WHAT CAN PIAGET OFFER LONERGAN'S PHILOSOPHY OF BIOLOGY?

by Chris Friel

Abstract. In *Insight*, Bernard Lonergan provides, albeit schematically, a unique philosophy of biology which he takes as having "profound differences" with the world view presented by Darwin. These turn on Lonergan's idea of "schemes of recurrence" and of organisms as "solutions to the problem of living in an environment." His lapidary prose requires some deciphering. I present the broad lines of his philosophy of biology and argue that Jean Piaget's structuralism can shed light on Lonergan's intentions in virtue of his use of cybernetics and the isomorphism between biology and knowledge. In turn, Piaget draws on Waddington's restatement of epigenesis and I suggest that the result, "process structuralism," is a viable alternative to the modern Darwinian synthesis.

Keywords: Darwinism; emergence; epigenesis; Jean Baptiste Lamarck; Bernard J. F. Lonergan; philosophy of biology; Jean Piaget; process structuralism; Conrad Waddington

What Can Piaget Offer Lonergan's Philosophy of Biology?

The first assumption behind the question is that Bernard Lonergan did indeed have a philosophy of biology, an assumption as surprising to some, perhaps, as the preaching of the Apostle Paul was to the Ephesians who responded: We did not even know there was a Holy Spirit! (Acts 19:2). Still, I think the claim can be defended. Having outlined a general context for the philosophy of science that provides an alternative to positivism, Lonergan goes on, in two brief chapters of *Insight* ([1957]1992), to tackle ideas pertaining (not exclusively) to botany and zoology—Lonergan refers to this as "genetic method." Thus, he sketches a body of ideas that touch on a score of significant issues, clarifying notions such as development,

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for example, with a view to shedding light on theological anthropology. I believe that this constitutes a unique and interesting project worthy of further research, the broad outlines of which I will sketch below. Lonergan is building upon a worldview he calls "emergent probability" developed in the first four chapters of *Insight*. Emergent probability is "parallel in its formal structures" to the Darwinian world view (it involves statistical explanation) but Lonergan tersely explains that there are "profound differences" connected with the idea of "schemes of recurrence." A further difference arises in Lonergan's intellectualist notion of the organism as a "solution to the problem of living in an environment." The point is obviously significant for Lonergan but his explanation appears slightly obscure and in need of closer examination.

The second assumption behind my question, then, is that Lonergan's ideas *can* benefit from the thought of Jean Piaget (who in turn draws on Conrad Waddington). Where Lonergan speaks of schemes of recurrence Piaget provides more detail by drawing on the idea of cybernetic feedback loops, and where Lonergan speaks of explanatory species as solutions to problems Piaget develops at some length an isomorphism between biology and knowledge. My suggestion is that an exploration of Piaget's research proposal offers a helpful way of bringing Lonergan's neglected voice into the conversation.

To this end I will list the main points of what I take to be a Lonerganian philosophy of biology. I will then make some brief remarks on Lonergan's reception of Piaget, whom Lonergan cited from 1959 onwards. I will then consider Piaget's structuralism, taken from a work Lonergan recommended. This will introduce the isomorphism between biology and knowledge, just alluded to, that Piaget pursues in *Biology and Knowledge* ([1967]1971). I shall draw on this work so as to elaborate some difficult texts in which Lonergan critiques Darwinian thought. Finally, I will try and situate a Lonerganian research program ("process structuralism") in the contemporary landscape.

Lonergan's Philosophy of Biology

Lonergan, of course, was a theologian who devoted much effort to the question of method. He was not a specialist, and never *fully* developed his "philosophy of biology," a new discipline that was emerging in the decades after Lonergan completed *Insight* around 1953. He could perhaps be thought of as attempting to formulate a new paradigm, to use Thomas Kuhn's phrase, leaving to others working in "normal science" the job of mopping up. Or again, it could be claimed (to employ terms that Lonergan used to describe his own theological method) that Lonergan offers a *model* for philosophy of biology:

> In general, what we shall have to say is to be taken as a model. By a model is not meant something to be copied or imitated. By a model is not meant a

> description of reality or a hypothesis about reality. It is simply an intelligible, interlocking set of terms and relations that it may be well to have about when it comes to describing reality or to forming hypotheses. As the proverb, so the model is something worth keeping in mind when one confronts a situation or tackles a job. (Lonergan 1972, xii)

That is, Lonergan thought it important to direct our attention to certain key issues in biology, the idea particularly worth keeping in mind being that of *development*.

Lonergan went on to make a stronger claim about his theological method: "However, I do not think I am offering merely models." This, too, seems applicable to Lonergan's biology, because, as he darkly suggested, development has been "peculiarly subject to the distorting influence of counter-positions" (Lonergan [1957]1992, 476). Lonergan does not elaborate, but it seems fair to think that he had in mind, if not Darwin himself, notions "associated with the name of Darwin" (Lonergan [1957]1992, 290). Presumably, the "interlocking set of terms and relations" that Lonergan offers in *Insight*—these are later termed "general categories"—are designed to critique this counter-position.

Turning to this philosophy of biology, a score of issues are addressed. Here it might be worth offering a list, partly to indicate that Lonergan's project was reasonably comprehensive, and partly to help situate the more specific contribution attempted in this essay. Lonergan, then:

1. formulates a body of ideas (cognitional theory) that includes the notions of the "pure desire to know," direct and inverse insight, implicit definition, higher viewpoints, and the empirical residue;
2. draws on cognitional theory to give an account of explanation as relating things in themselves (as opposed to description, which relates things as they are to us);
3. uses his cognitional theory to ground a unique philosophy of probability that is related to the types of questions identified by Aristotle (what is it? is it so?) and so distinguish probability from chance;
4. develops a notion of real randomness in terms of the lack of intelligibility in concrete processes;
5. draws on a notion of statistics as objective and empirically grounded so as to critique mechanistic determinism;
6. argues for the complementarity of classical and statistical laws so as to provide methodological foundations for an evolutionary perspective that finds its *explandum* in biogeographical diversity;
7. introduces the idea of "schemes of recurrence" as the units of an evolutionary world view named "emergent probability" that makes use of classical and statistical explanation;

8. generalizes such a worldview to include "things" (roughly, Aristotelian substantial forms) and in particular, living things characterized by "flexible circles of ranges of schemes" in a manner that observes canons of scientific parsimony;
9. addresses problems relating to the "tautology" of the "survival of the fittest" by speaking of the probability of the emergence and survival of schemes;
10. gives an intellectualist account of organisms as solving problems of living;
11. understands such problem solving dynamically as an ongoing series of problems are solved (for example, in an environment increasingly populated by threats and opportunities);
12. extends to biology the idea of "conjugate forms" (laws such as $\mathbf{F} = m\mathbf{a}$ connect terms that are implicitly defined) so that the nexus between structure and function is intelligently grasped;
13. uses this notion to sketch the idea of an explanatory account of genera and species;
14. urges that the distinctive tasks of the biologist must include ethology (animal psychology);
15. formulates the idea of an "integrator" as a systematic set of conjugates;
16. formulates the idea of an "operator" to explain the emergence of new conjugates in biological development;
17. proceeds to give a general account of development that can coherently embrace both ontogeny and phylogeny;
18. formulates the concept of "genetic method" for understanding development analogous to the use of mathematics deployed by classical physics;
19. uses his account of the act of insight to provide an analogue for the phenomenon of emergence;
20. uses his account of "symbolic images" (as heuristic rather than representative) to offer an alternative to logical empiricist accounts of reduction;
21. uses his account of "higher viewpoints" (roughly, intellectual developments that shift paradigms) to unify science in a manner that steers a middle course between positivism and pluralism;
22. argues for finality in the universe based on an understanding of increasing differentiation and systematization;

23. develops a (broadly) Aristotelian perspective of nature ("a principle of movement and rest") in the light of evolutionary insights in a manner that avoids vitalism;
24. integrates the key concepts of genetic method with a reconceived Thomist metaphysics of substantial and accidental matter, form and act; and
25. clarifies such an account by a contrast with the critical idealist/neo-Kantian position (Cassirer) to argue for a critical realist philosophy of biology.

Such are the main points addressed especially in the eighth and fifteenth chapters of *Insight*. They are still at the heart of contemporary discussions, and Lonergan's powers of synthesis and judgment, I think, stand up well (though his omission of heredity seems glaring in our postgenomic age). On the other hand, Lonergan is sometimes terse to the point of incomprehension, and his inchoate remarks cry out for expansion. Here, Piaget can be of assistance, as Lonergan may have realized. At any rate, I shall now turn to Lonergan's Piaget with a view to attempting a development of Lonergan's thought. In various ways the more detailed thought of the biologist turned child psychologist permits a fleshing out of Lonergan's ideas.

Lonergan's Piaget

Jean Piaget was a highly philosophical theoretician of cognitive development, who was, of course, famous as an educationalist. Although Lonergan had some prior acquaintance with Piaget (Lonergan 1982, 54), Lonergan first cited him in 1959 in order to prepare lectures for a summer school that were published later as *Topics in Education* ([1959[1993). Although he gave just a single lecture on Piaget, Lonergan cites twenty of his volumes. Lonergan introduces some of Piaget's key ideas, such as adaptation (see below) and group theory. He maintained his interest, however, reading John Flavell's *The Developmental Psychology of Jean Piaget* in 1963, and throughout the 1960s Lonergan frequently invoked Piaget in his courses on theological method to illustrate, for example, the idea of concrete operations, which he took as a modern analogue of the Aristotelian habit. Indeed, Lonergan would illustrate the intellectual development of Aquinas's thought (the subject of his doctoral dissertation) using Piaget. Lonergan would at last bring Piaget into his own system at the beginning of his account of "The Human Good" in *Method in Theology* (1972). Lonergan was interested in the development of skills, and it is in this context that *Method* makes its first reference to God.

Lonergan did, however, draw an explicit contrast between Piaget's notion of development and his own "genetic method" presented in *Insight's* chapter on "Elements of Metaphysics." In "Time and Meaning", he explained that Piaget's "beautiful" analysis of development (of the stages of cognition in children) was far more detailed than his own which had sought to "treat things just in the grand blocks of main differences and interconnections" (Lonergan [1963]1996, 109). In this context, Lonergan is referring to the "differentiations of consciousness" that result from the accumulation of insights in science and common sense. Piaget's fine-grained analysis would prove too unwieldy for Lonergan's purposes.

In articulating Piaget's concepts, Lonergan rarely conflated them with the term of art that he made his own, "insight." However, he did on occasion bring the two concepts together, and interestingly, he repeated the point in his final lecture, "Unity and Plurality" (Lonergan [1982]1985), in some ways a "last will and testament" recapitulating his leading ideas. Piaget's thought is applied to practical knowledge:

> [C]ommon sense does not syllogize; it argues from analogy; but its analogies resemble, not those constructed by logicians in which the analogue is partly similar and partly dissimilar, but Piaget's adaptations which consist of two parts: an assimilation that calls on the insights relevant to somewhat similar situations; and an adjustment that adds insights relevant to the peculiarities of the present situation. (Lonergan [1982]1985, 241)

Finally, in a work that will be discussed in the next section, Lonergan drew on Piagetian structure to explain the eight-fold functional specialties that he believed could unify theological method. In a 1971 interview, he explained:

> So it's a structure, and you can have an analogy to it in Piaget's *Le Structuralisme*—a very thin little book in which he conceives this structuralism as a matter of independent, self-regulating, ongoing process. The eight functional specialties are a set of self-regulative, ongoing, interdependent processes. They're not stages such that you do one and then do the next. Rather, you have different people at all eight and interacting. ([1972] 1974, 211)

The most important discovery of Lonergan's career, his *novum organon*, so to speak, is described in terms drawn from Piaget.

Structuralism

Piaget's *Structuralism* ([1968]1971), in particular the eight pages on "Biological Organisms," provides an insight into Piaget's project. It will now be presented. In the next section a brief text from a later chapter (on functional invariants) follows so as to introduce Piaget's guiding hypothesis regarding the isomorphism between biology and knowledge and the significance of diachrony and synchrony as regards different evolutionary theories. The motivation is to open up further lines of inquiry that might shed some light on Lonergan's project.

Perusal of the contents of Piaget's volume indicates that structuralism can be applied to a range of disciplines—mathematics, physics, biology, psychology, linguistics, social sciences, and philosophy—a fact that makes definition difficult. Negatively, structuralism is opposed to functionalism, historicism, and also empiricism. Positively, it finds the notion of a *structure* to be self-sufficient, and at a first approximation "we may say that a structure is a system of transformations." These transformations involve laws which preserve the structure, that is, structure deals with a "system closed under transformation," and so Piaget treats in turn of "wholeness," "transformation," and "self-regulation."

Wholeness is the defining mark of structures, and one problem that Piaget raises is a question that will be discussed below. Are structures preformed, or do they emerge gradually? Regarding transformations, Piaget explains that structured wholes depend on laws of transformation, and here Piaget notes the importance of implicit definition (elsewhere he speaks of "reflective abstraction"), illustrating the point using the example of the system of integers. The mathematical concept of the group (possessing closure, an identity element, inverses and associativity) can be thought of exhibiting self-regulation. Extra-mathematical structures are governed by cybernetic regulations.

In his short section on "Organic Structures," Piaget explains that the organism is, in a way, the paradigm of structure: a systematic whole of self-regulating transformations. The challenge is to understand this structure (a physic-chemical system) and its functioning (the organism's behavior). Piaget rejects reductionism, whether Cartesian ("animal machines") or Darwinian (if this is taken as a theory of evolution by "fortuitous variation cum selection"). Here, Piaget appeals to the nature of "progress in physics" which does not merely add on new knowledge but involves the "complete recasting of preceding knowledge" and the formulation of higher syntheses. Moreover, the purported "reductions" (of more complex branches to the more simple) actually involve an enrichment of the latter rather than an impoverishment of the former. Thus Piaget finds common cause with the opposite extreme, vitalism, referencing Lloyd Morgan (who had spoken of emergent evolution) and Hans Driesch (whose work on embryonic development disclosed regulatory mechanisms). However, Piaget has no sympathy for the mystery mongering that led Driesch into the retrograde step of espousing Aristotelian metaphysics, and points instead to the organicism of Bertalanffy (who had developed a "general theory of systems"), and the physiologist, Claude Bernard, who can be taken as anticipating "systems biology."

Piaget mentions Cannon's "homeostasis," the tendency of a system, especially the physiological system of higher animals, to maintain internal stability, owing to the coordinated response of its parts to any situation or stimulus tending to disturb its normal condition or function. Organic self-regulation differs from mechanistic in three ways: it is ensured by differentiated organs of regulation; the functioning of an organism's substructure is tied to the functioning of the whole; and the functioning of living things take account of *meanings*.

If homeostasis represents the achievement of self-regulation of the mature organism as an accomplished fact, Piaget is no less keen to draw attention to that system of self-regulation on the way to being acquired, and so Piaget attends to the genetic system. This insight—that genes are to be regarded as part of a regulatory whole—is particularly to be celebrated by the structuralist. Thus Piaget welcomes the *population* geneticist, Dobzhansky, for explaining that genes perform "no longer as soloists but as members of an orchestra." Piaget was very cognizant of what subsequent developments have only reinforced—that genes can perform the regulatory function of controlling other genes. Thus, in the modern (neo-Darwinian) synthesis, variation is to be attributed to recombination rather than mutation.

Piaget now draws on the work of Conrad Waddington, an embryologist turned geneticist, whom Piaget knew had grasped the idea of regulatory genes (and indeed, that of the epigenetic system) in the 1940s—there are feedback loops that permit information from the environment to affect the genome (see Waddington 1961). Here structuralism welcomes the discovery of "organizers" (a point illustrated by the experiments of Driesch who was astonished to discover that the divided embryo of a sea urchin in very early stages was found to develop into *two* smaller embryos). The embryo develops along certain necessary paths that can be compensated for if normal development is interrupted. Thus, balancing mechanisms exist, not only for the developed organism, but also for the developing organism: Piaget cites Waddington's notion of "homeorhesis" (from the Greek: "similar flow"). The embryo possesses a dynamic tendency to get back on track. Again, Piaget employs Waddington's idea of genetic assimilation—that is, the fixation of acquired characteristics:

> Roughly, Waddington views the relations between the organism and its environment as a cybernetic loop such that the organism selects its environment while being conditioned by it. What this means is that the notion of structure as a self-regulating system should be carried beyond the individual organism, beyond even the population, to encompass the complex milieu, phenotype, and genetic pool. Obviously, this interpretation is of the first importance for evolutionary theory. (Piaget [1968] 1971, 50)

Lamarck had argued that as animals are faced with new needs they will develop new structures which are then passed on to their offspring—acquired characteristics are transmitted to the next generation. Genetic assimilation can be thought of as a "neo-Lamarckian" mechanism, without recourse to Lamarck's explanation.[1] Modestly, Piaget refrains from illustrating the idea with his own doctoral discoveries in 1929 on the adaptations of the length of snail's shells and their behavior which also exemplify the mechanism. Instead, Piaget points out the significance of an old debate, namely between epigenesist and preformationism. Waddington has reestablished the role of the environment in the gradual development of the embryo, so that the environment can be seen as setting problems to which genotypical variations are a response. In this sense, preformationism is rejected.

Finally, Piaget points to the importance of ethology (the comparative study of animal behavior) to furnish the basis of psychogenetic structuralism. "We may even go so far as to speak of a "logic of instincts" whose several "levels" can be subjected to analysis" (Piaget [1968]1971, 51). Piaget does not regard animal knowing as "mere groupings with which empirical knowledge begins," but as involving assimilation to structures that are more settled and coherent.

Biological and Cognitive Functions

At this juncture some general remarks on the "functional invariants" of Piaget's genetic epistemology can serve as a bridge to the next section on the isomorphism between biology and knowledge, given that epistemology is modeled on biology.

Both cognitional and biological functions are conceived in terms of adaptation and organization. In biological terms, an adaptation can be thought of as an encounter of an organism with an environment so that the outcome is favorable to the organism; for example, an animal takes in nutriment and so incorporates food into its body. This adaptation has two aspects: of assimilating new material to old systems, and adjusting old systems to new material. Initially the transformation may involve chewing, or some equivalent, so that sharply contoured objects become pulpy and formless. Further transformations digest that material until it is completely assimilated. Conversely, the organism must also accommodate itself to the demands of the object, opening its mouth, chewing, and swallowing so that digestion is possible—every assimilation is simultaneously an accommodation. This metaphor can be extended to psychology:

> The functional factors are *assimilation*, the process whereby an action is actively reproduced and comes to incorporate new objects into itself (for example, thumb sucking in the case of sucking), and *accommodation*, the process whereby the schemes of assimilation themselves become modified in being applied to a diversity of objects. (Piaget [1968]1971, 63)

Insofar as the adaptation is considered from the side of the organism such functioning involves organization. The digestive system, for example, involves a highly complex internal structure. In his account of child development Piaget will explain how distinct stages are organized—for example, the pattern of behavior of thumb-sucking in the sensory-motor stage in which Piaget draws on group theory, and so on for other stages such as "concrete operations" and "formal operations."

The Isomorphism between Biology and Knowledge

In *Biology and Knowledge*, the hypothesis that there is an isomorphism between cognitive functions and the functions of living organisms serves as a regulative ideal that guides Piaget in many inquiries conducted over nearly 400 pages. Piaget begins by insisting that knowing is not a matter of copying, "the mere registering of data furnished by the environment" (Piaget [1967]1971, 3), and so he faults the abstract mechanisms of stimulus and response favored by associationist psychology. Knowledge, rather, involves assimilation to previous structures (Piaget [1967]1971, 4), and Piaget promptly recalls Waddington's "genetic assimilation." In the early stages of a child's development, such assimilation involves reacting to reality actively by way of "action schemata" (Piaget [1967]1971, 7); for example, by the child's activity of ordering bricks by piling them up, and pulling them down again (Piaget [1967]1971, 9). Such actions are coordinated, and here Piaget introduces the central questions of "equilibration or autoregulation"—the production of balance that Piaget finds to be the mechanism that motivates development (Piaget [1967]1971, 10). This is more organized than haphazard groping (Piaget [1967]1971, 11). Piaget is very interested in regulatory mechanisms at all levels, including the mechanisms that generate the organized system, and here Piaget again refers to Waddington's homeorhesis whereby such dynamic equilibrium is achieved (Piaget [1967]1971, 12). Again, Piaget draws attention to the epigenesist/preformationism problem, pointing out that the discoveries of molecular biology concerning the structure of DNA, whilst superficially lending plausibility to preformationism, are unacceptable to the embryologist (Piaget [1967]1971, 14). An understanding of the gradual differentiation of organs argues in favor of epigenesis and Waddington's comparison of epigenetic construction with a progression of geometric theorems is cited approvingly (Piaget [1967]1971, 14). Piaget draws on his own discoveries regarding the stages of child development (Piaget [1967]1971, 16–18), and continues to build on the ideas of Waddington's creodes (developmental paths) and the dynamic equilibrium that is gradually reached (Piaget [1967]1971, 23).

Having set out this context, Piaget can explain his guiding hypothesis. "Cognitive processes seem then, to be at one and the same time the outcome of organic autoregulation, reflecting essential mechanisms, and the most highly differentiated organs of this regulation at the core of interactions with the environment" (Piaget [1967]1971, 26). Just how cognitive functions are also "differentiated regulatory organs," occupies much of Piaget's later inquiry. He will address memory, anticipation, learning, reflexes, instincts, perceptions, conditioning, innate knowledge, and logicomathematical knowledge. I will consider only the initial stage of Piaget's inquiry. This regards the development of biological thought itself, which Piaget considers almost in Hegelian terms, as superseding Darwin.

Diachronic and Synchronic Notions in Biological Theories

Piaget notes that biological knowledge involves two dimensions. Just as physics involves dynamics and statics, so biology involves a diachronic and synchronic dimension. Biology, then, is historical; it involves the notion of time. Here (after Waddington), four distinct time scales can be envisaged: (1) in a very brief duration oxygen is assimilated into the respiratory system so as to be available to other systems such as the digestive and locomotive; (2) an individual organism has a life cycle of development, growth, maturity, and senescence; (3) one generation inherits traits transmitted by previous generations; and (4) finally, in the vast time scales of evolutionary history, new species may evolve.

Piaget particularly focuses on aspects taken from the second and fourth time scales, ontogeny and phylogeny: embryonic development, especially, is taken as a prototype. One reason for the privileging of ontogeny is the recognition that genes are to be seen in the context of a network of regulations, so that the genotype is not to be regarded in isolation but within Waddington's "epigenetic system." Evolutionary selection is not merely a sieve that weeds out the unfit, but it is the genome as a whole that makes "functional responses." The resulting picture is one of cybernetic control and autoregulation.

Piaget notes that development culminates in a state of relative equilibrium that involves self-regulating mechanisms ([1967]1971, 85). These synchronic notions have had to be developed in the history of biological thought, which Piaget tends to read according to "dialectical triads," a thesis being opposed by an antithesis eventually being sublated by a higher synthesis. This development testifies to the fact that biological understanding requires both synchronic and diachronic notions (structure and process)—a difficult achievement, because structure is often opposed to process.

For example, the notion of a biological species was, in preevolutionary times, understood according to static, logical categories. Piaget mentions the classifications of Linnaeus. To their credit, such attempts at biological science grasped the holistic idea of a species as a totality. With evolutionary thought, it was realized that species adapt according to changing environments. Thus the insight emerges that species must be understood relationally. The difficulty here is the tendency towards atomism, and the realistic notion of species gives way to nominalism. The higher synthesis involves grasping the reality that species are to be conceived as in both relational terms and as a totality:

> To sum up, having first entertained a realist notion of species, and then an atomistic and nominalist one, biology today is turning toward a relational study of functional totalities in the framework of which the species is seen in nature, which leads one to believe in the primacy of the notions of equilibration and regulation by virtue of the fact that conceptually, they go far beyond the antitheses originally presented. (Piaget [1967]1971, 89)

A similar narrative applies to the genetic system. The progress is from "transcausal totality" (thesis) to atomism (antithesis) and from that to relational totality relying on autoregulatory mechanisms (synthesis). By "transcausal" Piaget has in mind the Aristotelian conception of causality which he regards as a prescientific attempt at explanation. The opposite view was taken by Weissman who made a sharp distinction between the germ line and the hermetically sealed soma. Piaget anticipates the language of Richard Dawkins in describing the genes as "immortal" in contrast with the mortal soma. Whilst these genes might mutate, they can hardly be said to respond to the environment, and so the resulting atomism needs to be superseded. Once more, with the recognition of the genetic system one arrives at the idea of a totality which is both relational and responsible to functional development (Piaget [1967]1971, 92).

Regarding the individual organism, yet again the idea of relational totality (a totality characterized by autoregulations) is vindicated. Here, the thesis is represented by vitalists and those espousing the life force or finality. Piaget is keen to distinguish this mysterious notion from those based on cybernetics—he appeals to feedback loops rather than final causes. Thus he can reject the antithesis, reductionism, and posit the synthesis that does justice to biological organization (Piaget [1967]1971, 96). In arguing for "relational totality," Piaget finds suitable parallels with epistemological concepts; for example, Piaget cites Kohler's work with chimpanzees (Piaget [1967]1971, 96).

A fundamental isomorphism for Piaget is between the organism and the environment, on the one hand, and the knowing subject and the object on the other. Once again the higher synthesis of relational totality is to be affirmed. However, biology also needs to appreciate three aspects: (1) the molding influence of the environment, (2) the internal hereditary structures of the organism, and (3) the reciprocating interactions of organism and environment. The important thing is not to conceive of evolution as involving the first without the second, or the second without the first.

Once again, a dialectical triad emerges: Lamarck, mutation (Darwin), and Waddington's *tertium quid*.

Piaget rejected Lamarck, but as he explains, "Lamarckism still holds much interest for us even if it is no longer acceptable" (Piaget [1967] 1971, 104). Indeed, Piaget references Lamarck on about thirty-four pages, five times as many as those referencing Darwin. Conceding the weakness of certain arguments (the giraffe's neck was elongated by stretching) and the experimental evidence refuting inherited characteristics, Piaget points to mechanisms that give the appearance of Lamarckian results that eschew Lamarck's faulty explanations, namely, Waddington's genetic assimilation. Piaget cites his experiments on fruit flies: "Apparently the transversal vein in these wings was disconnected at the phenotype stage because of a change in environmental temperature and then remained fixed in this state after several generations, even when the temperature reverted to its original state" (Piaget [1967]1971, 107). The point is that the genotype is to be regarded as a potentiality that can produce a range of phenotypes according to different environmental pressures (the reaction norm) and so, in virtue of their plasticity, genes are buffered against environmental shocks, and thus can give the appearance of inherited characteristics. Lamarck appreciated the shaping effect of the environment but failed to recognize the need for the formation of internal hereditary structures that react actively and not merely submit to external events (he grasped the first but not the second of the three aspects above). For him, the organism is pure passivity, and here Piaget draws the cognitive parallel with Humean empiricism.

By "mutationism," Piaget refers to a neo-Darwinian theory that relied on the mechanisms of chance variation and progressive natural selection. Although the sixth edition of *The Origin of Species* had granted the essence of Lamarckianism into the conception of evolution, the rediscovery of Mendelian genetics led to a synthesis that stressed the internal nature of chance variations—genetic mutations. Thus, although similar to Lamarckianism in some respects (as regards its functionalism), the mutationist stresses internal hereditary structures at the expense of environmental influence. Moreover, an abstract approach of population genetics leads to atomism. Piaget draws a cognitive parallel with *a priorism* and conventionalism.

Waddington's higher synthesis draws on the realization of the organized nature of genetic systems, and the evolutionary processes by which they are brought about (Piaget [1967]1971, 113). The result is a cybernetic, nonvitalist finalism: the system governs itself by information that is fed back to the system. Waddington envisages a series of feedback loops in interconnected systems: genetic, epigenetic, physiological responses to the environment, and the actions of natural selection. Genuine *inter*action between organism and environment is upheld. The correlative in cognitional theory is clearly Piaget's own genetic epistemology.

Piaget obviously feels that it is very difficult to synthesize structure and process, synchrony and diachrony, as the famous debates between Cuvier and Geffroy St. Hilaire show. To invoke one last triad: structure without process (thesis) and process without structure (antithesis) must yield to process structuralism, or equivalently, "genetic structuralism." The key to this realization lies in schemes of recurrence (to employ Lonergan's phrase), or more specifically, cybernetic loops between organism and environment.

Sublating Darwin

Lonergan esteemed Darwin for providing the paradigm of statistical explanation that paralleled the views he would formulate, but limitations of space forbid a careful (and positive) exposition (see McShane 1970; Byrne 2006). Rather, the aim will be to consider just two texts in which Lonergan criticizes aspects of Darwinism. Lonergan makes important points so briefly that they are difficult to grasp. As intimated, Piaget can clarify.

A first text arises at the end of a highly complex argument in which Lonergan had developed a worldview that combines both causal and statistical explanations. Emergent probability is then contrasted with "The Darwinian World View." Having expounded the rudiments of the idea of chance variation and natural selection, Lonergan adds:

> Moreover, these combinations of variations, which possess probabilities of emergence and of survival, are relevant to schemes of recurrence. For the concrete living of any plant or animal may be regarded as a set of sequences of operations. Such operations are of kinds; there are many of the same kind; and those of the same kind occur at different times. There are, then, in each set of sequences recurrent operations, and the regularity of the recurrence reveals the existence and functioning of schemes. (Lonergan [1957]1992, 156)

Lonergan gives illustrations and introduces an idea that he will develop in the fifteenth chapter ("flexible circles of ranges of schemes"):

> Again, the plant or animal is a component for a range of schemes. Unlike the planets, which stick to their courses in the solar system, and like the electrons, which may be imagined to hop from one orbit to another, the plant or animal enters into any of a range of sets of alternative schemes. This range is limited by immanent structure and capacity. Still, though it is limited, it remains open to alternatives. For without change of structure or of basic capacity, the plant or animal continues to survive within some variations of temperature and pressure, of circumambient water or air, of sunlight and soil, of the floating population of other plants or animals on which it lives. (Lonergan [1957]1992, 156)

Lonergan then marks a difference from Darwin:

> At this point, however, the differences between Darwinism and emergent probability begin to come to light. Emergent probability affirms a

> conditioned series of schemes of recurrence that are realized in accord with successive schedules of probabilities. Darwinism, on the other hand, affirms a conditioned series of species of things to be realized in accord with successive schedules of probability. The two views are parallel in their formal structures. They are related, inasmuch as species of living things emerge and function within ranges of alternative sets of schemes of recurrence. Nonetheless, there is a profound difference. For Darwinian probabilities of emergence and survival regard, not schemes of recurrence but underlying potential components for any schemes within a limited range, and the Darwinian series of species is a sequence of higher potentialities that exhibit their development by their capacity to function in ever greater ranges of alternative sets of schemes. (Lonergan [1957] 1992, 156–57)

Lonergan goes on to explain that he has not yet reached the stage of the argument when he can draw on the notion of the *thing* (roughly, the metaphysical notion of "substantial form") that might be thought to fall foul of scientific parsimony. This will be developed in the eighth chapter. What is the advantage in speaking in terms of the probability of *schemes* rather than *species*? Lonergan seems to be suggesting that by speaking more comprehensively of schemes he can envisage an ecological scale that provides a less abstract perspective—organisms must be understood in their environment. However, Lonergan would not wish to think of species merely as passive responses to the environment, and so Lonergan also seems to be drawing a contrast between the idea of species as constrained within schemes of a *limited range* as opposed to the correct idea (that the Darwinian ought to posit) of species*, exhibiting their development by their capacity to function in ever greater ranges of alternative sets of schemes*. Lonergan clearly wants to uphold an anti-reductionist concept of species. The suggestion of this article is that by encompassing the various forms of circular causality frequently alluded to by Piaget (cybernetic feedback loops and so on) in his recurrence schemes, Lonergan's intentions can be further strengthened by an authentic development of his thought. It is interesting to note that, whereas Lonergan did not continue to devote much attention to biology, he could intimate that "Darwin's accumulations of chance variations have gained respectability as probabilities of emergence" (Lonergan [1976]1985, 24–25). Lonergan seems to be alluding to "respectable" scientific opinion that chimes with his own opinion. In this and similar texts Lonergan never gives a hint of what he has in mind, but it is not impossible that he was recalling Piaget or Waddington.

A second criticism appears in the sixth section of the eighth chapter, "Explanatory Genera and Species." The question of species is still controversial—the literature sports over a score of species concepts, and Lonergan offers yet another: the *explanatory* notion. Here Lonergan has in mind not merely the biological species, but the physical, chemical, psychological, and rational. This, in fact, is recognizably an evolutionary descendent of the "great chain of being." Still, he appears to offer a model to philosophers of biology. Very roughly, Lonergan is agreeing with those who feel that something like the evolutionary tree ought to relate to biology as the periodic table relates to chemistry, but he avers that more thought is required in understanding what it is that actually evolves. The task of wrestling with Lonergan's text (which is quite difficult at times) must be left for another occasion, however. The gist, I believe, is that by "explanatory species" Lonergan means "higher system on the move" where "system" refers to "an integration of structure and function." Lonergan, in fact, attempts to do justice to the idea that Piaget conceded was so difficult: the ongoing emergence of structure. Once again, Lonergan draws a line between his view and "that associated with the name of Darwin."

Lonergan makes the claim that species are to be thought of as solutions—not, then, unlike discoveries grasped by insight. The idea is introduced in a paragraph that reads:

> Though the same formal structure [glossed just now as "higher system on the move"] yields both the chemical and the biological species, the greater complexity of the latter necessitates their markedly dynamic characteristics. An inspection of the periodic table reveals some elements to be extremely inert, others to be highly unstable, some to possess fewer and others more numerous capacities for combination. It follows that chemical elements and compounds will not be all equally suitable for the aggregates of processes to be systematized biologically. Moreover, in a universe in which concrete events are never more than probable, the higher biological system will have the function not merely of systematizing what otherwise would be coincidental but also of extruding what has become inept and intussuscepting fresh materials. Again, the fulfillment of the twofold function will be only probable, and so there follows a third function: of reproduction, of starting up a new instance of the system in fresh materials. Again, the system can shift its ground; instead of maintaining and reproducing a single cell, it can maintain and reproduce an ordered manifold of cells; and this shift involves a new dimension of growth and differentiation in the functions of the system. Thus the biological species are a series of solutions to the problem of systematizing coincidental aggregates of chemical processes. Minor changes in the underlying aggregates yield variations within the species; major changes that are surmounted successfully yield new types of solution and so new species. The existence of a series of such major changes is the biological content of the sequential postulate of generalized emergent probability. (Lonergan [1957]1992, 288–89)

Here it can be observed that in drawing the parallel between organisms and solutions to problems, Lonergan adopts a perspective akin to Piaget's. The notion of *function* is introduced. It is not, indeed, that Lonergan thinks of species merely in functional terms at the expense of structure, (adaptation without organization, in Piaget's language) for Lonergan does not neglect "relational totalities" (structures); he speaks of "systematizing what otherwise would be coincidental." Moreover, Lonergan clearly has a dynamic notion of function in mind that is not dissimilar from Piaget's adaption, because "the system can shift its ground." But Lonergan is short on detail. In developing his isomorphism, Piaget continues his argument by considering the various correspondences that obtain between structure and function, which again may be of assistance in elaborating Lonergan's thought.

A few paragraphs later, referring to plants and animals, Lonergan writes of "an enormous shift of emphasis and significance from the materials to be systematized to the conditioned series of things and schemes that represents possibilities of systematizing." This resides in "the realm of intelligible possibility"—a phrase that is slightly unclear, but which probably refers to the "intelligible solutions to the problem of living" that Lonergan has just introduced. Again Lonergan mounts a criticism:

> Accordingly, emergent probability has quite different implications from the gradual accumulation of small variations that is associated with the name of Darwin. The fundamental element in emergent probability is the conditioned series of things and schemes; that series is realized cumulatively in accord with successive schedules of probabilities; but a species is not conceived as an accumulated aggregate of theoretically observable variations; on the contrary, it is an intelligible solution to a problem of living in a given environment, where the living is a higher systematization of a controlled aggregation of aggregates of aggregates of aggregates, and the environment tends to be constituted more and more by other living things. . . . Though later species are solutions to concrete problems in concrete circumstances, though they are solutions that take into account and, as it were, rise upon previous solutions, still a solution is the sort of thing that insight hits upon and not the sort that results from accumulated observable differences. (Lonergan [1957]1992, 290)

Here it becomes clear that Lonergan seeks to avoid an atomistic (or "mutationist") conception of species as "an accumulated aggregate of theoretically observable variations," preferring instead a holistic approach of structures (grasped by insights). Moreover, reference to *controlled* aggregates suggests a cybernetic dimension. Lonergan's sublation of Darwin seems to be quite in accord with Piaget's.

Process Structuralism

In this article, I have tried to do several things. I have attempted to give some sense of the "paradigm shift" that Lonergan attempted in what I have described as a philosophy of biology, and what he himself called "genetic method." For this reason, I sketched the main lines of Lonergan's project in the belief that it offers a set of ideas worthy of closer consideration. Lonergan situates his biological philosophy within the context of a nonpositivist (yet nonpluralist) philosophy of science offering, in particular, a clarification of notions such as development, for the sake of wider theological and anthropological ends.

I have tried to show that, whilst, of course, Lonergan had the greatest respect for Darwin's achievement, he also had a distinctive contribution to make, a contribution, however, which had parallels with Piaget whom Lonergan also appreciated. But I also wanted to indicate that Lonergan's thought admits concrete development—it can be regarded as a research program—and so I tried to show what this might entail, again by using Piaget. Both thinkers, in fact, might be described as "process structuralists." They embarked on the difficult task of rejecting structure without process and, as well, process without structure. For this reason, each had criticisms of "mutationism." They both responded with strategies that involved exploiting parallels between intellectual and biological development. Whereas for Lonergan "the prototype of emergence is insight" (Lonergan [1957]1992, 506) for Piaget "the organism is the paradigm of structure" (Piaget [1967] 1971, 44). Thus, each thinker sheds light upon the other. I have suggested ways that Piaget's detailed explorations can be used to fill out Lonergan's broad sweeps.

There are differences between the two: on account of what he took to be the discovery of insight, Lonergan probably had a greater esteem for Aristotle than Piaget; Lonergan's notion of "the pure desire to know" appears distinct from its Piagetian correlate "equilibration," with the result that Lonergan's invitation of self-appropriation is unique; Lonergan's cognitive structure always affirms three elements: experience, understanding, and judgment; and finally, although Lonergan appreciated the virtues of organicism, his primary concern was to affirm a critical realism. But these contrasts have not been considered. Rather, attention has focused on some positives that Piaget has to offer Lonergan's philosophy of biology.

The hope has been to promote interest in a promising research program.[2] It is increasingly recognized that the modern Darwinian synthesis has failed to incorporate the insights of development (Depew and Weber, 1995; Goodwin, 1994), and philosophers of biology are now more fully aware of the anti-reductionist implications of a bewilderingly sophisticated genetic system (Griffiths and Stotz, 2013). Although not exactly the "mystery hidden for ages" (Eph. 3:9)—Philip McShane's work must be acknowledged—process structuralism appears to be a coherent set of ideas whose time has come, or at any rate, is in the process of emerging.

Notes

1. "Genetic assimilation" is sometimes conflated with "the Baldwin effect" (an idea simultaneously discovered by James Baldwin, C. Lloyd Morgan, and Henry Osborne around 1895). For a modern reconsideration see Depew and Weber (2007).

2. For a recent accessible work on evolution drawing on Lonergan but written for a broad audience, see Crysdale and Ormerod (2013). In their Chapter 4, "Evolving World: Purpose and Meaning," these authors use Lonergan's finality to conceive the directedness of evolution developing Lonergan's work, not with Piaget and Waddington, but with more recent work by Stuart Kauffman, Sean Carroll, and Simon Conway Morris.

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