

CHAPTER 21

Inheritance, Genetics, and the Particulate View of Life

This chapter about the gene-centered (“genocentric”) view of evolving organisms shouldn’t have needed to be written. Today genocentrism has been challenged from so many different sides, by so many leading biologists, and in such an ever more insistent manner, that it might easily seem a waste of time to raise the usual issues afresh here. So I won’t.¹

But there are caveats. One is that, despite the criticism, the idea of the masterful, controlling gene remains as strongly entrenched as ever in the minds of most biologists. This is especially true of evolutionary theorists, for whom the word “genetic” has long been synonymous with “heritable”. In other words, for purposes of evolutionary theory genes substitute for the entire, one-celled living being that in fact passes between generations — and also for the whole organisms capable of producing such heritable cells. This means that, as participants in an inheritance-based evolutionary lineage, organisms themselves scarcely exist for the theorist.

The century-long habit of genocentrism is seemingly resistant to all criticism. As three Duke University biologists summarized the matter in 2017, “Everyone understands” that the idea of a definitive *gene for* this or that feature of an organism “is a distortion of the biological facts, yet, as a profession, we have yet to rid ourselves of this crutch” (Gawne, McKenna and Nijhout 2018).

Much of the criticism of genocentrism has arisen from the field of evolutionary-developmental biology (“evo-devo”). Yet even here, according to a leader in that discipline, “increasing gene centrism characterizes the field today”:

This reductionist attitude continues to be upheld, even though overwhelming evidence points to the fact that it is not gene expression and regulation that singularly define body structures but the systemic processes of interaction between genes, cells, and tissues as well as the physics and physiologies of the involved entities and their interactions with numerous factors of the environment (Müller 2019).

A second caveat, even more discouraging, is that, for the most part, the critics themselves leave the door wide open for the persistence of genetic reductionism. This is because few if any well-positioned, reputable biologists are willing, at the risk of reputation and career, to speak out against the reigning materialism of their profession.²

It is this dogma that supports machine models in biology and that requires there to be physical “controlling factors” determining the lives of organisms. Whether these factors be genes or something else doesn’t much change the distorting effect upon biological understanding. The qualitative *way of being* of every organism, the immaterial *organizing ideas* shaping their lives, and the purposive *coordination* and *direction* of physically causal processes in order to satisfy the organism’s *needs* and *interests* — these foundations for biological understanding are swept away before the religious fervor supporting the restrictions upon thought imposed by the materialist faith.

Most immediately, however, this dogma invites an almost worshipful regard for the all-

determining, informational gene — a machine-like gene intelligently designed and engineered from outside by the “creative forces” of evolution. In this way the theorist employs the gene as a lifeless stand-in for the present and effective wisdom that moment by moment lives and expresses itself in every animal’s inner, qualitative, perceptual experience (however primitive) and in its meaningful response to that experience.

In what follows I will review the genocentrism of the received evolutionary theory, and then explore some fundamental problems with genocentrism — problems the present critics of genocentrism cannot allow themselves to recognize at risk of violating the materialist taboo. This exploration will continue into the next chapter, where we will look at the contrast between the evolutionarily stable (“potentially immortal”) genetic particles that Richard Dawkins celebrates so vehemently, and the evolutionarily stable *yet dynamically transformative* whole organism.

DNA as the essential substance of evolution

As we saw in Chapter 16 (“Let’s Not Begin With Natural Selection”), evolution is said to be inevitable once three conditions are met: (1) There must be trait *variation* among individuals in a breeding population; (2) This variation must to some degree be *inherited*, so that offspring generally resemble their parents more than they resemble others; and (3)

Individuals possessing different variants of a trait must, at least in some cases, exhibit *differential fitness* (or differential survival) — that is, they must produce, on average, different numbers of offspring, whether immediate offspring or later descendents. This is often referred to as *survival of the fittest*, or the principle of *competition*.

We also saw in that earlier chapter that these three conditions — insofar as they are abstracted from the life of the organism and its agency — become a hollow formula that tells us nothing about why a given species in a particular location evolves in one direction, while another species evolves in a different direction. That is, until we reckon with what organisms *do* as a function of their entire way of being, the so-called “core logic” (Stephen Jay Gould), or “algorithm” (Daniel Dennett), of evolution can tell us little about their evolution or about the diversity that may arise from them — or even about whether they will evolve at all. And when we do reckon with the active life of organisms, it is this reckoning itself, not some core logic of inheritance and selection, that elucidates the evolutionary trajectory of a species.

The chief excuse for ignoring what organisms do has been found in a distorted picture of genes and DNA. This picture gives to the core principles of natural selection described above what little biological content they have:

- **Variation:** All or nearly all the variation that matters for evolution (so the theory goes) is ultimately accounted for by mutations in the genetic sequence.
- **Inheritance:** So far as it bears on evolution, inheritance equates completely or nearly completely to the replication and transmission of genetic sequences.

- **Differential fitness:** The organism's differential fitness, so far as it matters for evolution, is regarded primarily as the result of traits that in turn result from instructions carried by genetic sequences.

So genes are the one unquestioned material foundation and efficient cause upon which, from the organism's side, the modern edifice of evolutionary theory has been erected. As defined in a classic introductory text, the process of evolution "includes all mechanisms of genetic change that occur in organisms through time..." (Hartl 1988, p. 143). Evolution, in this view, looks very much like a matter of genes and their fate — and not much more.

Once one adopts this view wholeheartedly enough, it becomes all but impregnable. If genes are First Causes of the organism, then even the gene-independent lipids and sugars (for example) that play such fundamental roles in the cell can be said to have their fates interwoven with the proteins that genes "code for", and therefore to be under the "control" of genes. And it's true that, because of the integral unity of the cell, proteins are involved in just about everything that goes on, including lipid metabolism and the formation of the lipid-based cell membrane.

But, as we saw in [Chapter 4](#) ("The Sensitive, Dynamic Cell"), that same integral unity of the cell makes it possible to claim (as some have) that the cell membrane or the cytoskeleton is the true "master controller" of the cell. But recognizing this integral unity, on one hand, and claiming for any element of this unity the role of master controller or First Cause, on the other, are entirely different things.

It's the latter sort of claim on behalf of genes that (as biologists Tobias Uller and Heikki Helanterä have pointed out) may lead one to ignore a beaver's agency and activity in dam building as an evolutionary cause and instead claim that dam building "is itself an adaptation" brought about by gene mutations in the past. And so "the beaver's impact on its environment, which both maintains the adaptive value of its phenotype and may bias further evolution" counts for nothing (Uller and Helanterä 2019).

In this way the organism's agency — an actual *power of purposive, end-directed activity* — drops out of the picture of evolutionary causation, replaced by inert genetic "particles". And yet, genetic "effects" themselves reveal (by being dependent on) a whole-cell physiological organization and power of activity — a power never brought into mainstream evolutionary theory. Do you find anything strange in this picture?

The aggressive claims of population geneticists

It was preeminently the population geneticists who framed the twentieth-century "Modern Synthesis" as the definitive formulation of evolutionary theory. It is likewise the population geneticists who still today speak most forcefully about the primacy of genes. And it is the population geneticists (regarding themselves as working at the pinnacle of evolutionary theory) who continue to dominate the evolutionary field today.

Their life's work has always centered on calculations relating to the transmission of genes between parents and offspring, and the changing distribution of genes within populations. The more advanced, technically impressive results of this work often take the form of

sophisticated equations that tend to be more or less opaque to working biologists outside the field of population genetics.

Here are two examples of comments from population geneticists:

Michael Lynch, who holds the Distinguished Professorship of Evolution, Population Genetics and Genomics at Indiana University and was formerly president of the Genetics Society of America, has remarked that “the litmus test for any evolutionary hypothesis must be its consistency with fundamental population-genetic principles”. He freely admits that organisms themselves, as “phenotypic products”, result from “more than a change in gene frequencies”. But the crucial conclusion remains, if only by brute assertion: “If we are concerned with the process of evolutionary change, then evolution is indeed a change in genotype [gene] frequencies” (Lynch 2007a; Lynch 2007b, p. 371).

And then there is Dan Graur, author of a textbook on *Molecular and Genome Evolution*, who proceeds in the same confidently dogmatic spirit (to which he adds his own unique brand of arrogance, in which — judging by his presentation of himself in social media — he apparently revels):

Evolutionary biology is a mature science. It is a coherent discipline with a handful of logical principles, each of which repeatedly withstood rigorous empirical and observational testing. Evolution is not difficult to define. If one ignores the obfuscations of the creationists, the casuistry of the philosophers, and the ruminations of the “sophisticates,” evolution turns out to be merely the process of change in allele [gene] frequencies over time. The only mandatory attribute of the evolutionary process is a temporal change in allele frequencies (Graur 2015).

This is truly amazing — a stunning contraction of human understanding among the would-be elder statesmen of evolutionary theory, smugly satisfied that they do indeed sit at the pinnacle of their discipline. The organism’s entire way of being along with its needs, interests, and agency have been reduced, for purposes of evolutionary theory, to one material part — DNA. The underlying drive appears to be the reduction of mindedness to mindlessness, *logos* to meaninglessness, *telos* to chance — all reflecting a horror of interiority.

What seems to these two population geneticists so obviously and incontrovertibly true is nothing but the extremely one-sided, absolutely genocentric, twentieth-century theorizing about evolution, which yielded a body of impressive technical knowledge about gene flows in populations — knowledge to which they have wedded themselves while wearing blinders. The main problem, disastrous in any science, lies in their inability and unwillingness to step outside their particular training and try to see their discipline from outside, as it might appear to critics. This requires, not an aggressive assertion that the fundamental principles of their theory cannot be questioned, but rather an ability to become questioners themselves.

The habit of ignoring organisms is so stubbornly entrenched among population geneticists that their ability to recognize crucial evolutionary issues seems scarcely to exist. Think, for example, of the problem of the origin of innovation — that is, the problem of the “arrival of the fittest”, or the arrival of new, living performances (traits) for natural selection to act upon. (We looked at this in Chapter 16.) Armin Moczek, a prominent evolutionary developmental biologist at the University of Indiana, remarked that “fields such as population-genetics have long stopped asking the question how evolution innovates, not because it is not a

foundational question in evolutionary biology, but because population genetics lacks the ability to even frame the question” (Moczek_2022).

They have stopped asking in part because the fact that some genes can make a more or less stable difference in some existing traits (Chapter 22) has convinced them that they need not consider all the other, less experimentally and mathematically tractable features of an organism’s life that also make a difference. Nor need they inquire into the principles of organization through which cellular and organismal identity are stably maintained, and through which alone a trait can come into existence as an integral and viable aspect of the larger whole. And they are least of all inclined to consider whether the organism’s most dramatically demonstrated capacity — its capacity for directed developmental change and metamorphosis consistent with its own way of being — might be relevant to evolution.

Who defines what counts as an evolutionary process?

The population geneticists, in the manner of those adhering to many an aging and rickety scientific viewpoint, have constructed for themselves an institutional and intellectual fortress whose final crumbling must, as the rather brutal saying has it, await the dying out of its last, well-known defenders.

In the meantime, one thing giving a sense of impregnability to the fortress is the fact that evolution has been aggressively *defined* in terms of genes, as we heard above. One is then bound to argue that whatever is not adequately gene-like cannot be important for evolution.

This argument by definition is why population geneticists routinely dismiss epigenetic factors (Chapters 7 and 14) as irrelevant to evolution: such factors, they tell us, often don’t have the long-term, transgenerational stability usually ascribed to genes, and therefore can’t contribute much to evolution.³

In other words, “Since epigenetics doesn’t give us the kind of genetic stability we want to see as the essence of a mindless and strictly mechanistic sort of evolution, we refuse to consider what evolutionary potentials it *does* give us”. Those who think this way can scarcely imagine that epigenetics presents us with a revealing expression of the highly adaptive processes of continual, directive change we discover in every sort of whole-organism activity — for example, in the many differentiating cell lineages of our own developing bodies. These lineages result from the changing organization of whole cells, which includes their changing ways of employing their genes.

Such transformative processes — which one might think would be the first things looked for by evolutionists — are ruled out of evolutionary theory on the grounds (now known to be false) that nothing occurring in development affects the *genetic* inheritance of the next generation. But even if that were true, so what? This constricted focus on genetics overlooks the holistic nature of cellular inheritance revealed during cell differentiation. This inheritance is not only dramatic, but undeniably a *whole-cell* phenomenon. If biologists dismiss the significance of developmental processes for evolution, it is only because they have planted their flag and staked their claim in advance: “We’re not interested in the potentials of the whole cells that contribute an inheritance to the next generation, but only in the genes those cells contain.

So we're simply going to ignore the actual performances of real cells".

As with so many perverse doctrines, there is a dim and distant reflection of the truth in the gene's-eye view of evolution, although it is a truth lost on Lynch, Graur, and their kin. DNA is indeed caught up in, and informed by, the character of the whole organism, including its adaptive character. Therefore we can in one way or another expect to find the whole organism reflected in DNA. Such is the case with all the other major aspects of any organism, as we have already seen in our discussion of cell membranes and the cytoskeleton ([Chapter 4](#), "The Sensitive, Dynamic Cell").

Getting to the bottom of things?

One of the most common strategies for honoring the materialist taboo in all sciences is to describe a microscopic level of supposedly meaningless and inherently inert, mindless things, or particles, possessing fixed, well-defined natures with causal powers. (The fact that causal powers are *powers*, not material things, is conveniently ignored.) Then one claims that whatever really counts in the explanation of

phenomena derives from various effective combinations of these particles.

In Richard Dawkins' biological theorizing, the particles at issue are genetic elements with a wonderfully computational nature. "Digitalness", he has said in what must have been one of his rashest statements, "is probably a necessary precondition for Darwinism itself to work" (Dawkins 2006, p. 163). "What is truly revolutionary about molecular biology", he wrote, "is that it has become digital". We know that genes "are long strings of pure digital information ... The machine code of the genes is uncannily computerlike. Apart from differences in jargon, the pages of a molecular-biology journal might be interchanged with those of a computer-engineering journal" (Dawkins 1995, pp. 17-19).

The meaning of "digital" can be illustrated by the game of basketball. The game is so designed that the making of a basket is always definite and unquestioned. The ball either goes through the hoop, or it does not. A team either earns points for the basket or it does not. How graceful or awkward, skillful or random the shot may have been has no bearing on the matter. A player's approach to the basket can be ugly as sin, but if the ball ends up going through the hoop, the points are counted. There's a clean, yes-or-no, "ones-and-zeros" aspect to the proceedings. The number of points earned is always exact and countable. There are no half or three-quarter points, but only whole numbers. Everything is precise, and there is no ambiguity.

Dawkins' claim accordingly is that, when it comes to the identity and role of genetic particles, "there are no half measures and no intermediates or compromises" — certainly nothing we might recognize as qualitative or as a power of subtle self-transformation. "Our particles of inheritance ... don't blend, but remain discrete and separate as they shuffle and reshuffle their way down the generations" (Dawkins 2006, pp. 159-63).

So this is what Dawkins assumes to be the essential character of our genetic material, which he situates at the causal root of every organism: it consists of discrete and separate causal elements that do not interpenetrate, neither are they subject to half measures,

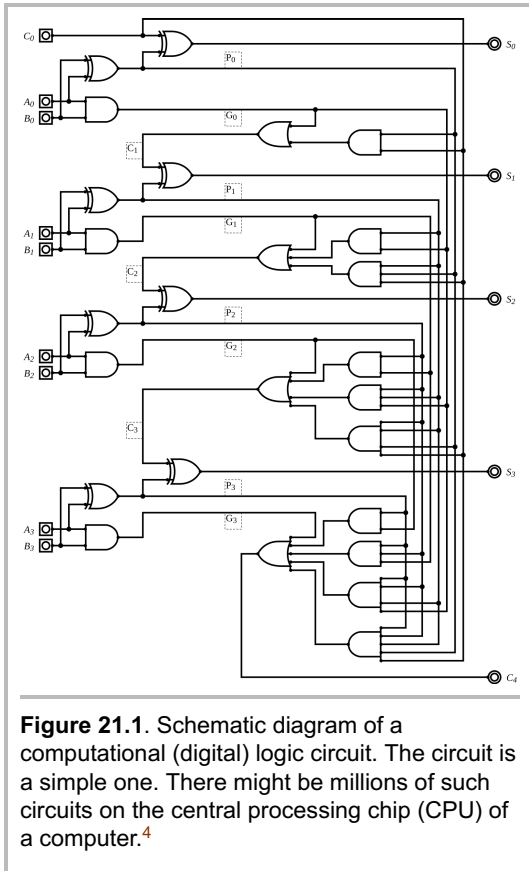


Figure 21.1. Schematic diagram of a computational (digital) logic circuit. The circuit is a simple one. There might be millions of such circuits on the central processing chip (CPU) of a computer.⁴

intermediates, or compromises. His reference to genes as strings of “pure digital information” makes it clear how paradoxically abstract his thinking has become — a common feature of materialist thought, which tends to be not nearly material or “enfleshed” enough. His “causal” factors come very close to being nothing more than elements of computer logic.⁵

The convergence in Dawkins’ mind of (1) causal force and (2) compelling, computational logic — a symptomatic conflation running through much biology today — is ironic in light of his materialist commitments. If in fact the pure conceptuality of logic finds revelatory application in science, it would only reveal a world causally governed or organized according to thought, even if, in the case of thought reduced to logic, it is highly constricted and vacuous thought. By contrast, the very real mindfulness we encounter in our concrete and engaging interactions with the world, and above all with organisms, is far more profound — and far more replete with meaningful content — than a mere play of logical form.

It hardly needs saying that Dawkins’ genetic informational bits are, by definition, incapable of participating in living wholes. Because their identity is conceived as almost eternally fixed, unblending, and quantifiably (digitally) specifiable, they cannot lend themselves to being qualitatively transformed or reimagined in harmony with the fluid, organizing ideas and intentions at work in every organism. It is the mutual interpenetration (“blending”) of features and organizing ideas in the organism that makes its unity possible, and since Dawkins wants none of this, the unity is hidden to him.

But Dawkins gets his digital, non-blending particles of inheritance only by defining them into existence. Reality gives us a very different story.

How the image of “particles” has distorted the biologist’s imagination

Digital, unblending genetic elements of pure, computational *logic* or *information*: where is one even to begin a critique of these impossible notions, upon which so much biology and evolutionary theory is erected? Where in the living organism do we find the slightest justification for them? Can Dawkins show us even one DNA sequence that functions in a strictly digital fashion?

We might start thinking about this at a fairly remote distance from Dawkins’ immediate genetic meanings by looking at an illustration offered by twentieth-century cell biologist, Paul

Weiss. He reminded us of the commonplace pictures and models of molecules, represented as conglomerates of colored, spherical “billiard balls”, each standing for an atom, and each seeming to be a stable, self-contained unit. (An example — not Weiss’ — is shown in Figure 21.2.) He then contrasted that with the image in Figure 21.3, which shows how the constituent atoms of a molecule interpenetrate (“blend” into) each other as continuous fields or a complex system of mutually shaped forces. These “blur the former sharpness of the outer boundary of the molecule and let it melt into the surrounding molecular domains” (Weiss 1971a, p. 9).

Weiss also remarked of figures such as this that “one is reminded of the contour maps of mountain ranges. Domains of particles are no more truly isolated than are mountain peaks” (Weiss 1971b, p. 235). Moreover, the parts of such an interactive system are rather “like islands”, so that they must be “conceived as interconnected, though not so solidly as by a bed of rock, but loosely by the all-pervading mesh of forces and interactions” (Weiss 1971a, p. 11).

This may remind us of the discovery (mentioned in [Chapter 5](#)) of how water interacts with DNA. Lifting one paragraph from that earlier chapter:

Early efforts to develop a computer simulation of a DNA molecule failed; the molecule (in the simulation) almost immediately broke up. But when [the researchers] included water molecules in the simulation, it proved successful. “Subsequent simulations of DNA in water have revealed that water molecules are able to interact with nearly every part of DNA’s double helix, including the base pairs that constitute the genetic code”.

Needless to say, this interaction of DNA with water alters the entire landscape (or seascape) of DNA, very much in the manner of [Figure 21.3](#) above. None of it suggests much of a defense “at the bottom” for the idea of independent, digital, unblending genetic particles. But this point will become more explicit and more directly aimed at genes as we move along.

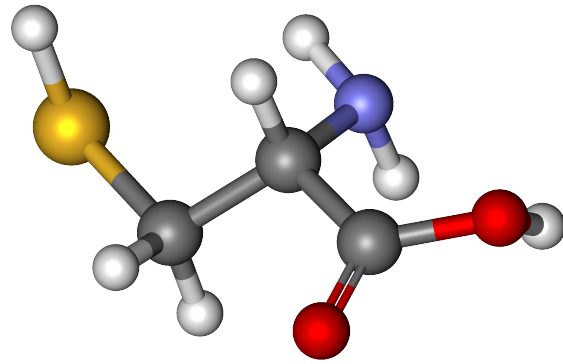


Figure 21.2. A conventional ball-and-stick model of a cysteine molecule.⁶

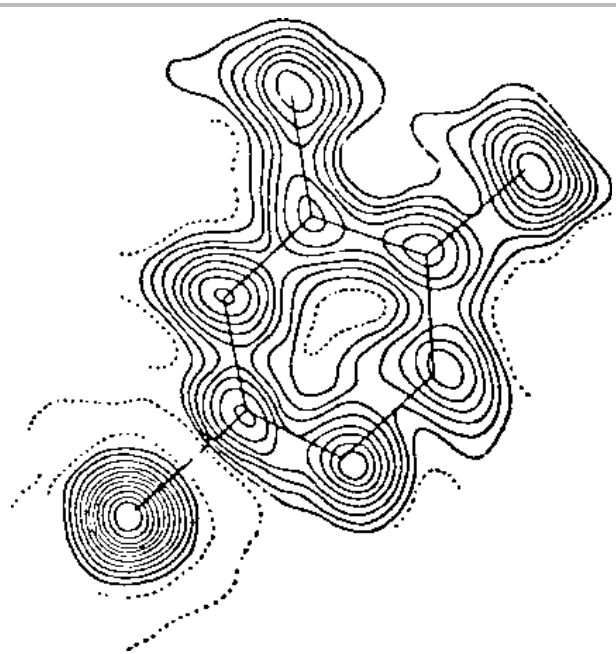


Figure 21.3. Schematic, two-dimensional representation of a molecule, where concentric “circles” are intended to map electron distributions of individual atoms, and straight lines artificially represent bonds between the atoms. NOTE: this drawing is not intended to represent the same molecule shown in the figure above.⁷

The fundamental reality of the matter was already glimpsed in the nineteenth century by the great experimental physicist, Michael Faraday. He recorded his prescient, “final brooding impression” that “particles are only centres of force” and that, for instance, water does not consist of atomic particles “side by side”, but rather of “spheres of power mutually penetrated”. And in notes for a talk given to the Royal Institution, he suggested that “matter is not merely mutually penetrable, but each atom extends, so to say, throughout the whole of the solar system, yet always retaining its own centre of force” (quoted in Barfield 1971, pp. 201n11 and 244n17).

Facing up to the gestural reality of DNA

What, then, do we see when we take even a cursory look at DNA? Exactly what Faraday and Weiss would have expected.

We have already heard about the positive and negative supercoiling of the double helix (Chapter 3, “What Brings Our Genome Alive?”). Both reflect a dramatic re-organization of forces along the DNA molecule — forces from which neither genes nor single nucleotide bases (“letters”) of DNA can claim to be immune. These forces are not respecters of the boundaries between genes, and their re-shaping effects are known to help determine the functional role of genes within the organism.

But supercoiling is only one of many ways the genome is continually restructured. The DNA molecule, while inherently rather stiff and inert, lends itself, under cellular influences, to endless, plastic, structural change, both subtle and not so subtle, under the forceful pressure of its cellular environment.

Consider, for example, the many protein transcription factors that come to bear upon gene expression. In the simplistic thought of an earlier day, they were assumed to be just about the sole factors implementing the rigid “control logic of the genetic program”. Moreover, they were said to bind DNA in a manner strictly determined by the abstract sequence of DNA “digital letters”. The determining role of the abstract sequence was then supposed to justify the geneticists’ belief that genes were the real agents in control of their own expression. But this conclusion sounds farcical today.

Transcription factors are now well known to engage in a gestural dance with the matrix of physical forces constituting the reality of the DNA sequence. They contribute their own forces to the infinite variations in the way genetic sequences “blend” together with each other and with innumerable regulatory molecules.

Actually, even within the terms of the earlier view, there were all sorts of unanswered questions about transcription factors. For example, what determined when and how often a particular factor was bound to the supposedly controlling DNA sequences? Why did it bind more to some of those sequences and less to others? And how was its activity coordinated with that of the many other transcription factors participating in the complex task at hand, which might involve the need for balanced expression of hundreds of genes?

Beyond this, however, the old concept of transcription factor binding (or not binding) to DNA is now recognized as hopelessly one-dimensional. The reality of DNA is difficult to think of

as anything other than a play of ongoing *gestural form* orchestrated by the cell as a whole. You don't need to know the complex details of the terminology in order to get a sense for what it means when an article in the journal *Nature* reports how transcription factors interact with “shape features of the DNA sequences, such as minor-groove width, roll, propeller twist and helical twist” (Burgess 2015). These ever-changing shape features are subject to influences arising from the limitless cloud of regulative molecules (including water molecules, as we heard above, as well as the transcription factors themselves) that more or less transiently swirl around a cell's DNA. None of the analog shape features looks very much like Dawkins' concept of digital or computer-like elements of a genetic program.

The vast majority of our DNA is tightly and forcibly bent so as to wrap around millions of nucleosome core particles in the cell nucleus. The nucleosome, as we saw in [Chapter 14](#) (“How Our Genes Come to Expression”), is perhaps the central integrator of signals bearing on gene expression and coming from all corners of the cell.

The wrapping of DNA around these protein core particles is probably never exactly the same in the case of any two of the thirty million or so nucleosomes in our genome, nor ever the same at any two different times in the case of a single nucleosome. The bending and shape changes in the DNA require a great variety of force interactions between DNA and the core particle, all in the presence of numerous associated molecules. So we hear (as before, in the case of transcription factors) that the functionally critical spacing and location of nucleosomes along a stretch of DNA can vary, depending on transient DNA features influenced by the cell “such as propeller twist, opening, electrostatic potential, minor groove width, rise, stagger, helix twist, and shear and roll ... and buckle” (Kurup 2019). Everything is subject to dynamic variation.

The gestural form we are looking at in the case of DNA and related molecules appears to have no limit in its extent or its significance for gene expression. It cannot even be said that the double helix is always even close to being a standard double helix, or a double helix at all:

Alternative conformations (including left-handed DNA, three-stranded triplex DNA, four-armed cruciforms, slipped-strand DNA with two three-armed junctions, four-stranded G-quadruplex structures and stable, unpaired helical regions) can exist in the context of chromosomes. Rather than being a static helix, DNA possesses dynamic flexibility and variability, as evidenced by helix regions that can be curved, straight or flexible. Differences result from variations in base stacking and twist angles inherent in different DNA sequences. DNA supercoiling⁸ [induced, for example, by transcriptional enzymes], particularly unconstrained supercoiling, plays a major part in the dynamic flexibility and topological contortions of the DNA double helix (Sinden 2013).

Everything we have been hearing about is fundamentally qualitative and gestural rather than digital, and it counts not only toward whether a “basket is scored” (a gene is expressed), but also toward the “size of the score” — for example, will there be a large, rapid burst of expression, or a low-level, steady-state expression? Crucially, there is also the question of the *nature* of the score: for example, which of several functional variants of a protein will be synthesized — that is, what sort of protein is the DNA sequence effectively “coding” for? So the qualitative, gestural features mentioned above bear hugely on the practical meaning of a gene for the organism. They help to define what any given gene is at a given moment.

DNA, when caught up within the whole cell, is a phenomenon of movement brought

about by its context. Of the endless variety of its movements, two are referred to as “DNA breathing”. One of these (which we heard about in [Chapter 3](#), “What Brings Our Genome Alive?”) involves the rhythmic loosening of parts of the double helix from the nucleosome core particles around which they are wrapped. This has great influence — rhythmic influence — on the accessibility of portions of the DNA to gene-regulatory proteins. The other sort of breathing consists of local, transient separation of the two strands of the DNA double helix, which also affects the accessibility of the DNA.

Furthermore, the foregoing represents only a minuscule introduction to all the ways gene expression turns out to be a fluid, non-digital, and non-machinelike expression of dynamic, gestural form. I have not even mentioned what is widely considered to be the most prominent way DNA “letters”, or nucleotide bases, are modified and the play of forces re-sculpted — namely, by the attachment of methyl groups to nucleotide bases in a process called “DNA methylation”. This is the most common of a fair number of modifications to DNA, affecting many millions of nucleotide bases in our genomes. By this means the letters become *different letters*. This is one of the ways the cell makes a lie of the supposed constancy of the “digital DNA code”.

Neither have I mentioned the large range of factors affecting the structure of RNA, an essential molecular carrier of the “genetic code” (and a mediator between DNA and actual protein production) whose liveliness of functional form is, if anything, even more obvious than what we see in DNA. So once a stretch of DNA is transcribed into RNA, we are again looking at a vast range of potential transformations of the “coding” sequence.

And then there is the actual translation into protein at the hands of what is called a “ribosome”. Here, for a third time, a huge array of molecules somehow “aware” of the cell’s contextual state and needs, come to bear on the proceedings.

And, perhaps most important of all, I have not cited the massive research effort today dealing with the form and movement of chromosomes — for example, the critical looping movements that bring genes and regulatory elements of DNA into functional proximity within the three-dimensional space of the nucleus. We are looking here at a gestural performance that many investigators can hardly resist referring to as a “dance” or an elaborate “choreography”. We encountered some of this in [Chapter 3](#) (“What Brings Our Genome Alive?”). How that dance occurs critically shapes how genes will be expressed. Genes are as far from being discrete, well-defined, independent causes as two ballet dancers engaged in a *pas de deux*.

Finally, all the foregoing can give you at least some slight sense for how the cells in our bodies — all working from a single inherited genome — can nevertheless pursue such diverse pathways of differentiation, from pancreas to blood to brain to muscle to retina to bone ([Chapter 17](#) “Evolution Writ Small”). It seems just obvious that the range of uses to which the cell can apply its genes is all but unbounded. The cell can gesture or dance in countless different ways with whatever genome it has been dealt.

A gene that, within the full contextual life of the organism, can be interpreted as a self-contained and determinate cause or a bearer of strict, univocal, digital logic does not exist.

To view from the bottom or view from the top?

Evolutionary theorists, so it appears, have great difficulty recognizing as significant either the stable and highly distinctive character of the whole cell and whole organism, or the remarkable interior (mind-like) capacities through which that character is consistently expressed and sustained amid all the transformations of individual

development. And so they find it easy to discount everything living. They discount, that is, the future-directed powers of self-realization, adaptation, and whole-cell (whole-organism) reproduction — the very powers that hold the most obvious relevance for inheritance and evolution.

Organisms as such simply don't show up through the death-shroud that is the particulate view of life. As for the particles themselves — the supposedly unblending, unexpressive, qualitatively inert genes and nucleotide bases ("letters" of the genetic code) — they are, in reality, illusions. The upshot of the foregoing discussion is that the discrete, non-blending, genetic particles that Dawkins, for example, is so quick to idealize as controllers of the organism's evolution, do not actually exist as real, material entities. They exist only as logical or digital constructs fancifully projected upon the living cell by a materialistic mindset that can't seem to face actual materiality with its insistent expression of interior being.

The situation can also be summarized by saying that evolutionary biologists are currently blind to organisms as beings *organized from within*. To speak of interiority is anathema to them, and therefore any genuine recognition of *organizing ideas* is also anathema. Which is too bad, because either organizing ideas in the material world have real consequences, or else the terms biologists freely use to invoke such ideas subconsciously — "organizers", "organization", "self-organization" — are symptoms of shamefully vacuous theorizing.

Think of it: take away the organizing *ideas*, and what would be left of any sort of "organizing" or "organization"?⁹ "Capable of constituting a kind of *meaningful* order or coherence" is just what the word "organizing" means. When we think of any organizing principle, we are thinking of a principle, not a thing. Every science necessarily seeks immaterial (ideational) *principles of order*.

Consider the much-criticized but still endemic idea that there are *genes for* particular traits. If we believe that genes possess, in their own right, the essential, organizing or directing power to realize traits — traits that are in fact qualitative, non-discrete, interpenetrating, and expressive of a specific (species-related) "way of being" — then we are ascribing to genes a living power to *organize* almost unthinkable complex physiological processes requiring a kind of moment-by-moment active judgment governing a virtually infinite number of molecular interactions in a fluid, continually changing context. (I focused especially on such processes in Chapter 8, "The Mystery of an Unexpected Coherence".)

Genes surely do *participate* in such a power, but it is a power of activity belonging to the whole organism and is not properly attributed to any collection of material elements, such as

genes, that are caught up in it.

Those who want to adhere to materialist principles gain nothing by contradicting them. They gain nothing, that is, by transferring the interior, organizing ideas of the cell or organism to genes. If genes really possessed their own “informational” powers for sensing their wider context; if they really could encode messages tuned to moment-by-moment changes under infinitely varying circumstances; if they really had a way to direct the interactions among countless billions of molecules in a fluid medium, enabling those molecules to carry out indescribably intricate operations such as RNA splicing, and if in general they really were able to *inform* and *organize* the life of the entire cell¹⁰ ... well, once we have accepted this impressive play of wisdom through the genome, what reason would remain for denying it to the vividly expressive cell or the whole organism, where we actually observe it?

If “context matters”, as so many biologists are now telling us, it can only be because it really does substantively matter. It makes a difference to what happens. The context exercises, in other words, its own, over-arching sort of causal power. It’s not a kind of power that can be transferred to materialistically conceived particles — particles abstracted from cell and organism (“the context”) as if, by themselves, they carried a decisive causal logic independent of the living matrix in which they find their real existence.

Looking Beyond Particulate Inheritance

Biology today is governed by a taboo: *The biologist must never acknowledge stepping outside the materialist framework — or at least must remain unaware of doing so.* She must never grant that animals have an interior — that every animal is an integral, unified whole possessing, or possessed by, an active, wise agency.

The biologist's materialist commitments are impossible to keep. They would render the organism, as a living being, invisible to scientific investigation. This is why biologists can hardly avoid preserving the organism's agency by covertly transferring it to special molecules (DNA). But at the same time — in order to keep an illusion of observing the taboo — they speak of these wonderfully effective, "informational" molecules as if they were "things" uninformed and ungoverned by the agency of the whole.

This double-talk, which would have DNA possessing the creative powers of life while at the same time consisting of "mere chemical stuff", is somehow easier to stomach in the case of molecules than in the case of whole organisms. Molecules, being non-phenomenal (invisible to sense perception), lend themselves more obligingly to the projection of our mechanistic/animistic fantasies.

It is population genetics, above all else, that has converted evolutionary theory into a theory about genes rather than organisms. As we heard from one population geneticist, "The only mandatory attribute of the evolutionary process is a temporal change in allele [gene] frequencies".

There is little beyond quantifiable (digital or logical) entities in this picture — nothing material, plastic, and expressive, nothing qualitative, nothing through which the interior life of organisms can shine. We cannot connect anything in the particulate gene to our own conscious awareness, or to animal sentience, or to perceptual experience and cognition, or to the organizing ideas underlying animal form and behavior. If particulate genes account for these aspects of life, no one has a clue how it could be. Yet these genes are routinely posited as the evolutionary basis for understanding *all* life.

We have also found more than ample reason to question the notion of genes as fixed, inert, particulate, unchanging entities passing down through the generations unaffected by their bodily hosts. There are, in reality, countless ways, both subtle and obvious, in which the whole cell lends to DNA its present and ever-changing meaning for the life of the organism. This is, in the first place, how cells manage to turn their DNA toward the end of cell differentiation, resulting in the hundreds of cell types in our bodies, from muscle, blood, and bone to brain and liver.

In the next chapter we will, finally, consider Richard Dawkins' defense of the idea that the heritable basis of evolution must consist of "potentially immortal" elements passed down through the generations without undergoing change. We will see that this apostle of evolution offers us a principle of stability and duration, but nothing like a

principle of evolution (change or transformation).

Notes

1. For the record, currently relevant criticisms of genocentrism go all the way back a century. There is, for example, the brilliant work by marine biologist E. S. Russell, especially his 1930 book, *The Interpretation of Development and Heredity: A Study in Biological Method*, which I discussed in the previous chapter. In the modern era, one could start with *Exploding the Gene Myth* by Harvard professor of biology Ruth Hubbard and Nobel Prize recipient Elijah Wald, or the essay, “Unraveling the DNA Myth”, by cell biologist Barry Commoner.

The physicist, biologist, and philosopher of science, Evelyn Fox Keller, has illuminated genocentrism from many sides, including in her book, *The Century of the Gene*, published in 2000, and her chapter on Genes as Difference Makers in 2013. The one-time molecular biologist and now philosopher of science, Lenny Moss, wrote an incisive and influential critique titled *What Genes Can't Do* in 2003. And his book chapter, “Darwinism, Dualism, and Biological Agency” (2005), has perhaps never been exceeded for the succinctness and penetrating depth of its take-down of the controlling gene.

There are many other worthy commentaries on genocentrism, of which one (Gawne, McKenna, and Nijhout 2018) is cited in the main text below. See also Holdrege 1996, Rose 1998, Moczek 2012, Noble 2013, Walsh 2015, Noble 2018, and any number of other books and journal articles published over the past couple of decades.

Special mention also goes to University of Chicago microbiologist James Shapiro's book, *Evolution: A View from the 21st Century* (second edition, 2022). Evolution can only occur if there is useful variation, or potentials for variation, in the evolving organisms. And Shapiro provides overwhelming evidence that, whatever whole-organism features may count as viable heritable variation, organisms certainly have the genetic aspect very well covered. That is, they possess a sophisticated and wide-ranging ability to revise their own DNA — and they put it to use in a huge variety of ways. One could prefer that Shapiro not rely so heavily on computer and program metaphors, but nevertheless he makes abundantly clear the organism's effective exercise of a well-directed agency with respect to its DNA.

2. Disappointingly, those who continue giving support to genetic reductionism include proponents of the “extended evolutionary synthesis” and the “third way of evolution”. As near as I can tell, these movements remain as thoroughly materialist in their fundamental assumptions as the evolutionary mainstream. It truly does appear that any questioning of the materialist creed in biology is likely to spell the immediate dimming, if not the end, of an otherwise promising career. The persistence of such metaphysical dogma in science ought to be ringing alarm bells on all sides.

3. For a discussion of the question of stability, see Chapter 22, “A Curiously Absolute Demand for Stable Variation”.

4. Figure 21.1 credit: Trex43 CC0

5. Here is a slightly different angle on the present paragraph in the main text and the two following paragraphs:

We might say that, with his digital information, Dawkins relies on formal principles, or formal causation. But he doesn't realize this because his "form", having become one dimensional and logical/mathematical, shorn of full-bodied expression and meaning, has been reduced toward the vanishing point. This severely abstracting tendency is the usual end result of a strong materialistic bias. The real essence of that bias is a flight from meaning into mindlessness. This necessarily becomes a flight from the material world, because this world, if received in its vital, perceptual ("sensual") reality, is always found to be an expression of meaning. Hence the preference for abstract thought. Compare Dawkins' seeming abhorrence of the stuff of bodies:

"There is no spirit-driven life force, no throbbing, heaving, pullulating, protoplasmic, mystic jelly. Life is just bytes and bytes and bytes of digital information".

See also [Chapter 24](#), "Is the Inanimate World an Interior Reality?"

6. Figure 21.2 credit: [MarinaVladivostok](#) (CC0 1.0).

7. Figure 21.3 credit: from [Weiss 1971a](#).

8. I offer a very brief explanation of supercoiling in [Chapter 3](#) ("What Brings Our Genome Alive?").

9. To speak of organizing ideas at work in an animal's life is not to imagine the animal *thinking them*. As the facts of instinct can remind us, an organism may be more *possessed by* its intelligence than in willful or conscious possession of it.

10. Everything becomes nonsensical if we overlook or deny the inner power of the whole when in fact we have quietly transferred it to a part while pretending not to believe in it. Already in 1930 E. S. Russell recognized the consequences of this transfer:

The germ-plasm, even in its modern genic form, is [thought to be] something which itself remains unaltered while acting as the cause of visible change in the organism. Aristotle would have recognized in this almost mystical conception something strangely like his "soul"! (Russell 1930, pp. 267-68).

I have no wish to belittle the idea of the soul. But anyone who believes in it should believe in it — not transfer it "under the table" to particular material particles, genetic or otherwise.

More recently the philosopher of biology Jason Scott Robert remarked on the "*animistic* (and otherwise problematic) idea of a genetic programme" (Robert 2004, p. 37). One of the most obvious ways DNA is treated as if it were by itself an animated, living being lies in the common, yet false, conviction that it exercises not only the powers of a human programmer to maintain and modify a single inherited "program" for the highly divergent purposes of hundreds of cell types (and trillions of cell contexts), but also the power to reproduce itself. In reality both the replication of DNA and its adaptation to the needs of different cell types are extraordinarily complex activities of whole living cells and organisms — activities of the sort we looked at throughout the preceding chapters of this book.

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