Genes and the Single Organism

Stephen L. Talbott

This article comprises part of a chapter tentatively titled "Inheritance: The Whole Organism" in Steve's book-in-progress, Evolution As It Was Meant To Be – And the Living Narratives That Tell Its Story. *All the currently written chapters are available on The Nature Institute's adjunctive website, BiologyWorthyofLife.org/bk/ (or bwo.life/bk/).*

In 1923, Wilhelm Johannsen, the Danish plant physiologist and pioneering geneticist who had earlier given biologists the word "gene," expressed concern about the way genes were being conceived as neat, cleanly separable causal units. He made the following curious remark, which remains today as intriguing as ever, despite its never having prompted much serious discussion within the field of genetics as a whole:

> Personally I believe in a great central 'something' as yet not divisible into separate factors. The pomace-flies in Morgan's splendid experiments continue to be pomace flies even if they lose all "good" genes necessary for a normal fly-life, or if they be possessed with all the "bad" genes, detrimental to the welfare of this little friend of the geneticists (Johannsen 1923, p. 137).

The pomace-fly, of course, was the fruit fly (*Drosophila melanogaster*) that Thomas Hunt Morgan, in his Princeton University laboratory, was famously converting into a "model organism" for genetic studies. Thanks to procedures for mutating genes, controlling the mating of the flies, and tracing the inheritance of traits, this was the fateful period during which "genetic" was becoming synonymous with "heritable." The fact that whole cells — and not merely genes — pass between generations was progressively losing its significance in the minds of biologists interested in inheritance and evolution.

Johannsen saw that this new genetic work was based on an analysis of the organism into separate and distinct traits, and therefore left untouched what might easily be seen as the central problem of inheritance: the faithful reproduction of kind, or type. While mutated genes might result in (often pathological) *differences* in certain narrowly conceived traits, this sort of change never reached through to the fundamental identity of the organism. Whatever the introduced variations (mutations), the pomace-flies always remained pomace-flies.

But what sort of *differences* are we talking about? In his brilliant, and still decisively relevant 1930 book, *The Interpretation of Development and Heredity*, the British marine biologist E. S.

Fruit Fly (*Drosophila melanogaster*)

Russell took up Johannsen's point. "When we say that a child shows a hereditary likeness to its father," Russell wrote, "we mean that it resembles its father more closely than it does the average of the population. *The likeness is observable in respect of those individual characteristics that distinguish the father from the rest of the race*" (emphasis added).[1] Much the same can be said of the child's resemblance to its mother.

It's also possible that there will be no particular resemblance to either parent. "But yet in all three cases the child would show the characteristics of its species and its race — it would be a human child, distinguishable as belonging to the same racial type as its parents." As Russell then noted, this general resemblance in type, whereby all members of a species *share* an entire manner of development and way of being, can hardly be compared to the inheritance of this or that inessential feature wherein a parent happens to *differ* from most other members of the species. This distinction between a fundamental, shared nature and individual peculiarities has practical implications for genetic research:

> The broad general resemblances of type give no hold for experimental or statistical treatment, and have accordingly on the whole been ignored. But it is this *general* hereditary resemblance which constitutes the main problem. [The gene theory] deals only with *differences* between closely allied forms, and with the modes of inheritance of these differences; it leaves the main problem quite untouched as to why, for example, from a pair of *Drosophila* only *Drosophila* arise. It takes for granted the inheritance of Johannsen's "great central something" — the general hereditary equipment of the species (Russell 1930, pp. 269-70).

Whole versus Part

The issue here concerns the distinction between, first, individual features of an organism imagined as discrete and more or less separable parts (traits or "characters") somehow *caused* by particular genes; and, second, the integral unity whereby every organism exists and functions as a single whole. Isolated "characters" — for example, the color of a pea or of an animal's eyes — are much more easily assessed and compared than the *character* of two whole organisms of different types. The usual genetic breeding experiments that compare differences in isolated traits of closely related organisms can hardly be applied to the different natures and ways of being of an antelope and a bison — let alone an eagle and a pig — if only because the fact of infertility between fundamentally different types normally renders routine experimental inter-breeding impossible in such cases.[2]

You might think that, given the broad fact of infertility between different types, biologists would have cast around for new approaches to the problem of an organism's inherent governing nature, even if it required quite different methods from those they were trained in. What is at stake, after all, is our understanding, not only of the organism, but also of evolution. We certainly cannot answer all the questions we have about fundamental evolutionary change — for example, questions relating to the origin of basic body plans — merely by looking for how specific genes correlate with differences between closely allied forms of the same general type.

The picture I have been developing in this book shows us that organisms are in fact coherent, qualitative, story-telling wholes that inform and define their own parts. Being so informed, the parts share in each other's identity and become inseparable features of a larger unity. Some such picture has been acknowledged by many biologists throughout the history of their discipline. *If the picture is accurate, then the power to maintain this larger unity across generations — which also suggests a power to transform the unity — would seem to be central to our understanding of heredity and evolutionary change.*

The issue here is truly decisive. Have biologists in our day lost sight of the whole organism because of their fixation upon the molecular parts known as genes? And have they lost sight of evolutionary dynamics because of their fixation upon the hereditary transmission of genes rather than entire living cells?

Russell laid direct hold of this matter when he considered what it meant to realize that the activity of an organism cannot be reduced to the actions of its individual parts. If it is truly the case that the organism as a whole plays a governing role whereby it continually informs its parts with its own character and "catches them up" within its own activity, then the performance of the whole "can be [hereditarily] transmitted only by a whole, i.e. by the egg in its entirety, which at the very beginning of development *is* the new individual" (Russell 1930, p. 283).

Russell then cited a 1903 comment by the German botanist F. Noll (who was writing before the word "gene" came into usage):

> If the egg-cell of a lime tree is already a young lime tree, there is no need of any idioplasm, germ-plasm, pangens, or heredity-substance to render possible its development into a lime tree; the egg-cell *as a whole* is the heredity-substance (Russell 1930, pp. 287-8).

Change and Continuity

In the drama of human cell differentiation, hundreds of cell types, sometimes outwardly differing from each other as much as an eel differs from a goldfinch, are woven with almost infinite attention, intricacy, and complexity into the integral, ever-adapting unity of the organism as a whole.

Is this not one angle from which to view Johannsen's "great central something"? The *something* in this case is not in fact a *thing* at all, nor is it a steady state, or stasis. It is an activity — and always an activity with counter-balancing tendencies. In a developing organism we find ourselves looking at change within continuity — the ongoing transformation of an enduring unity. All the cell lineages (including the germ-cell lineage) undergo differentiation even as they continue to participate in the forward-looking and adaptive way of being of the whole organism.

Change and continuity: every organic whole embodies — *lives* — a harmonization of these contrasting principles. But these are exactly the principles that any theory of evolution must somehow reconcile. It's obvious enough that you can't have evolution without change. But so, too, without continuity there is only the arbitrary substitution of some elements of a mere aggregate for others, with nothing that lends significance to the result. If the change is to be non-arbitrary or coherent, there must be a persistent character attributable to the whole. Without continuity no enduring, nameable entity or being exists of which we can meaningfully say, "Yes, *this* is evolving."[3]

So every organism already shows us the sort of reconciliation, or harmonization, of change and continuity that evolution requires. And yet, because the complex developing organism generates its stunning diversity of cell lineages after having received but a single inherited genome, we cannot point to random genetic changes, or mutations, as the explanation for the dramatic and observable differences between lineages.[4]

The whole-cell transformation of a differentiating lineage just does not represent the kind of power evolutionary theorists are interested in. It is too living, too complex, too holistic — and therefore too difficult to analyze into a set of unambiguous, discrete causes. In the spirit of reducing the whole to experimentally tractable parts, theorists have, bizarrely, insisted on regarding mutations in the heritable genetic sequence as the primary or sole basis for all evolutionary change. They somehow feel more comfortable dealing with the neat, statistically manageable occurrence of supposedly particulate, difference-making mutations than they do when facing the transformative capacities of living beings.

On the face of it, the failure of biologists to explore the powerful explanatory potentials of the organism's more-than-genetic, whole-cell capacity for directed change seems to reflect one of the most egregious and crippling blockages of thought in all the history of science. Why should a forward-looking, adaptive capacity, natural to all organic activity and powerfully evident in all the cell lineages of the body, cease altogether at just one decisive point: namely, the point where the germ cell lineage contributes a gamete to the next generation?

If anyone is appealing to mysticism or magic, presumably it is those who posit such an otherwise unexplained hiatus in the organism's routine management of its differentiating cells.[5]

An Extraordinary Power

Think of it this way. In a young human embryo there are slightly differentiated cells of many distinct types, called *progenitor cells*. A progenitor cell of any given type can, by dividing, initiate a particular cell lineage. Through a process of repeated division and differentiation, the lineage "evolves" toward one of the many, often strikingly diverse cell types of the body. So each progenitor cell possesses a potential to enlist all its resources, including its genes, in a journey often extending over many cell generations, leading to a particular sort of "creature" — a living entity such as a muscle cell, a liver cell, a kidney cell, a skin cell, a neuron, and so on.

Now think of the zygote. It is formed from the fusion of two gametes, followed by their profound metamorphosis into a single-celled, functioning organism. This zygote is the *progenitor of all progenitor cells* in the new organism, possessing in itself all their combined potentials. This vast range of potentials, *held by the zygote as a carrier of inheritance*, is actualized and manifested as a power of whole-cell reorganization involving all present and future cellular resources, first, in the zygote itself, and then in all descendent cells along their many lineage trajectories.

We can hardly help acknowledging the overwhelming reality of this inherited power of whole-cell transformation — a power that proves highly adaptive in the presence of novel circumstances, and a power that vividly demonstrates the organism's ability to employ its one inherited genome in the service of radically divergent living entities (cells). And yet, in the face of this reality, generations of biologists have almost unanimously declared that the only things passed through inheritance that can account for evolutionary change are differences (mutations) in the genetic sequence. The transformational power of the inherited cell as a whole, extending vastly beyond the influence of its genes, can, they've told us, be disregarded. All this without any effort actually to investigate the evolutionary significance of the power of the whole cell, and even with an occasional acknowledgment that "we wouldn't know how to begin pursuing such an investigation."

And this is the "settled science" that everyone interested in evolution is required to accept at risk of being called a "science-denier"?

The sort of complex, circular, "everything-affects-everything" causal interplay of whole cells and whole organisms is readily observable by every researcher, and has been recognized ever since Immanuel Kant first drove the point home in his *Critique of Judgment* in the late eighteenth century. So why has it been such a struggle, throughout the subsequent history of biology, for biologists to hold on to an awareness of the wholeness and self-transforming activity of organisms? And why have evolutionary biologists allowed their judgment to be so distorted by a simplistic preoccupation with randomly mutated genes as difference-makers?

As we have seen, E. S. Russell rejected the gene fixation that has now bedeviled geneticists and evolutionists for a century. His work was part of a broad, international effort among biologists during the first half of the twentieth century to found biology upon facts of the organism that anyone could see. But then came the "Modern Synthesis" with its gene-centered view of evolution, followed at mid-century by the molecular biological revolution, which, so it was thought, powerfully reinforced the gene-centered view of the organism. So the organism that anyone could see disappeared, giving way to an imagined organism viewed through a purely conceptual, gene-shaped lens. And with the triumph of the gene, the proponents of whole-organism biology were erased from biological narratives, except as quaint historical examples of "mystical" or "vitalist" thinking.

If there has ever been a greater example of willful refusal to face obvious truths within a major field of science, I am not aware of it. In the remainder of this chapter, I will look at some of the underlying inclinations behind what I am calling "the genetic distraction," which has so powerfully wrenched evolutionary biology away from any reckoning with the actual life of organisms.

Notes

1. On the relevance of Russell's work today, see "Heredity, Development and Evolution: The Unmodern Synthesis of E. S. Russell" by Maurizio Esposito (2013).

2. Hybridization does in fact sometimes occur between distinctly different species and, as I pointed out in Chapter 20 ("Development Writ Large"), it is possible that this contributes to rather dramatic evolutionary change. But such instances hardly lend themselves to the usual search for genes that make particular differences, since hybridization is likely to generate massive genetic change and cellular reorganization — changes far too extensive and global to allow for conventional genetic approaches. So one is still left with the unsolved "problem of the whole" — the problem that genetic analyses were designed to steer clear of by focusing on particular genes causing particular trait differences.

3. Many biologists would doubtless say, "We don't *want* to speak of the organism as a meaningful entity or being. It really *is* just a mere material aggregate that happens by chance and natural selection to have the features it does." But this is not honest, since every biologist, so far as she is doing biology and not physics, speaks of organisms as living beings with a recognizable, sustained, and consistent nature — and speaks with a vocabulary overflowing with the meaning of that nature. On this, see the discussion of a dog and its corpse in Chapter 2 ("The Organism's Story"). If one felt oneself really to be speaking of a mere aggregate, one could no more talk about its evolution than one could talk about the evolution of an arbitrary arrangement of pebbles upon a patch of ground. Moreover, it is impossible to cite natural selection without invoking all the capacities of active beings who strive for life, assemble inheritances, and, in general, carry out all the performances implied by their particular natures.

4. Evolutionists are interested in germline (heritable) genetic mutations as the primary basis for evolutionary change. No one will quarrel with the fact that we lack any such mutational basis for the very great changes that can occur in the differentiating cell lineages of a complex, multicellular organism. But we *can* ask whether there are non-germline ("somatic") mutations along the various paths of cellular differentiation, and whether these are important for the success of differentiation. The question is being actively explored today. But we can already say this much: to whatever degree somatic mutations do occur and are important to cell differentiation, the fact would show that the organism manages and directs its own genetic mutations. Why? Because cell differentiation (and development in general) are such obviously *directed* processes. If mutations are an essential part of these processes, we can hardly believe they play their roles in a random manner.

5. The tendency of evolutionary biologists at this point is to claim there is no evidence for anything like a whole-organism, future-oriented, transformative capacity taking hold of germ cells or gametes. This is to ignore the fact that the development and specialization of the germ cell lineage is at least as dramatic and well-directed as the differentiation of any other cell lineage in complex organisms. But, just as important, the claim of "no evidence" for more-than-genetic, whole-cell inheritance usually reveals itself as spectacularly circular, being based on the argument that, whatever the transformation we witness in germ cell lineages, we don't see corresponding changes in the genetic sequence. In other words, an insistent *assumption* that all heritable change must take the form of germline genetic mutations is being used to refute the claim that there is more-than-genetic, whole-cell, heritable change.

When confronted with the problem of the character of the whole cell, biologists have a tendency to cite the impossibility of carrying out their usual analyses wherever one insists on speaking of "wholes." In self-defense they sometimes add that the very idea of a whole invites vitalist or mystical thinking. And so there has never been a major research program aimed at tracking how whole-cell inheritance might play into evolution.

References

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