

## Toward a Biology Worthy of Life

*Stephen L. Talbott*

For over three years now, I've been writing a series of articles aimed at characterizing the organism as it is being sketched by current work in molecular biology – especially genetics, epigenetics, and gene regulation in general. This has seemed necessary because the truth emerging from this work is so dramatically at odds not only with the scientific reporting available to the general public, but also with the machine metaphors and materialistic assumptions of the researchers themselves. A number of my articles have been published in the influential journal, *The New Atlantis*, and have also been picked up in other venues.

I have worried, however, that the length, technicality, and general “heaviness” of the articles limits their audience. This seems particularly unfortunate because the responses I have received to the articles – for example, from interested laypeople and from teachers and other professionals desiring to understand current developments in molecular biology – have been extremely positive. We at the Institute have therefore decided to undertake a major project intended to bring this ongoing work to a wider public. By the time you read this, we expect to have the initial phase of this web-based project in place at <http://nature-institute.org/txt/st/org>. It is entitled, “What Do Organisms Mean? — Toward a Biology Worthy of Life.” (Some articles were originally published under the heading, “On Making the Genome Whole.”)

The idea is to present and re-present the work in a variety of ways, with various alternatives for browsing the material according to one's interests, scientific background, and available time. We want a fascinating collection of web pages that will draw viewers from around the world and from many walks of life. And we want to supply ample supporting and supplemental information, ranging from highly technical to popular, from undisputed to controversial — to begin with, a glossary of technical terms contained in the texts. We think the website has the potential to become a major resource for both professionals and the general public.

You'll find an approximate image (in black and white) of the beginning of the introduction to the new website on the following page.

### A Sample of the Content

One way to browse the website is by going to a section of selected excerpts from the major articles. The excerpts — of which there are currently over one hundred — are organized by topic. One can immediately jump from any one of the excerpts to its location in the article from which it is taken. Obviously, we cannot include this feature in a hardcopy publication, but we can at least give you a taste of the material by providing a group of excerpts below relating to one of the topics: “Contextuality, plasticity, and wholeness.” (The source article is listed at the end of each excerpt below.)

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### An overall pattern governs its own parts

In the very young embryo a given cell can be moved from one place to another, resulting in a completely different fate for that cell within the developing organism. This indicates that the cell's fate is determined “on the fly”: a governing dynamic disposes of each part according to the needs of the overall pattern. The developing relations between the individual cells are more a result of than a cause of the order of the whole.

Evidently, besides its full complement of “genetic information”, each cell needs still additional “topical information” derived from the field structure of the collective mass. How otherwise could any unit know just what scrap from its full grab bag of inside information to put to work at its particular station in order to conform to the total harmonious program design? Clearly, left solely to their own devices, the individual cells and their entrapped genomes would be as incapable of producing a harmonious pattern of development as a piano with a full keyboard would be of rendering a tune without a player. (Weiss 1973, p. 35)

It is crucial to realize what Weiss is *not* saying. He is not saying that the laws of physics are violated in the formation of organic patterns. He himself spent many years elucidating the play of physical forces in such situations. What is being coordinated is nothing other than this play



**After Crick and Watson** unraveled the structure of DNA, molecular biologists were destined, so they thought, to understand organisms as physical mechanisms and nothing more. Instead, ever more sophisticated experimental techniques have been revealing organisms of meaning whose wisdom and subtlety, whose powers of development and adaptation, whose perceptive insight and effective communication, and whose evolutionary ingenuity far outstrip our current capacities for comprehension. Yes, new molecular “mechanisms”, isolated from the organism as a whole,

continue to be proclaimed daily. But when we restore these products of our one-sided methods to their living contexts, allowing them to speak their own meanings, what they actually show us is this: every organism is intent upon pursuing the eloquent story of its own life. Its purposes govern and coordinate the lawful physical performance of its body, not the other way around.

**No, you have probably not heard** about these developments in the technical world of molecular biology; they don't make the pages of the *New York Times* or even *Scientific American*. Indeed, many biologists themselves lament that their unavoidable focus on the minutia of their own narrow research topics prevents their paying adequate attention to wider fields of discovery. But the reality now being proclaimed from the pages of every technical journal could hardly be more dramatic. Perhaps the central truth is this: we human beings discover our conscious, inner capacities — our capacities to think and mean, to plan and strive — unconsciously and objectively reflected back to us from every metabolic process, every signaling pathway, every gene expression pattern in all the organisms we study. We are akin to these organisms in ways we have long forgotten. This matters in a world whose future has been placed in our hands. No form of life is alien to us.

**You deserve to know** what is going on — not via the heated and fruitless rhetoric of the science–religion wars, and not through vague, “Age of Aquarius” references to vibrations, energy fields and quantum mysteries, but rather directly from molecular biologists themselves. That's what this project is about. I call it:

## What Do Organisms Mean? *Toward a Biology Worthy of Life*

Stephen L. Talbott

Organisms are creatures of meaning. Biologists imply as much — whether or not they pay any attention to the fact — when they employ standard technical terms such as “information,” “code,” “message,” “signal,” “program,” “response,” “communication,” and so on. No one would call something a “message,” for example, if they were not imagining a cognitive and intentional content. In biological usage, *all* these words similarly rely upon our taking them as pointers toward the language-like and meaningful. And if the organism's life is a life of meaning, we would do well to allow it to speak for itself.

Our growing awareness of the speech-like meaning of the organism is leading us inexorably toward a *new science of biology*. The literature today, at least around its edges, is rife with hints of creative thinking and new directions that would have sounded revolutionary and unthinkable a few decades ago. My aim here is to bring some of the current and unexpected trends in biology to a wider audience, piecing together a broader picture that shows us what the biology of the future may look like, particularly as we can glimpse it through the work of molecular biologists wrestling with the problems of genetics, organismal development and evolution.



of forces. His point is that, whatever the level we analyze, from macromolecular complexes, to organelles, to cells, to tissues, to individual organs, to the organism as a whole, we find the same principle: we cannot reconstruct the pattern at any level of activity by *starting from the parts and interactions at that level*. There are always organizing principles that must be seen working from a larger whole into the parts. [From “The Unbearable Wholeness of Beings”]

### Unexpected plasticity of the genome

Pluripotent cells such as stem cells, which bear certain similarities to germline cells, possess genomes that are “amazingly plastic”: “The incredible plasticity of pluripotent genomes is a notable discovery, and reveals the view of an unexpectedly dynamic mammalian genome for many of us” (Blasco et al. 2011). [From “Natural Genome Remodeling”]

### The direction of molecular biological research

Is there any subdiscipline of biology today where research has been reducing cellular processes to a more clearly defined set of causal mechanisms instead of rendering them more ambiguous, more intentional, more plastic and context-dependent, and less mechanical? [From “The Unbearable Wholeness of Beings”]

### Of cross-talk and “horror-graphs” (1)

In the conventional machine model of the organism, signaling pathways were straightforward, with a clearcut input at the start of the pathway leading to an equally clearcut output at the end. Not so today, as a team of molecular biologists at the Free University of Brussels found out when they looked at how these pathways interact or “crosstalk” with each other. Tabulating the cross-signalings between just four such pathways yielded what they called a “horror graph,” and quickly it began to look as though “everything does everything to everything” (Dumont et al. 2001). In reality, we see a “collaborative” process that can be “pictured as a table around which decision-makers debate a question and respond collectively to information put to them” (Levy et al. 2010). This directed, corporate decision-making is not the stuff of mere physics and chemistry. [From “The Unbearable Wholeness of Beings”]

### Of cross-talk and “horror-graphs” (2)

Our problem lies in adequately imagining the reality. When a single protein can combine with several hundred different modifier molecules, leading to practically infinite combinatorial possibilities, and when that protein itself is an infinitesimal point in the vast, turbulent

molecular sea of continual exchange that is the cell, and when the cell is one instance of maybe 100 trillion cells of some 250 different major types in the human body, from muscle to bone, from liver to brain, from blood to retina — well, it’s understandable that many researchers prefer not to stare too long at the larger picture. Nevertheless, we should keep in mind that the collaborative process mentioned above involves not just one table with “negotiators” gathered around it, but countless tables with countless participants, and with messages flying back and forth in countless patterns as countless “decisions” are made in a manner somehow subordinated to the unity and multi-dimensional interests of the organism as a whole. [From “The Unbearable Wholeness of Beings”]

### Of cross-talk and “horror-graphs” (3)

Whenever we imagine a biological process aimed at achieving some particular result, we need to keep in mind that every element in that process is likely playing a role in an indeterminate number of other significant, and seemingly goal-directed, activities. The mystery in all this does not lie primarily in isolated “mechanisms” of interaction; the question, rather, is why things don’t fall completely apart — as they do, in fact, at the moment of death. What power holds off that moment — precisely for a *lifetime*, and not a moment longer? [From “The Unbearable Wholeness of Beings”]

### Controllers that don’t exist

When regulators are in turn regulated, what do we mean by “regulate” — and where within the web of regulation can we single out a *master* controller capable of *dictating* cellular fates? And if we can’t, what are reputable scientists doing when they claim to have identified such a controller, or, rather, various such controllers?

If they really mean something like “influencers,” then that’s fine. But influence is not about mechanism and control; the factors at issue just don’t have controlling powers. What we see, rather, is a continual mutual adaptation, interaction, and coordination that occurs *from above*. What we see, that is — once we start following out all the interactions at a molecular level — is not some mechanism *dictating* the fate or *controlling* an activity of the organism, but simply an organism-wide coherence — a living, metamorphosing form of activity — within which the more or less distinct partial activities find their proper place.

The misrepresentation of this organic coherence in favor of supposed controlling mechanisms is not an innocent inattention to language; it’s a fundamental misrepresentation of reality at the central point where we are

challenged to understand the character of living things. [From “The Unbearable Wholeness of Beings”]

### **Contextuality turns causality upside down**

To realize the full significance of the truth so often remarked in the technical literature today — namely, that context matters — is indeed to embark upon a revolutionary adventure. It means reversing one of the most deeply engrained habits within science — the habit of explaining the whole as the result of its parts. If an organic context really does rule its parts in the way molecular biologists are beginning to recognize, then we have to learn to speak about that peculiar form of governance, turning our usual causal explanations upside down. We have to learn to explain the part as an expression of a larger, contextual unity. [From “Getting Over the Code Delusion: Biology’s Awakening”]

### **Causes are lifted into the service of the organism**

We find in every organism a *meaningful coordination* of its activities, whereby it becomes a functioning and self-sustaining unity engaged in a flexible and well-shaped response to the infinitely varying stimuli of its environment. By virtue of this coordination, every local or partial activity expresses its share in the distinctive character of the whole. The ability of the organism to pursue its own ends amid an ever-shifting context means that causal relations become fluid and diffuse, losing all fixity. They are continually subordinated to, or lifted into service of, the agency of the organism as a whole. [From “The Unbearable Wholeness of Beings”]

### **Its life all the way down**

The one decisive lesson I think we can draw from the work in molecular genetics over the past couple of decades is that life does not progressively contract into a code or mechanism or any other reduced “building block” as we probe its more minute dimensions. Trying to define the complexity of the chromosome, according to geneticists Shiv Grewal and Sarah Elgin, “is like trying to define life itself”. Having plunged headlong toward the micro and molecular in their drive to reduce the living to the inanimate, biologists now find unapologetic life staring back at them from every chromatogram, every electron micrograph, every gene expression profile. Things do not become simpler, less organic, less animate. The explanatory task at the bottom is essentially the same as what we faced higher up. It’s rather our *understanding* that all too easily becomes constricted as we move downward, because the contextual scope and qualitative richness of our survey is so extremely narrowed. [From “Getting Over the Code Delusion: Biology’s Awakening”]

## **Eat to Regulate Your Genes?**

As you may have learned in biology class, a protein-coding gene is a segment of DNA that can be “transcribed” into messenger RNA, which then is (or may be) “translated” into protein. The entire process is broadly known as “gene expression.” However, one of the hottest fields of research in molecular biology over the past decade or two has to do with DNA regions that produce a wide assortment of non-protein-coding RNAs. These noncoding RNAs perform a wide range of regulatory functions in the cell. And one of the most important classes of these regulatory molecules consists of what are called “microRNAs,” or miRNAs. Their manifold functions primarily have to do with the regulation of gene expression, and their activities are interwoven with almost every aspect of an organism. Likewise their malfunctioning: the presence of the wrong miRNA in the wrong place at the wrong time contributes to many diseases, including cancers.

It has long been regarded as impossible for an miRNA ingested in an animal’s food to function as an miRNA in that animal. Avoiding degradation, getting from the digestive tract into the bloodstream, and moving from the bloodstream into tissues and organs—these seemed to be insurmountable barriers. But researchers have now brought the startling and wholly unexpected news that animals, including mammals, can assimilate in functional form at least some of the miRNAs they ingest from food. For example, plant-derived miRNAs have been identified in the blood serum and tissues of mice. One of these miRNAs was found to regulate gene expression in such a way as to affect levels of low-density lipoproteins in the mice. That same plant-derived miRNA is present “at a relatively high level” in human serum. The researchers (Zhang et al. 2012) conclude that “plant miRNAs in food can regulate the expression of target genes in mammals.”

Commenting on the implications of this research, another team of biologists write: “For decades there have been debates on the safety of transgenic [genetically engineered] food with regards to human health and the environment. This profound discovery by Zhang et al. should make decision takers more cautious when considering the issues that may arise from the consumption of transgenic crops.” (Jiang et al. 2012)

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### REFERENCES

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