Praefatio
Le reflet de la vie

J'ai toujours préféré le reflet de la vie à la vie elle-même.

[I have always preferred the reflection of life to life itself.]

— François Truffaut (1970)
Téléciné, No. 160
(«Spécial Truffaut», mars 1970)

Welcome to the continuation of our exploratory journey in relational biology! My previous book

More Than Life Itself: A Synthetic Continuation in Relational Biology

was published in 2009. It dealt mainly with the epistemology of life. In its Chapter 13, Ontogenic Vignettes, I briefly mentioned several topics that would be expanded elsewhere, in "my next book". This monograph you are now reading is that "elsewhere". It will deal with the ontogeny of life as well as how life evolves from the singular to the plural. This 'Opus II' of my epic on relational biology is thus a 'second image', hence 'reflection'.

The roots of the Latin word *reflectere* are *re* 'back' and *flectere* 'to bend'. In geometry, a 'reflection' (also spelt 'reflexion') is an isometric mapping from a Euclidean space to itself that has a hyperplane as the set of fixed points. When a point is reflected about an axis, for example, the point is 'bent back' to a symmetric position on the opposite side of the axis. A reflexive relation 'bends back' every element so to be related to itself. In physics, 'reflection' is the transition, 'bending back', of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated. Metaphorically, the word 'reflection' can mean 'turning back one's thought on some subject', whence long and careful consideration, an indication, an account, or a description. 'Reflection' is a noun of action; it entails plurality. Any object may be the material cause of reflection and be bent back under a formal cause of reflective morphism. The efficient cause of reflection is the interaction of the to-be-reflected entity with its reflector (that which reflects), and the final cause is the

genesis of the reflected output. Common reflected entities are light, heat, sound, and water waves, and—by extension—colour, image, thought, concept, and idea, thence verily exemplified in the sight and sound of *la Nouvelle Vague* that is above all 'human self-reflection'.

This *liber secundus* of my synthetic continuation in relational biology is, therefore, a 'reflection' in every literal and metaphoric sense of the word. Indeed, modelling, the representation of one system in another, is the art that is the ultimate revelatory reflection of life. This is why I have chosen to name this book *The Reflection of Life* (and, for me, the exceedingly *à propos* Truffaut quote clinches it). I nominate it thus, despite being fully aware that the title is somewhat generic and formulaic: the shelf of books entitled *The Y of X* is quite crowded. (Incidentally, *The Origin of Species* is not a fitting example here. Although this arguably most famous scientific publication is often referred to by this more declarative name, Charles Darwin's original 1859 title was the verbose *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*.) Even in my subject area of mathematical biology, the name *The Y of Life* is well represented; among them are, for example, Denis Noble's 2006 *The Music of Life* and Ian Stewart's 2011 *The Mathematics of Life* (both, I may add, excellent books). My rather specific subtitle for the book should, nevertheless, serve to distinguish it: I am reasonably certain (in the strong-limit sense of almost sure convergence), an infinitude of typing monkeys notwithstanding, that the very sequence of words *Functional Entailment and Imminence in Relational Biology* has not appeared in print elsewhere.

A main theorem in relational biology says:

A natural system is an organism
if and only if it is closed to efficient causation.

If such a central issue of what life is can be so succinctly defined, then why is relational biology not as well known as it deserves to be? It may be because category theory, the *lingua franca* of relational biology, is not a very accessible branch of mathematics; it is not uncommon for a university student graduating in mathematics not to have taken a course on the subject. It may also be true that many in the rest of the community of biologists at large were antagonistic towards the Rashevsky-Rosen school, perhaps not so much on petty personal(ity) conflicts than on points of philosophical difference.

We are not denying that an underlying material basis is needed and that *some* information on living systems may derive from their material bases. The real *nature* of living systems, however, is not conveyed by their material basis. Physicochemical structures do not dictate functions; physicochemical structures are manifestations of functions.

Many biologists are convinced that "biology is inherently messy", and some aggrandizers have even presumptuously spoken for all and proclaimed as a "conviction" of biologists that the actual complex behaviour of real organisms would be lost in simple even if elegant idealizations. They regard cells and organisms as machine-like systems, a metaphor that even today dominates biology. Even for those biologists that are not as blatantly reductionistic, they would still

brand relational models "(over-)simplifications", and advocate (and advertise) the euphemistic "biologically realistic models" or "models of biological relevance". But what do "realistic" and "relevant" imply? Do they not implicitly remain the insistence that everything in biology must be explainable in terms of the underlying physicochemical materials? Contrariwise, from the standpoint of relational biology, machine-like systems are in fact simple; biological systems are complex precisely because their essence is lost when modelled as machines.

I may conjecture that this physicochemical bias has puritanical roots. Let me state that I am not referring to (capitalized) Puritanism that is the theological creed and social vision, but only to a debased, secularized, conservative form of (lower-case) puritanism, that of "anguished self-flagellation" and "suffering is purposeful". To wit, the slogan of many experimental biologists is that "real biologists" must "get their hands dirty", and that they must keep their "feet on the ground" (extolled from their *pieds-à-terre* in ivory towers; *cf.* [Rosen 2006] for an anecdote)! It is not that they do not appreciate that nature *itself* is beautiful; it is just that they feel the worthiness of an experimenter's *study* of nature ought somehow to be linked to the degree of messiness and dirtiness of the endeavour.

I wonder how people can appreciate the ontological beauty of nature but then insist on its epistemological ugliness.

Function dictates structure: relational biology begins with mathematical ideas and seeks realizations in natural systems. The Book of Nature is written in the language of mathematics. A theorist's conception of nature is based on *beauty*. I shall let G. H. Hardy, pure mathematician *par excellence*, have the last word:

> The mathematician's patterns, like the painter's or the poet's, must be *beautiful*; the ideas, like the colours or the words, must fit together in a harmonious way. Beauty is the first test: there is no permanent place in the world for ugly mathematics.
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> — G. H. Hardy (1940)
> *A Mathematician's Apology*
> § 10

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