

Obscurantist Holism Versus Clear-Cut Analysis: Will Anthropology Obviate the Biology-Culture Divide?

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Abstract. Although holism has long been a central theme in anthropology, current perception is that anthropological discourse is being pulled apart along its biology-culture seams. Despite reservations among sociocultural theorists, Darwinism remains the only body of theory that purports to link sub-disciplines of anthropology. The importance of holism in anthropology is reconciled here with disciplinary fragmentation and evolutionary theory. While Darwinism appears to provide interdisciplinary theoretical ties, it cannot successfully relate sub-disciplines of anthropology because this theory itself relies on a preformationist divide between inherited and acquired characteristics. Increasingly subtle language of genetic information and constraints does not ameliorate this problem. Research potential for the ecological constraints model in biological anthropology is discussed. Developmental systems theory (DST) is advocated as a tool for working toward a holistic anthropology [Susan Oyama, Paul Griffiths, and Russell Gray, “Introduction: What is Developmental Systems Theory?,” in Susan Oyama, Paul Griffiths, and Russell Gray, eds., *Cycles of Contingency: Developmental Systems and Evolution* (Cambridge, MA: MIT Press, 2001), 1–11].

Keywords: Holism, developmental systems theory, ecological constraints, evolution, preformationism, inheritance, information, control, nature-nurture

Professional anthropologists ask undergraduate students at the outset because anyone who studies needs help understanding: “What is anthropology”? Yet with research specialties come interdisciplinary difficulties with the overarching answer. Sub-disciplines have been bound from the top-down with a theoretical commitment to anthropological holism. From the bottom-up, responsibility has been on anthropologists to reinforce this unity. It has thus been stated and restated: “American archaeology is anthropology or it is nothing”.¹ It may be further insisted that human existence is a requisite to knowledge, and therefore that anthropology is a foundation of all branches of science. Nevertheless, whether a mother of sub-disciplines, or a mother of all disciplines, identity does not boil down to an arbitrary preference between lumping and splitting. The definition of “holism” is variable as

it is encompassing. It is explored here to flesh-out the meaning of anthropology.

The biology-culture divide runs deeply through anthropological thought. Recently, it has been of interest to some anthropologists, perhaps most notably Tim Ingold, to obviate this dichotomy altogether.² Questions speak more to theory than do boundaries, so it is imperative to observe how distinctions are used, in order to discover why some types appear indispensable yet desirable to demolish. It is argued that the multiply flavored nature-nurture, biology-culture, inherited-acquired, and semi-reduced, very lop-sided genes-environment dichotomies commonly and incorrectly frame ontogenetic form as being caused more or less by interactants (or resources) belonging to either side of these dichotomies, when manifestation of form is always equally dependent upon both. The function of these internal-external (to the organism) dichotomies for understanding evolution by natural selection has been to privilege a subset of “inherited” ontogenetic resources as most formative, directive, and essential, while relegating the remaining vast array of resources to the developmentally supportive status of evolutionary irrelevance. My purpose with this review is to show a path toward a resolution of the biology-culture divide by incorporating ideas from developmental systems theory (DST) into the history and developing potential of a holistic anthropology.

1. Forms and functions of holism

Holism gets a bad rap when seen as a distinctly non-Western, anti-scientific, or female mode of thought. In most caricaturized form, it is taken to mean that we should not or cannot draw distinctions, or that everything is dependent upon everything else. Seeming to blur the independently analyzable component parts of nature, a holistic cosmology frustrates our most taken-for-granted assumptions about the way the world really works. Considerable criticism has thus been levied against such radically holistic ideas as the Gaia hypothesis, in which the Earth is likened to a single organism, complete with mutually maintaining symbiotic systems.³

In anthropology, holism carries a predominantly sociocultural connotation, and refers to how people, institutions, symbols, and behavioral patterns are interrelated.⁴ William Haviland argues that anthropologists must relate the social, political, economic, and religious

parts of society, without placing undue emphasis on one part at the expense of others.⁵ Unconcerned with yet reliant upon the biology-culture divide, the aim of this brand has been to focus on the “big picture” of society as opposed to the narrow components it comprises. Despite the value of seeing a system as more than a sum of its parts,⁶ some anthropologists have welcomed ambiguity inherent to complexity as an opportunity to deny the validity of cross-cultural comparisons and/or to reject biology outright. These problems exacerbate the already widespread biology/objective and culture/subjective mappings.⁷ Though ambiguity itself should not be shunned, in principle, nor should it be used to intentionally obscure knowable structure. Far from binding “the study of people”, sociocultural holism, in all its nuances, has served only to hold it apart.

Few biological anthropologists have written on holism, though Connie Anderson is a notable exception.⁸ She takes holism to mean that anthropologists strive to explain a wide range of phenomena from a wide range of data. Observing that Neanderthals displayed medio-laterally elongated pubic rami compared with coeval anatomically modern humans of the Upper Paleolithic, Anderson puts forth an array of creative hypotheses for why this difference existed. Although environmental causes of development such as climate and nutrition are discussed, these causes are seen to be of minor importance, and at odds with selection. Anderson makes the common claim that anthropology is unique among the social sciences in that it takes components of humanity as “necessary parts of functionally integrated wholes”, but does not substantiate the holistic method of anthropologists or theoretically elaborate upon why sociocultural and biological “parts” must relate.⁹

In a review of 3,264 articles published in *American Anthropology* between 1899 and 1998, Robert Borofsky found that only 311 articles drew substantially on more than one anthropological subfield in the analysis of data.¹⁰ The romanticized claim that anthropology is committed to a kind of holism that integrates sub-fields appears to be almost pure rhetoric. Borofsky attributes the propagation of the holistic “myth” to a frustration with the specialization and fragmentation of modern academic life. But this cannot explain its inception. Anthropologists of the early 20th century did not have the wealth of knowledge available to us at present that readily allows for interdisciplinary merger, as Borofsky recognizes. They did, however, know the direction they wanted us to travel, and it seems we are moving there today.

Contrary to the common perception that holism was a quality of the good-old days, we see interdisciplinary endeavors have actually increased over the past three decades, and are currently at their highest historical frequency.¹¹ Perhaps the more common and true myth is that we cannot live up to the hopes of our heroes, whomever they may be.

Historical inertia continues to hinder theoretical attempts to bridge anthropology's parts. Craniometry and raciology preoccupied biological anthropologists during the 19th and early 20th centuries.¹² Some of these anthropologists had less genuine interest in variation than preconceived motives to build an empirically legitimized typological hierarchy of human advancement based on superficial morphological markers of ethnic affiliation.¹³ Unsurprisingly, social theory of the day was characterized by similar ethnocentric motives to explain why culturally "primitive" peoples lagged linearly behind the "more evolved" races. With the arrival of Darwin's *Origins*, these preexisting trends were further bolstered with biological rationalization. For early anthropologists, the biology-culture distinction was very blurry indeed. As we will see, however, racism is fueled by a theoretical reduction of biology and society to developmental potential believed to be fixed by our blood, not by a supposed conflation of biological with cultural behavior, or even by an open or closet advocacy in the existence of hierarchical organization.

Anthropologists have not been interested solely in the lives of unfamiliar peoples; they have also sought to understand themselves and their immediate neighbors. In the decades preceding World War II, increasing economic and political instability in Europe and North America gave rise to nationalistic attitudes that reinforced the notion of a linear biosocial hierarchy.¹⁴ With hopes of dispelling this racial tension, the father of American anthropology sought to "separate clearly" biological from social problems.¹⁵ Following recognition that a vastly greater amount of variation exists within races than between them, biological anthropologists likewise have since shifted their attention toward describing variability non-hierarchically. However, as with any well-worn distinction, racial constructs are reified through repeated use, including efforts to discredit their validity. We try to mean, "do not stereotype" and "do not discriminate", but appeal to the very in-group/out-group barriers we seek to dissolve. The segregation of sociocultural from biological anthropology marked a break only in the integration of theory, not the theory itself by which we have so long perceived each isolated sphere of humanity to interact along external lines of contact.

I am not arguing that there has been no theoretical union within anthropology. A classic case to the contrary is Livingstone's discussion of how fitness of the sickle-cell genotype has increased where cultivation practices cause conditions conducive to malaria.¹⁶ Moreover, entire sub-disciplines of anthropology, such as archaeobotany, are dedicated to biosocial relations. I am arguing that disciplinary segregation persists in anthropology because "holism" is taken as a passive acceptance of independent social and biological realms of existence, not an active integration with the common overarching label of either.¹⁷ It is for this reason that anthropology departments are held together along a tenuous thread of validity, and almost no elaboration or maintenance of this validity is conducted, or indeed allowed, as doing so would require theoretical integration. So by what rationale should sub-disciplines be joined? Anthropology departments today are often sharply split along bio-social lines, with members of each side espousing opposing world-views.¹⁸ Consequently, it is common that newly created departments avoid lumping social with biological anthropology altogether.¹⁹

Now the assumption that it is possible to isolate the function of sociality from that of biology is incomprehensible, and this problem is wearing heavily on anthropology's already weak interdisciplinary glue. How are people both biological and cultural, yet describable in terms and portions of one or the other? And just how are we to distinguish biological from cultural behavior? If anthropology cannot address these kinds of questions, its sub-disciplines will most likely continue to be assimilated by Darwinism, where the above questions artificially appear sound. Rookie anthropologist Melvin Konner believed sociobiology unassailable, yet unlikely to cannibalize anthropology as sociobiologists predicted, but nonetheless wrote with liquid ink on his vision of a birth of a new paradigm in biological anthropology, a kind of New Physical Anthropology that would provide a "biologically based account of developmental processes in behavior".²⁰ Although Konner saw it desirable to spread explanatory power among the so-called nonbiological disciplines, and correctly pointed out that the only way for anthropologists to argue against biological determinism is to understand biology, his purpose was to reunify disciplinary fragmentation within biological anthropology using the neurotransmitter and hormone as "the behavioral molecule".²¹

In the prologue to a collection of essays aimed at uncovering the conceptual barriers that have divided anthropology within itself, of which Konner's was one, editors E. Adamson Hoebel and Richard

Currier predicted, “skeptical as many social anthropologists (even seasoned physical anthropologists as Washburn) may be, the consensus of conferences is clearly that the anthropological paradigm in forthcoming decades will be predominantly evolutionary and sociobiological”.²² A perusal of any journal database substantiates the editors’ prediction. Paradoxically, although Darwinism appears to be the prime candidate to solve the theoretical divide in anthropology, it is ultimately unable to offer a solution because it is based on the very nature-nurture distinction that has so long been problematic for anthropology.

2. Problems with evolutionary theory

Until recently, the nature-nurture dichotomy has been less problematic for biology than anthropology, because of tremendous advances in the associated “natural” sciences by way of reductionist analyses of micro-level causation (as in medical and nuclear technology). In evolutionary biology, during the early to mid-20th century, the predicted particles of inheritance were discovered, as Mendelian inheritance was tied to the structure of DNA. During the latter half of the 20th century, Darwinian principles were elaborately applied to behavioral characteristics with the development of sociobiology. The result has been a highly integrated theory for the evolved bases of morphology and behavior. Nevertheless, there has been a small but historically deep and now growing unease with this theory.²³

Although we say we know the inherited-acquired dichotomy cannot identify the source of phenotypic traits, we continue to believe it locates information “for” traits within DNA. The language of “inherited traits” is said to be shorthand for speaking of inherited DNA. As outgrowths of Platonic ideas, derived from the Greek verb “to give birth”, and the same root as “genius” and “generation”, genes for traits are now plans, representations, blueprints, or codes for organisms.²⁴

Despite (and because of) the psychological impact of these metaphors, sociocultural anthropologists continue to follow Boas by giving environmentally determined explanations for behavior, while recognizing but minimizing the importance of hereditary characteristics. A problem with this approach, identified by many sociobiologists, is it offers only a sprinkling of proximal description on top of ultimate genetic causation, the basis for the expression of the genotype. Under the seemingly reasonable gene-environment “interactionist” Darwinian model, sociocultural anthropologists cannot compete for causation with

the assumption that an informational genetic basis will express itself, so long as supportive, environmental resources are “environmentally supplied”.²⁵ A point of DST, however, is that because many resources interact during ontogeny, none hold the form of the organism that other resources bring out.²⁶ Ontogenetic form is not a zero-sum commodity, coming more from some places than others. Our “causation” and “interaction” locutions must be reconsidered in the contexts in which they are used.

Heritability is said to indicate the proportion of phenotypic variation that is attributable to genotypic variation. What is usually meant by “attributable to” is “caused by”, so it is important to be precise as to what concept of causation is being employed. In one sense of the word, a number of variables combine to produce a single result. We may use mathematics to describe this process. If a number of equal sized water droplets fill a glass, we may partition the quantitative contribution of its contents into equal sources. This is perhaps the most widely used idea of causation because things, such as animals, are the everyday focus of our attention. Unfortunately, when we inquire into causes of ontogeny, we must most often do away with this use.

A different concept of causation is required for a legitimate understanding of ontogeny, which does not come from places, or become necessitated more or less by genetic or environmental influences, but is constructed through irreducible gene-organism-environment interaction. This interaction is irreducible in that all traits require a body, and that no body develops in the absence of traits, genes, and environments. It is impossible and nonsensical in principle to partition or assign quantitative values to the relative causal importance of equally necessary types of ontogenetic means. This is not to deny the physical impact interactants have on development, but to *emphasize* their co-determining, systemic effects. In terms of outcome, phenotypic traits are caused 100% by the environment, and 100% by genes.²⁷ But does this fact offer an outlet? It appears to insinuate analytic paralysis.²⁸

3. Toward a developmental systems approach to holism

Richard Lewontin perhaps correctly but forcefully argues, “Darwin’s alienation of the outside from the inside was an absolutely essential step in the development of modern biology. Without it, we would still be wallowing in the mire of an obscurantist holism that merged the organic and the inorganic into an unanalyzable whole”.²⁹ The same

may be true of the biology-culture divide in anthropology.³⁰ Lewontin continues that the time has come to reconsider the relation between insides and outsides, but then contradicts himself with unconditional condemnation: “it seems abundantly clear to us now that the holistic view of the world obstructs any possibility of a practical understanding of natural phenomena”.³¹ Richard Dawkins similarly writes: “holistic preaching becomes an easy substitute for thought”.³² Roy Rappaport recalls in a kinder context: “someone once said—it may have been Gregory Bateson—that there are two styles of thinkers in this world, the simple minded and the muddleheaded”.³³

Susan Oyama aims with DST to “adopt a more dynamic, holistic approach to biological processes”, but is more or less ambivalent toward the woolly holism of early systems theory, not wishing to evince a clarity-obscurity boundary.³⁴ Pioneering anthropological systems thinkers were inspired by Leslie White, who described the advancement of cultural systems, distinct from biology, as a consequence of ever-increasing energy capture, ultimately provided by the sun.³⁵ Subsequent thought sought to describe cultural development in a rigidly mechanistic, cybernetic framework of energy flow, input and output, and positive and negative feedback. For example, Conrad Arensberg, an advocate of general systems theory and “interaction theory”, links the idea of holism with systems, but takes holism itself to be synonymous with determinism.³⁶ Of interest here with the systems concept is the openness or roominess it provides for describing ontogeny otherwise construed in internalist terms of genetic programs.³⁷

Most closely in line with DST is Lewontin’s observation that organisms cannot exist without environments as environments cannot exist without organisms.³⁸ Categorically, this is because there is an infinite number of ways an environment may be encircled into a niche, almost all of which would seem arbitrary because no organisms occupy them; more significantly, this is because organisms do not occupy empty holes in the environment, but actively alter and construct their surround.³⁹ Species do not passively adapt to their changing environment, but are actively involved in a reciprocal process of co-construction with it.⁴⁰ The DST shift in metaphor is from selection to construction, and the argument is thus one part critical, and another equally necessary part constructive. The benefit is to highlight the mutually defining and interpenetrating attributes of organism-environment systems, while doing away with the Darwinian analytic barrier between selected and selector, and resulting nonsensical “inherited” characteristics.

In Darwinism, DNA is said to represent inherited characteristics because it is pre-established as the inherited resource. Because only DNA is inherited, it is also the only resource capable of undergoing evolution, and therefore must be something of a Master Molecule for development. How else can we explain the intergenerational predictability and seemingly goal-directed nature of ontogeny?⁴¹ There is another more broadly systematic way, but it requires that we relinquish the notion that traits are transmitted. Developmental resources may be transmitted if they move from one animal (or any other source) to another, but phenotypic traits undergo no such transmission.⁴² Skin color, for example, is caused by an indirect interaction of ultraviolet radiation and genes, as well as a host of other factors, yet there is no sensible reason to think this trait metaphorically preexists itself, in some detached form, in some interactants, inside the genes or inside the sun. The sun persists in a way that “replicating” entities as DNA, cytoplasm, organisms, and linguistic systems do not. Yet the “replication” of these systems is contingent upon the functioning of the entire evolving developmental system, and the relevance of these “replicators”, as with invariant features of the system, is sensitive to the activities of organisms. In terms of origins, resources eventually transmitted to organisms may be constructed through the previous activity of those organisms, through the activities of extragroup organisms, or made available via the environment directly. But these distinctions do not indicate developmental need, interactive contingency, or evolutionary relevance.⁴³ As DNA is necessary but insufficient for development, so “replication” is for evolution. Phylogeny need not be seen as a sea of permutating strobe lights. It is always on.

Far from a genetic expression of pre-specified form, ontogenetic growth is completely dependent upon and saturated with environmental activity. This acknowledgement requires a rejection of the dual-level of existence by which we have so long contrasted ourselves against other animals: whereas humans are seen as both persons with interpersonal subjective relations and biological organisms with ecological needs, all other animals are seen as all organism.⁴⁴ The anthropological consequence of this problem, with the concept of foraging derived from ecology, is that even today hunter-gatherers are widely compared in their life to nonhuman animals in a way that farmers, herdsmen, and urban-dwellers are not.⁴⁵ The error is perpetuated by a taken-for-granted anthropocentric hierarchy of life, with humans placed above and beyond the top: “The story we tell in the West about the

human exploitation and eventual domination of animals is part of a more encompassing story about how humans have risen above, and have sought to bring under control, a world of nature that includes their own animality".⁴⁶ As form is not given to animals from alternate inherited or acquired sources, nor do people live in alternate realms of nature and society. From bipedalism to bike riding, no behavior is more dependent upon genes than environments.⁴⁷

When describing inheritance, careful scientists often speak of inherited variance rather than characteristics. However, with this shift comes misunderstanding that the original objects of study have been substituted with a correlation, not a much-wanted representation or indication of the causal potency genes exert upon these objects. Traits with high heritability coefficients may be quickly and easily altered by simple environmental change. Moreover, genetic (or environmental) variance is not the amount of variation that remains if the environmental (or genetic) variance is removed. Variation in populations cannot be summed up from different causes. Total variance may be *increased* by removing a cause of it, as when genotypes that cause differences in phenotypes in some particular environment less than they do on average over a range of environments are removed from the analysis of phenotypes in that range.⁴⁸ There is an important distinction between causes of states, as in the water glass exemplified above, and causes of differences, implied by correlations, that do not say anything of how development proceeds. Although we are interested in the first type of cause, we are limited to the latter type when using measures of heritability. Although the term "heritability" sounds as though it should refer to variants, it actually refers to variance, a local, relational description of variability derived from all developmentally relevant resources (not only genes) that are passed between particular generations.⁴⁹ This begs the question of what is passed on during evolution in general.⁵⁰

The definition of heredity is tautologically true when reserved for DNA transmission, and it is a very misleading tautology when used to isolate "information for" ontogeny. As with inheritance, information for ontogeny cannot justifiably be limited to DNA. Nor is it stored in some resources, waiting to reveal its form-giving function. Information does not preexist the processes that give rise to it.⁵¹ Normal development is not a selected realization of a finished organism, but a constructive coordination of regularly recurring required resources, none of which single-handedly direct outcome. Whereas the genetic information

metaphor is supposed to explain the regularity of development, it actually presupposes it.⁵² If this metaphor is to be retained, it must be applied symmetrically to all ontogenetic interactants. However, this proposal remains unappealing because it ruins the neat picture of prepackaged inheritance, and remains incoherent for its static and context-independent characteristics.⁵³ (While it may be possible for some purposes to speak of information for skin color as residing inside the sun, this can only make sense when people are found in the context of the sun and because people are already developing in this context.) An outlet that begins to show a path through these problems is to reformulate our concept of heredity to include all those transgenerational resources that recur (passed through the blood, or otherwise made available) and are required for the reliable reconstruction of normal life cycles. Many animals, such as social primates, construct and inherit many resources other than DNA during ontogeny, such as cellular machinery, a maternal reproductive system, conspecifics, parents, and other biotic and abiotic features of the developmental system.⁵⁴ Correspondingly, abnormal development is not error in, or introduced into a genetic plan, but is a result of an unreliable recurrence of such resources. Because the DST argument applies symmetrically to abnormal development, it may be used in this light as an alternate perspective to expose the inherited-acquired problem.

In the anthropological tradition of explanatory pluralism, Janis Hutchinson considers controversial theories for the cause of AIDS.⁵⁵ Peter Duesberg, a molecular biologist at the University of California at Berkeley and member of the National Academy of Sciences, argues that although HIV is correlated with AIDS, it is only a harmless passenger virus, not a cause of AIDS. Duesberg suggests instead that AIDS is caused by a multitude of other immune suppressing factors such as drug abuse, including the drugs that are used to treat AIDS.⁵⁶ Hutchinson acknowledges that Duesberg incorrectly denies a causal relationship between HIV and AIDS, but does not recognize the now familiar aspect of his mistake. Duesberg understands AIDS is only caused by many factors other than HIV, but then falsely concludes that HIV therefore does not cause AIDS. This mistake is no longer as subtle as it appears, and Hutchinson's solution, to describe AIDS as "the pathogenesis of HIV disease" misses the problem.⁵⁷ HIV is transmitted, but AIDS is not acquired. The genetic material of HIV thus does not hold preformed information for AIDS independent of the context in which it develops anymore than do corticosteroids or chemotherapy, both of which cause

immune suppression. This is not to show that these causes are the same, but that multiple developmental pathways, none of which are preformed, may lead to similar outcome.

The argument here is not one of harmony. All organisms consume and thereby destroy the resources required for their own existence. In other words, the conditions that constitute the stable functioning of a system become abolished by that system.⁵⁸ Reciprocally, sometimes conditions that disrupt the functioning of systems may perpetuate them. Holly Wardlow has studied macro-level problems in Papua New Guinea, where AIDS is taught to be a sickness inflicted by God upon immoral people.⁵⁹ The disease has caused a breakdown in familial, subsistence, medical, monetary, economic, and other interrelated institutions. Faced with these conditions, people utilize anything available to regain control, even if that thing is causing damage, knowingly or not. For all the idea of AIDS-as-sin may pull a community together with religious hope, or discourage promiscuity, it causes HIV proliferation through unawareness of transmission routes, and perpetuates propaganda of divine punishment.

The DST critique is not a softhearted attempt to fuzz a cold and selfish nature, red in tooth and claw. Christine Maggiore supports the argument that HIV does not cause AIDS, but is herself HIV-positive, and disturbed by despondency among people with the virus.⁶⁰ Her motivation differs from Duesberg's arrogance in the face of extraordinary social consequence, regardless of how he is wrong. Sometimes the truth is a serious cause for seriously high levels of anxiety, and sometimes we use "serious" interchangeably with "very" and "real". All of us struggle with desire to exist in one way or the other, but scientists are not generally in the business of revealing a difficult to swallow reality.

4. Levels of analysis

The causal "parity" or "symmetry" argument employed here is not that all causes are the same or equal. It is not identity, but consistency with respect to a criterion.⁶¹ (What are the criteria by which we judge resources to be inherited, causal, or informational?). Like boundaries, levels of analysis are functions of our analytic intentions. As parity may be used to reveal faulty use of distinctions, so it may reveal logical inconsistencies between levels. From the micro-morphological to the macro-behavioral and beyond, levels of analysis are not alternative causes of form for the same reasons that boundaries within levels do not

demarcate such causes. Separating these levels is a useful way to reveal analytic incongruities.

The growing organism-in-its-environment is a fluctuating developmental system, and there are sub- and supra-systems nested within and between entities in this system.⁶² This does not mean lower-level parts are subservient to wholes with minds of their own: "Behavior is not booty to be borne off by those who execute or successfully subvert reductive analysis".⁶³ But nor is control to be found as we move down hierarchical levels, or back in time to conception or common ancestors. Ontogeny is not a product of a one-way flow of causality, beginning with DNA, and ending with a finished organism. It may be well for some purposes to begin analysis at the moment of conception, but DNA is not more active than it is reactive. It is not an unmoved mover.⁶⁴ Consequently, it is important not to reduce (or expand) one level into an epiphenomenal result of another level, as for example to engulf or provide defenses for academic territories.⁶⁵

The Darwinian approach to evolution is a form of vulgar functionalism because it collapses the origins of form and function into the latter. Conventionally, although DNA is seen to be the lowest-level and primary giver of form to development, it is actually subservient to a greater formative force, the power of natural selection. As Darwin imagined, the natural selector is an omnipotent agent that gives form to species: "natural selection is daily and hourly scrutinizing, throughout the world, [of] every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good".⁶⁶ Jonathan Weiner concurs that selection is "an agent of creation ... [that] literally organizes life".⁶⁷ Whereas the selector is a kind of imaginary entity that creates biological form, DNA is the immediately physical incarnation of this creation. Although DNA is said to constrain ontogeny, it must ultimately bow to selection, which first and foremost constrains the evolution of DNA, where introns, repetitive elements, pericentromeric and AT-rich regions are permitted to evolve, while more functional components of the genome are preserved.

Conventionally, although characteristics are said to be adapted, we actually cannot ask how or why they evolved (though in practice, we do anyway) because individuals, the very context in which characteristics exist, do not evolve, but develop. Evolution, then, is an abstract, intergenerational, population based concept, and as it (change) is supposed to occur by selection (preservation), it is a very abstract concept indeed. In DST, hierarchies are utilized without drawing function from

an abstract source that enters reality through a pinhole, injected into DNA at the lowest level, to eventually dissipate throughout higher levels. Consider the problem that arises as we move to the protein level. Again, the rate of evolution is constrained by selection, though at this level there may or may not be a shift in supposed causal interface from imaginary-real to real-real, with constrained DNA now constraining the evolution of proteins, as is ambiguous in humans where histones evolve a thousand times more slowly than apolipoproteins. This vision of functional constraint, as originating with selection, and radiating hierarchically upward through DNA becomes increasingly dubious at higher levels. The nervous system in some species of mammals has evolved faster than other (digestive, reproductive) systems, but it does not make sense to say one is more functional than another. Similarly, interspecies comparisons show some species evolve faster than others, as chimpanzees have to humans, but again we would not single-out one species as most functional.

Natural selection is an abstraction that cannot deal with concreteness of reality. Rather than adhering to an *ad hoc* claim that individuals between species, and systems within individuals, cannot define function because they do not compete for funnels into imaginary slots in existence, as with alleles and corresponding phenotypic variants, our observations may be quickly reframed with a construction metaphor, whereby differing rates of evolution at multiple levels are explicable by what might be termed “directional” or “evolutionary” constraints. The shape of single-celled organisms evolves slowly because of surface tension constraints. The V-shape configuration of migratory birds may evolve slowly because of aerodynamic constraints. The structure of human interaction has evolved swiftly and independently at multiple locations across the globe from 10,000 years ago into the present because multiplying varieties of mutually accelerating constraints have rapidly emerged in human populations during this timeframe.⁶⁸ Simple to complex constraints of change are not functions “endogenous” to interactants that exert or determine, or partially determine form, but are functional *and formal* relations between interactants. Oyama cautions, “The claim that the genes circumscribe potential reminds me of a ploy used by the powerful when they realize that power must be shared, if only minimally: Delimit the scope of choice, then let the other party choose within fixed, non-negotiable boundaries”.⁶⁹ Developmental and evolutionary possibilities are probabilistic relationships contingent upon the history of the developmental system.

Russell Gray and Paul Griffiths put forth the suggestion that the entire developmental system is the unit of evolution.⁷⁰ They elaborate the idea, and locate the organism-niche system as the object of selection by an exceedingly distant external environment.⁷¹ In agreement with this view, Oyama argues that evolution occurs through a process of “reciprocal selection” between organisms and environments.⁷² Similarly, Kevin Laland et al. state that niche construction is a bidirectional selective process that involves the “selection” of habitats.⁷³ But these contortions of “selection” do not capture the meaning of the term, which has always been to isolate and preserve that which is formative.⁷⁴ Gray argues that it is not entities, such as genes, that are important for selection, but relations between entities in a niche, as for example those between the heterogeneous human genotype and an environmental presence of malaria.⁷⁵ However, reframing the problem in terms of relations does not move the metaphor in this case. It is said nature is blind to development and selects for outcomes,⁷⁶ but this only makes sense insofar as there is something inside animals that codes for their characteristics. This is what makes the selection metaphor evolutionarily meaningful. This is why selection is said to act most fundamentally at the gene-level. If no form-giving entity is in charge of the system, what explanation is to be gained by “selecting” it by anything? A wholehearted elaboration of the “construction”⁷⁷ metaphor is needed, whereby evolutionary trajectory cannot be predicted or explained without specifying the activities of organisms. Questions of evolutionary process are not necessarily orthogonal to those of development. For both short- and long-term problems, it may be appropriate to ask, “How is it constructed?” rather than, “Where does it come from?”

5. Systems of constraints

Increases in molecular complexity in the universe were underway long before the existence of life, and life on Earth existed long before drastic increases in living complexity. This implies that evolution may not be the result of a single, “silver bullet”, selective process. In addition, the convention of identifying evolving entities with high copying fidelity and fecundity is inadequate for understanding the accumulation of complexity by processes that entail more than replication. Evolution is thus more accurately understood not as the product of a singular process of

differential reproduction, but as a diverse array of interactive processes that constrain the direction of the developmental system.

Broadly considered, science is a study of limitations. When constraints are considered in an evolutionary context, however, they are regarded as limits upon selection, not inherently constitutive of genuine evolutionary parameters. Dawkins, for example, identifies allometric, temporal, historical, pleiotropic and genetic constraints upon the selectable material of variability.⁷⁸ Although he does point out, albeit with nauseating fervor, that historical constraints upon the efficiency in design of novel evolutionary inventions refute Creation, and as such are aptly served to “thrust down the throat of religious fundamentalists”, these limits are otherwise only seen to take on significance in the service of selection.⁷⁹ A move is needed that will pull the value of evolutionary constraints in line with what science shows us.

In biological anthropology, investigations into the ecological constraints of social organization have stimulated research over the past thirty years. The theme of the theory motivating this work is that social organization is constrained by ecological conditions. As a simple example, because food is a limited resource, increases in primate group size cause increases in rates of food depletion. Therefore, daily travel distance and home range size of social primates should increase with group size in order to sustain the dietary needs of the group.⁸⁰ This prediction has been consistently substantiated among frugivorous primates that feed on unevenly distributed patches of high-energy food. It has also been found to hold true among some folivores such as red colobus, Thomas’s langurs, northern muriquis, and Biwindi mountain gorillas.⁸¹ Conversely, other studies have found no relation between group size and daily travel distance or home range size, and raise the question as to what other variables require consideration in this context. Rainfall, for example, may simultaneously increase travel by increasing fruit availability and population size, but may decrease it by inhibiting thermoregulation.⁸²

Ecological constraints are understood as Darwinian tradeoffs between costs and benefits. Group fission is said to occur when the price of travel is not repaid by increased energy obtained by individuals.⁸³ However, because many constraints apply to groups, there is no need to reduce them to selfish strategy. Moreover, competition is only one such constraint. The upper size limit of a group is constrained by feeding competition. Conversely, lower limits may be constrained, and change with time, as predation risk increases. Multiple constraints, such as

social and sexual factors, operate in concert with other constraints, such as competition, to limit group size. Chimpanzee groups become larger when females are in estrus. Black-and-white colobus form groups smaller than red colobus, despite sympatric coexistence and similar diets between these species, possibly because of limits relating to male-male aggression.⁸⁴ Finally, constraints may emerge between species during co-evolution. Daniel Brooks and Amanda Ferrao argue that parasite-host switches between primate species are constrained by evolutionarily retained resource requirements, and that most switches have been associated with the opened options that occur during speciation and biotic expansion.⁸⁵

“Evolutionary constraints” is not another term for “selection pressures”. If constraints both internal and external to organisms are the material of evolutionary process, it is not necessary to divide them into competing categories of inherited and acquired impact, or to relate them to a prime-mover mechanism of selection. As an analogy to directional change, consider a neutrally buoyant balloon of water submerged 10 meters below sea level. If a current were to softly push the balloon in a direction, friction with the surrounding water would eventually slow the balloon’s trajectory. However, if the balloon contained air rather than water, and was weighted so as to maintain neutral buoyancy at its given depth, then a gentle current pushing the balloon to a greater depth would result in an accelerated descent, as air within the balloon compressed under pressure, causing the balloon to weigh more than the increasingly small amount of water that it displaced. Likewise, a balloon nudged toward the surface would enter an accelerated ascent, as it quickly expanded, causing it to weigh less than the increasingly large quantity of water it displaced. The balloon may reach a plateau at the ocean surface, unless it contained helium, rather than air, and its weights broke free during expansion, in which case the balloon might continue its ascent into the atmosphere. The point of this metaphor is that “external pressures” may be seen as integral and even initiative of change without being singularly directive. Relations that maintain buoyancy are the mutually determining conditions that allow movement of the balloon, by whatever variety of possible mechanisms, to cause its own acceleration. As discussed above, a definitively biological example of this phenomenon is how the increased travel distance of a primate species allows food consumption and population size to increase, which itself causes further increases in the travel distance needed to sustain that population throughout increased localized food depletion.

Evolution may occur when even slight irregularity emerges between any constraints of the developmental system that accelerates change in its own or another direction. Conversely, most random fluctuations within the system, including those between differential reproduction and genetic mutation, will even-out across generations, and have no effect on evolution. This view accords more closely with observation than the Darwinian concept of continual adaptation. Whereas Darwinism cannot explain how a highly complex species may be regularly reconstructed, more or less without organized change over the span of 100 million years, and under conditions of continually emerging competition and novel variation, this kind of observation is expected by a “systems of constraints” perspective, whenever relations between the array of constraints that maintain stability of a system do not break thresholds of direction. Once established, accelerated trajectory may open other directions both within and between otherwise stable species. A task for the future will be to clarify how intergenerational constraints in organism-environment systems are interrelated, and how slippery slopes of accelerated change in one domain of a system may cause the same in other domains. Much current research, as the type cited above, has already come a great distance in this direction.

6. We find what we study

Frequently in science, answers are discovered to different questions than the ones originally posed. And yet beliefs also persist with great inertia long after their initial justification has been rejected.⁸⁶ As with the idea of a genetic basis to heredity, the result is a lingering feeling of hidden truth that may be inferred indirectly: “one talks around it, looks just to the side of it, as at a dim star, or tries to define it by chipping away at what it is not, in the hope that its latent outline will be revealed”.⁸⁷ Even so, there is usually some reality to false beliefs, though it is not necessarily centered on a continuum. Sometimes metaphors are incoherently mixed, or not mixed when they could be. Although addressing the DST problem indirectly, saying what it is not, appears to waste time, I have learned it is helpful when attempting to fix well-worn paths without being trampled.⁸⁸ In a field where relativism and racism has wreaked havoc, I am less happy than Oyama to celebrate ambiguity, or to push without caution for “extended inheritance”.⁸⁹ New ideas are easily warped into old contexts.

Dichotomous thought is manifestly unavoidable by social scientists. Oyama finds, “one of the legacies of the nature-nurture dichotomy is that anyone criticizing one of the opposing positions will be seen as advocating the other”.⁹⁰ Multiple causes reinforce this problem. Attempts to break down distinctions (including barriers between sub-disciplines) must employ and reify them. Our mixed ideas of causation confuse dichotomously structured causes of differences with multiply contingent causes of states. As professionals become increasingly specialized, inter-domain (and -individual) knowledge disparity is underestimated and confused with ontological importance. We have an ego- and ethno-centric tendency to take our own knowledge as paramount. Intellectual contests spur the use of increasingly competitive either/or language. Yet these errors only hint at the active desire scientists have for opposition, and the opportunities for competition and cooperation it affords.

The sociology of science shows that participants in scientific institutions seek to legitimize their economic and existential positions by emphasizing the causal efficacy of their objects (or subjects) of study. When oppositions to the oppositions come forward, new oppositions are formed in the stuff with which careers are made. Oyama asks with respect to Symons’ (1987) essay *If we’re all Darwinians, what’s the fuss about?* “if we’re all interactionists, again, why the fuss?” and answers, “the fuss arises (and sometimes doesn’t arise when it should) because we haven’t figured out what either requires, much less how to be both at the same time.”⁹¹ But if we were all DSTers, what then would the fuss be about? To an untrained eye, Oyama’s claim to end the nature-nurture haggle itself would sound more like a ploy used by the powerful to quash uprisings of the underprivileged: delimit the scope of options for an out-group by reversing the definition of a crime for the good (in the name) of an in-group. But this would miss the point of DST altogether, which is precisely to understand the context specificity of causation, to elucidate how control is dialectically constructed between previously overlooked interactants, to attend to how distinctions are used in practice, and to dismantle just the kind of unprincipled artificial barriers designed to privilege a subset of interactants as most necessary for the normal functioning of systems.

There is more at stake with genetic just-so stories than verisimilitude. The racist errors committed by early anthropologists were not the negative product of unappreciated variability, nor is racism in general caused by a conflation of so-called biological with cultural behavior, as

the Boasian school imagined. It is fueled by a theoretical conviction that traits are inherited, and the corresponding conclusion that all significant differences between people are attributable to differences in our blood, now DNA. Racism, and other oppression, is about reducing options for one group of people, while increasing them for another, through limiting access to resources by way of institutionalized segregation, and making the boundaries between those groups appear indisputably clear-cut. In short, it is about control. By shifting our attention to the diverse array of otherwise “background” or “supportive” factors in development, we may refocus our research on our original biological, social, anthropological objects of interest, organisms, and ask not what is inside our genes, but what our genes are inside—the developmental system.⁹² Exclusive investigations into DNA as the substance of heredity have bolstered the notion of genetic “bases” with a massive amount of empirical data. Although the DST argument is not “things are more complex than that”, this can be an important observation, as theory is cause for selective attention.

The developmental systems approach to holism does not paralyze analysis or insist upon an unmanageably broad consideration of information. It is still acceptable to focus on specific variables of interest by holding others constant, though the conclusions drawn from resulting correlations may need to be evaluated with innovative caution. An important distinction is to be drawn between theoretical elaboration, as the type conducted here, and practical implication, as along the avenue of evolutionary constraints outlined above, which is a subject for future application.

7. Conclusion

As we enter the new millennium with unparalleled opportunity for interdisciplinary communication, we should not foresee the future of anthropology as stemming, in a preformed fashion, from roots of texts, predictable from great authors “alone”, but as a growth in which today’s scientists, and all with which they interact, will be irreducible stakeholders. With the large critical portion of this essay, I am not attempting to throw grandfathers of evolutionary biology out with the bathwater, or to take any past scientists out of their time. It certainly took a remarkable leap for ancient peoples to view the Sun as a God, a great prime mover of life. For those people, their star must have

represented a lot indeed. Though Darwinism has been a rich framework for understanding evolution, it inevitably leads to the myopic view that DNA is “the center of a web of radiating power”.⁹³ Dawkins began his adaptation of selection to behavior by identifying knowledge of biological evolution as the hallmark of an intelligent group of animals, then explained it, and elevated *The Selfish Gene* to a foundation of science.⁹⁴ Certainly, it is a mistake to collapse the complexity of science into a God-like principle of process. Nevertheless, more helpful than calling selfish genes “unbiological rubbish”, and then scolding the scientific community for taking them seriously,⁹⁵ is recognition that the idea of self-perpetuation is older than atheism (any animal that understands any thing understands it), not new, emotional, pretentious, or controversial.

DST is neither a new paradigm nor a linear outgrowth from existing theory, but an incorporation of logic for avoiding preformationism, and for pulling together research already developing in this direction. It aims not to answer previously unanswerable questions, but to ask questions in contexts previously unasked. Oyama assures that DST does not require Darwinism to be discarded. My feeling, however, is that it is insufficient to give Darwinian orthodoxy the shake it requires only to collect the free change that falls out. The construction metaphor of inheritance is fundamentally at odds with selection, which has always been meant to isolate and preserve that which is formative. When put to practice, the anthropologist’s holistic disposition provides a means to clarify this problem. The biology-culture divide is not to be unequivocally erased, but re-questioned and embraced, as the (any) organism-in-its-environment is an inescapable condition of being. Darwin did not take the first steps in evolutionary theory. People have been and will be growing together for a very long time.⁹⁶

Acknowledgments

I am most deeply indebted to Susan Oyama for a critique of this essay and for more than two decades worth of critical writing. I am also very grateful for helpful feedback provided by Michael Schillaci and Emily Birky. Funding was made available through a Canada Graduate Scholarship from SSHRC and a graduate fellowship from the University of Toronto.

Notes

¹ Gordon Willey and Philip Phillips, *Method and Theory in Archaeology* (Chicago: University of Chicago Press, 1958), 2; Lewis Binford, "Archaeology as Anthropology," *American Antiquity* 28 (1962): 217–225, 217.

² Tim Ingold, "From Complementarity to Obviation: On Dissolving the Boundaries Between Social and Biological Anthropology, Archaeology, and Psychology," in Susan Oyama, Paul Griffiths, and Russell Gray, eds., *Cycles of Contingency* (1996; repr. 2001), 255–280; Ingold, *The Perception of the Environment: Essays on Livelihood, Dwelling, and Skill* (London: Routledge, 2000); Ingold, "Beyond Biology and Culture: the Meaning of Evolution in a Relational World," *Social Anthropology* 12 (2004): 209–221.

³ James Lovelock, *The Ages of Gaia: A Biography of Our Living Earth* (New York: Norton, 1988).

⁴ Chia Longman, "Empowering and Engendering 'Religion'. A Critical Perspective on Ethnographic Holism," *Social Anthropology* 10 (2002): 239–248; Garry Ferraro, *Cultural Anthropology: An Applied Perspective* (Belmont, CA: West/Wadsworth, 1998); Robert Netting, "The Ecological Perspective: Holism and Scholasticism in Anthropology," in E. Adamson Hoebel, Richard Currier, and Susan Kaiser, eds., *Crisis in Anthropology: View from Spring Hill, 1980* (New York: Garland, 1982), 271–292; Robert Thornton, "The Rhetoric of Ethnographic Holism," *Cultural Anthropology* 3 (1988): 285–303.

⁵ William Haviland, *Anthropology*, 8th edn (Orlando: Harcourt Brace & Company, 1997).

⁶ Another sense of holism, as for example offered by Cor Van der Weele, *Images of Development: Environmental Causes in Ontogeny* (Albany: State University of New York Press, 1999).

⁷ Roy Rappaport, "Humanity's Evolution and Anthropology's Future," in Robert Borofsky, ed., *Assessing Cultural Anthropology* (New York: McGraw-Hill, 1994), 153–166; Walter Goldschmidt, *The Bridge to Humanity: How Affect Hunger Trumps the Selfish Gene* (New York: Oxford UP, 2006).

⁸ Connie Anderson, "Neandertal Pelves and Gestation Length: Hypotheses and Holism in Biological Anthropology," *American Anthropologist* 91 (1989): 327–340.

⁹ *Ibid.*, 336; for a related discussion, see also Rappaport, "Humanity's Evolution".

¹⁰ Robert Borofsky, "The Four Subfields: Anthropologists as Mythmakers," *American Anthropologist* 104 (2002): 463–480.

¹¹ *Ibid.*

¹² Ingold, "From Complementarity to Obviation".

¹³ Stephen Gould, *The Mismeasure of Man* (New York: Norton, 1981).

¹⁴ Bruce Trigger, *A History of Archaeological Thought* (Cambridge: Cambridge University Press, 1989).

¹⁵ Franz Boas, *Race, Language, and Culture* (New York: Free Press, 1940), 3.

¹⁶ Frank Livingstone, "Anthropological Implications of Sickle Cell Gene Distribution in West Africa," *American Anthropologist* 60 (1958): 533–562.

¹⁷ But see Conrad Arensberg, "Cultural Holism Through Interactional Systems," *American Anthropologist* 83 (1981): 562–581.

¹⁸ Ingold, "From Complementarity to Obviation".

¹⁹ Goldschmidt, *The Bridge to Humanity*.

²⁰ Melvin Konner, "Human Behavioral Biology: Preparations for the Birth of a Paradigm in Anthropology," in E. Adamson Hoebel, Richard Currier, and Susan Kaiser, eds., *Crisis in Anthropology: View from Spring Hill, 1980* (New York: Garland, 1982), 333–359, 341.

²¹ *Ibid.*, 348.

²² E. Adamson Hoebel and Richard Currier, "The Spring Hill Conference—Genesis and Concept," in *Crisis in Anthropology*, xiii–xxi, xix.

²³ Timothy Johnston, "Toward a Systems View of Development: An Appraisal of Lehrman's Critique of Lorenz," in *Cycles of Contingency*, 15–23.

²⁴ Jonathan Weiner, *Beak of the Finch: A Story of Evolution in Our Time* (New York: Alfred, 1995).

²⁵ John Alcock, *The Triumph of Sociobiology* (Cambridge, MA: Oxford University Press, 2001), 43.

²⁶ Oyama, Griffiths, and Gray, "Introduction: What is Developmental Systems Theory?"

²⁷ Susan Oyama, *Evolution's Eye: A Systems View of the Biology-Culture Divide* (Durham, NC: Duke University Press, 2000).

²⁸ Van der Weele, *Images of Development*.

²⁹ Richard Lewontin, *The Triple Helix: Gene, Organism, and Environment* (Cambridge, MA: Harvard University Press, 2000), 47.

³⁰ Rappaport, "Humanity's Evolution".

³¹ Lewontin, *The Triple Helix*, 72.

³² Richard Dawkins, *The Extended Phenotype: The Gene as the Unit of Selection*, 2nd edn (San Francisco: Freeman, 1999), 113.

³³ Rappaport, "Humanity's Evolution," 153.

³⁴ Oyama, *Evolution's Eye*, 77.

³⁵ Leslie White, "Energy and the Evolution of Culture," *American Anthropologist* 45 (1943): 335–356.

³⁶ Arensberg, "Cultural Holism".

³⁷ Susan Oyama, "Terms in Tension: What Do You Do When All the Good Words Are Taken?," in *Cycles of Contingency*, 177–194.

³⁸ Lewontin, *The Triple Helix*.

³⁹ Richard Lewontin, "Gene, Organism, and Environment," in *Cycles of Contingency* (1983; repr. 2001), 59–66.

⁴⁰ Kevin Laland, F. John Odling-Smee, and Marcus Feldman, "Niche Construction, Ecological Inheritance, and Cycles of Contingency in Evolution," in *Cycles of Contingency*, 117–126; Eytan Avital and Eva Jablonka, *Animal Traditions: Behavioral Inheritance in Evolution* (New York: Cambridge University Press, 2000).

⁴¹ Oyama, *Evolution's Eye*.

⁴² Susan Oyama, "Locating Development: Locating Developmental Systems," in Ellin Scholnick, Katherine Nelson, Susan Gelman, and Patricia Miller, eds., *Conceptual Development: Piaget's Legacy* (New Jersey: Lawrence Erlbaum, 1998), 185–208.

⁴³ Paul Griffiths and Russell Gray, "Developmental Systems and Evolutionary Explanation," *Journal of Philosophy* 12 (1994): 471–492.

⁴⁴ Ingold, *The Perception of the Environment*.

⁴⁵ *Ibid.*

⁴⁶ *Ibid.*, 87.

⁴⁷ *Ibid.*

⁴⁸ Richard Lewontin, "The Analysis of Variance and the Analysis of Causes," *American Journal of Human Genetics* 26 (1974): 400–411.

⁴⁹ Susan Oyama, *The Ontogeny of Information: Developmental Systems and Evolution*, 2nd ed. (Durham, NC: Duke University Press, 2000).

⁵⁰ *Ibid.*

⁵¹ *Ibid.*

⁵² Oyama, *Evolution's Eye*.

⁵³ Patrick Bateson, "Behavioral Development and Darwinian Evolution," in *Cycles of Contingency*, 147–166.

⁵⁴ Oyama, *Evolution's Eye*.

⁵⁵ Janis Hutchinson, "The Biology and Evolution of HIV," *Annual Review of Anthropology* 30 (2001): 85–109.

⁵⁶ Peter Duesberg, "Infectious AIDS—Stretching the Germ Theory Beyond its Limits," *International Archives of Allergy and Immunology* 103 (1994): 118–127.

⁵⁷ Hutchinson, "The Biology and Evolution of HIV," 85.

⁵⁸ Lewontin, *The Triple Helix*.

⁵⁹ Holly Wardlow, "You Have to Understand: Some of Us Are Glad AIDS Has Arrived: Christianity and Condoms Among the Huli of Papua New Guinea" (working paper).

⁶⁰ Christine Maggiore, *What if Everything You Thought You Knew about AIDS was Wrong?* 4th edn (Studio City, CA: American Foundation for AIDS Alternatives, 1999).

⁶¹ Susan Oyama, "Causal Democracy and Causal Contributions in Developmental Systems Theory," *Philosophy of Science* (Supplement) 67 (2000): S332–S347.

⁶² The inherited-constructed distinction maps roughly onto the entity-system distinction used here. Systems may be alternatively simplified as entities if they are functionally coherent and/or transport spatially as aggregate wholes. It may be useful to shift between these perspectives, depending on the focus of the investigator.

⁶³ Oyama, *The Ontogeny of Information*, 166.

⁶⁴ *Ibid.*

⁶⁵ *Ibid.*

⁶⁶ Charles Darwin, *On the Origin of Species: A Facsimile of the First Edition with an Introduction by Ernst Mayr* (1859; repr., Cambridge, MA: Harvard University Press, 1966), 84.

⁶⁷ Weiner, *Beak of the Finch*, 143.

⁶⁸ For a discussion of human evolution in light of DST, see Agustin Fuentes, "It's not All Sex and Violence: Integrated Anthropology and the Role of Cooperation and Social Complexity in Human Evolution," *American Anthropologist* 106 (2004): 710–718.

⁶⁹ Oyama, *Evolution's Eye*, 56.

⁷⁰ Russell Gray, "Death of the Gene: Developmental Systems Strike Back," in Paul Griffiths, ed., *Trees of Life: Essays in Philosophy of Biology* (Dordrecht: Kluwer, 1992), 165–210; Paul Griffiths, "Introduction," in Paul Griffiths, ed., *Trees of Life: Essays in Philosophy of Biology* (Dordrecht: Kluwer, 1992), 1–13.

⁷¹ Griffiths and Gray, "Developmental Systems and Evolutionary Explanation"; Paul Griffiths and Russell Gray, "Darwinism and Developmental Systems," in *Cycles of Contingency: Developmental Systems and Evolution* (Cambridge, MA: MIT Press, 2001), 195–218.

- ⁷² Oyama, "Locating development," 193.
- ⁷³ Laland et al., "Niche Construction," 120.
- ⁷⁴ Sean Blanchard, "Transfer Appropriate Processing as a Principle of Being, not Memory: A History of the Memory-Inheritance Parallelism" (working paper).
- ⁷⁵ Gray, "Death of the Gene".
- ⁷⁶ Oyama, *The Ontogeny of Information*.
- ⁷⁷ Lewontin, "Gene, Organism, and Environment"; Richard Levins and Richard Lewontin, *The Dialectical Biologist* (Cambridge, MA: Harvard University Press, 1985).
- ⁷⁸ Dawkins, *The Extended Phenotype*.
- ⁷⁹ Ibid, 39.
- ⁸⁰ Stuart Altmann, "Baboons, Space, Time, and Energy," *American Zoologist* 14 (1974): 221–248.
- ⁸¹ Jessica Ganas and Martha Robbins, "Ranging Behavior of the Mountain Gorillas (*Gorilla beringei beringei*) in Bwindi Impenetrable National Park, Uganda: A Test of the Ecological Constraints Model," *Behavioral Ecology and Sociobiology* 58 (2005): 277–288.
- ⁸² Ibid.
- ⁸³ Colin Chapman and Mary Pavelka, "Group Size in Folivorous Primates: Ecological Constraints and the Possible Influence of Social Factors," *Primates* 46 (2005): 1–9.
- ⁸⁴ Ibid.
- ⁸⁵ Daniel Brooks and Amanda Ferrao, "The Historical Biogeography of Co-Evolution: Emerging Infectious Diseases are Evolutionary Accidents Waiting to Happen," *Journal of Biogeography* 32 (2005): 1291–1299.
- ⁸⁶ Trigger, *A History of Archaeological Thought*.
- ⁸⁷ Oyama, *The Ontogeny of Information*, 109.
- ⁸⁸ Unaccounted ridicule runs rampant in academia. Shame on it! That competition is "in our face" is no excuse for closed-mindedness.
- ⁸⁹ Oyama, *Evolution's Eye*.
- ⁹⁰ Ibid, 154.
- ⁹¹ Oyama, *The Ontogeny of Information*, 5, citing Donald Symons, "If We're All Darwinians, What's the Fuss About?" in Charles Crawford, Martin Smith, and Dennis Krebs, eds., *Sociobiology and Psychology* (Hillsdale, NJ: Erlbaum, 1987), 121–146.
- ⁹² Oyama, *Evolution's Eye*.
- ⁹³ Dawkins, *The Extended Phenotype*, viii.
- ⁹⁴ Richard Dawkins, *The Selfish Gene*, 2nd edn (Oxford: Oxford University Press, 1989).
- ⁹⁵ Lewontin, "Gene, Organism, and Environment," 61.
- ⁹⁶ Unfortunately, the above notes refer mainly to the already most advertised scholars in their respective circles. This is not done primarily out of an appeal to authority, but is a limitation of my readings.