 'each of these mechanisms is capable of compensating the failure of the other' (ibid. p. 203).

In both these cases, wound-healing and the replacement of lost blood, it is the attainment of the normal end-state that matters; if one contributory means towards this end fails or is deficient, the others make up for it by persisting till the goal is reached, if reached it can be.

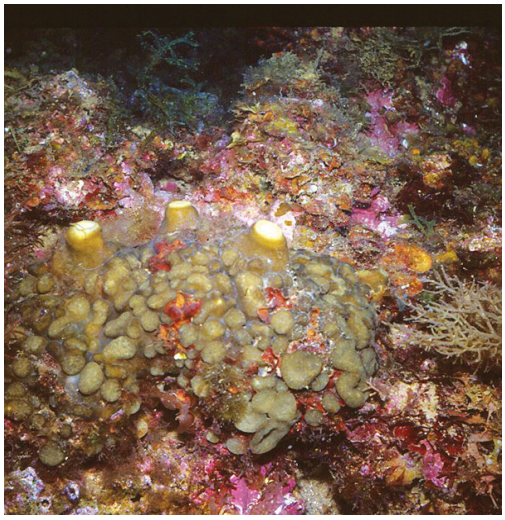
The work of Richter and his collaborators also points to the same conclusion. When the maintenance of body temperature by physiological means is upset in the rat by removal of the hypophysis [pituitary gland] and the consequent reduction in thyroid activity, the animal reacts by greatly increasing its nest-building activity; behavioural action compensates for deficient physiological regulation. We may recall here the observations of Gannon on the cat deprived of its main physiological defences against cold; it compensates for this loss by keeping in the warm, and by increased shivering.

Alternative Ways of Reaching the Same Goal

In regeneration it often happens that a structure is re-formed in a different way and from different cellular material than is the case in embryonic development; the result is the same, though the beginnings are radically different.

[Regarding the classical case of the regeneration of the lens in Urodeles, an order of amphibians that includes newts and salamanders:] In 1891 Colucci observed that if the eye was extirpated in the newt the new lens developed from the margin of the bulb. This was confirmed by G. Wolff (1895), who showed that the new lens was developed from the upper edge of the iris, a structure which in ontogeny has nothing to do with the formation of the lens. The process of lens formation from the iris is a very remarkable one. The iris consists of a double layer of epithelial cells, the inner layer of which is deeply pigmented. Cells proliferate from the top edge of the

iris, forming a spheroidal mass hanging down in the position of the lens. The pigment disappears, and the cells become transparent; those in front become cubical epithelium, those behind lengthen and form lens fibres, and so a normal lens is produced in this unprecedented way. The later stages of the process are similar to those occurring in ontogeny, but the beginnings of the process are entirely different; specialised cells having no connection with the original lens dedifferentiate, multiply and redifferentiate in such a manner and in such an arrangement as to produce a typical and functional lens. It seems that what is lacking, a lens, is formed by the means nearest to hand. The organism, as Wolff says (1894, p. 620), 'chooses the simplest way'. Thus, the same end-result is achieved as in ontogeny, but from a totally different starting point.



The sponge, *Cliona viridis*

The reconstitution of a complete organism from dissociated tissue cells is an extraordinary phenomenon which has been demonstrated to occur in certain sponges by H. V. Wilson, Galtsoff and others. In [the sponges] *Microciona* and *Cliona*, for example, cells isolated by squeezing a part of the sponge through fine bolting silk come together and form aggregates, which later organise themselves into little sponges.

> Under normal conditions, the essential features of sponge body, i.e. flagellated chambers, canals and spicules, are formed [from dissociated cells] within five or six days. Spongin [the collagen protein forming the fibrous skeleton of sponges] appears about the tenth day. The osculum [an excretory structure] appears by the end of the third week …The rebuilding of a new sponge is due to the activities and properties of individual cells forming an aggregate. The different types of cells forming a common mass find each other and then develop flagellated chambers, skeleton, mesenchyme, and other tissues' (Galtsoff, 1925, p. 248).

What greater contrast can one imagine with the normal process followed in development from the egg? A sponge is of course more an organised colony of essentially separate cells than a true metazoan organism, as Bidder (1937) has clearly shown, and more independence of action might be expected from its cells. But the phenomenon of reconstitution from dissociated tissue cells takes place also in the hydroid *Antennularia*, though here the reconstitution of the whole is not so complete (Morgan and Drew, 1913-15).

Goal-Directed Activity May Be Dominant over Conditions

In the examples described above it is clear that ends or goals are more important than beginnings; the same goal can be reached from quite different starting points, and by quite different routes. It is difficult then to think of goal-directed activity as being completely determined by its beginnings. Somehow, though we do not know how, the end or goal enters into the determination of these activities; they are, that is to say, directive.

The same conclusion imposes itself when we consider the fact that goal-directed activity is determined only in part by the conditions obtaining during its execution. When these conditions are unfavourable, the organism may yet achieve its biological ends, either completely or in a modified form. In dry or impoverished soil, for example, a plant may still achieve development and reproduction in spite of the adverse conditions, appearing in a stunted and depauperate form, which is the best that can be done in the circumstances.

A seed plant is normally dependent for its initial growth and development upon the stores of nourishment contained in the seed. If these are removed by operation or much reduced, a common result is the production of a stunted seedling. But this is not always the case. It has been shown by Raymond Pearl and his collaborators (Gould *et al*. 1934) that seedlings of the canteloup (*Cucumis melo*) from which parts of the cotyledons (containing the food reserves) have been removed show a more vigorous growth than unoperated seedlings; they are stimulated to utilise more fully and effectively the food material still remaining. Growth is not, as one might expect, proportional to the amount of food available, but considerably in excess of expectation where the amount is reduced. In fact, in the conditions of these experiments 'the larger the amount of cotyledonary tissue removed by operation the more rapid was the inherent growth rate of the seedling per unit of time' (p. 598). The

seedling reacts to deficiency of normal food supply by more efficient utilisation of what remains.

Regeneration in planarians [flatworms], as Morgan has shown (1901, 1902), is dependent only to a slight extent upon the food conditions. The size of the regenerated whole naturally depends upon the amount of food and energy available; if the regenerating piece is well supplied with food it may reconstitute a full-sized whole; if food from outside is lacking, it will reconstitute a whole of much reduced size, drawing the necessary energy and material from its own substance. Even a planarian that has been greatly reduced in size by long-continued starvation will, if cut in two, reconstitute two new though tiny wholes. This, as Morgan points out (1901, p. 28), is a very remarkable phenomenon, and well illustrates the dominance of 'drive' over conditions, for the tissues of the regenerating halves, which are already 'slowly starving to death', are depleted still further to supply material and energy for the growth and differentiation of the new tissue formed in the reconstitution of the new wholes. We see very clearly from this example that the directive activities of regeneration are not determined, though they may be influenced, by food conditions.

Looking back over the characteristics of goal-directed activity, we see that such activity does not fall into line with that shown in the inorganic world, but is clearly separate and distinct. Coming to a definite end or terminus is not *per se* distinctive of directive activity, for inorganic processes also move towards a natural terminus; the moving stone rolls down the hill till it reaches the bottom, or is stopped by some obstacle; the unstable system moves towards a stable equilibrium; the same stable equilibrium may even be reached from different starting points. What is distinctive is the active persistence of directive activity towards its goal, the use of alternative means towards the same end, the achievement of results in the face of difficulties. Goal-directed activity is no mere resultant of material conditions, as is the case with inorganic systems; there is in it an element of effort or striving, which sometimes, as in our own purposive behaviour, becomes conscious of itself and its aims, but is more often unconscious and blind. It is not dominated by conditions, but strives to surmount or utilise them in its movement towards its goal. One drive may dominate another.

This element of drive, effort or striving (which we experience in its highly developed form as conation [conscious human willing]) is one factor in all vital activity, behavioural, physiological and morphogenetic, which essentially distinguishes it from inorganic action. 'Living things are not completely at the mercy of their environment, whereas non-living matter has a totalitarian subjection to external surroundings. Thus a non-living mass of protein always rolls down a slope with unquestioning obedience to the law of gravity; living protein in certain forms *can* move up the slope, following its internal direction ... Motile bacteria can move against a slight stream of liquid' (Grainger, 1940, p. 539).

Behaviour, as we have seen, is just one of the means or methods of action through which the living organism achieves its biological ends; physiological and morphogenetic activities are also means or methods, functionally equivalent to behavioural action. It is not astonishing then that they should have the same characteristics as behavioural action, for all three share the fundamental character of directiveness.

REFERENCES

Adrian, E. D. (1933). *Nature*, London, 23 Sept.

Arber, A. (1941). *Biol. Rev.* xvi, 81-105.

Bickerton, W. (1927). *The Baby Bird and its Problems*. London.

Bidder, G. P. (1937). *Proc. Linn. Soc. Lond*. 1936-7, pp. 119-45.

Boycott, A. E. (1929). *Proc. Roy. Soc. Med.* xxiii (Section of Pathology, pp. i-ii).

Carrel, A. (1936). *Man the Unknown*. London.

Galtsoff, P. S. (1925). *J. Exp. Zool.* xlii, 183-256.

Gould, S. A., Pearl, R., Edwards, T.I. and Miner, J.R. (1934). *Ann. Bot.* London, xlviii, 575-99.

Grainger, J. (1940). *Nature.* Lond., cxlvi, 539-41.

Herrick, F. H. (1935). *Wild Birds at Home*. New York and London.

Jennings, H. S. (1906). *Behavior of the Lower Organisms*. New York.

Lecomte du Noüy (1936). *Le Temps et la Vie*. Paris.

Morgan, T. H. (1901). *Regeneration*. New York.

Morgan, T. H. (1902). *Arch. Entw Mech. Org.* xii, 179-211.

Morgan, W. de and Drew, G.H. (1913-15). *J. Mar. Biol. Ass. U.K.* x, 440-63.

Richter, C. P. (1941). *Psychosom. Med.* iii, 105-10.

Russell, E. S. (1919). *Proc. Zool. Soc. London,* pp. 423-39.

Russell, E. S. (1930). *The Interpretation of Development and Heredity*. Oxford.

Sherrington, G. S. (1922). *Rep. Brit. Ass.* 1922, pp. 1-15.

Waddington, C.H. (1934). *Sci. Progr.* 1934, pp. 336-46.

Wolff, G. (1894). *Biol. Zbl.* xiv, 609-20.

Wolff, G. (1895). *Arch. Entw Mech. Org.* i, 380-90.

References from Editor's Note

Russell, E. S. (1916). *Form and Function: A Contribution to the History of Animal Morphology.* Chicago: Chicago University Press.

Russell, E. S. (1945). *The Directiveness of Organic Activities*. Cambridge: Cambridge University Press.

Talbott, Stephen L. (2018). "Whole Organisms and Their Evolutionary Intentions: An Overview." http://RediscoveringLife.org/ar/2018/thesis_34.htm

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