Processes as Deductions and Programs, a successful paradigm for Computing, a misleading metaphor in Molecular Biology.

Giuseppe Longo
CNRS et Dépt. d'Informatique.
École Normale Supérieure, Paris
http://www.di.ens.fr/users/longo

Since Herbrand and Gödel's work the connections between Proof Theory and Computing have been at the core of Logic and Informatics. Type Theory and lambda-calculus brought the "deductive processes = programs = proofs" isomorphism, following Gentzen, Prawitz, Curry-Howard and Girard's work, at the limelight by several deep results.

Since the '30s and, more specifically, the '50s, also molecular processes in cellular reproduction have been often analyzed by the "the DNA is a program" metaphor or even model, in the physico-mathematical sense. Shroedinger by his 1944 book contributed to this understanding, but he lucidly hinted to the intended causal structure underlying the paradigm. Subsequent work by Monod, Lwoff and Jacob opened the way to a large use of this model or metaphor, as well as to a laplacian understanding of biological causality and randomness. After a short survey on the structures of determination, from Laplace to modern dynamics, we argue that both the metaphor and the model are causally inadequate, in particular if derived from the current empirical practices in Molecular Biology, based on the "differential method" (a mutation is observed or induced and its phenotypic consequences are observed).

Relevant work has already been done, in Biology, criticizing the programming paradigm. We will refer to empirical evidence and theoretical writings in Biology, yet our arguments will be mostly based on a comparison with the use of differential methods in Computer Science and in Physics, where this fundamental tool for empirical investigations originated and acquired a well-justified status. In particular, as we will argue, the programming/deductive paradigm is theoretically not sound as causal and deductive frame for relating the genome to the phenotype, even from the point of view of Physics and Programming, in contrast to the physicalist and computational grounds that this paradigm pretends to propose. The argument will briefly refer also to some theoretical tools in Programming Semantics, derived from Logic, which provide a mathematically sound frame for an analysis of the "differential method" in Computer Science.

(work in collaboration with P.-E. Tendero, see below)

References (*see:* http://www.di.ens.fr/users/longo)

Bailly F., Longo G. **Mathématiques et sciences de la nature. La singularité physique du vivant.** *Hermann, Paris, 2006* (english introduction downloadable)

Downloadable papers:

Bailly F., Longo G. *Randomness and Determination in the interplay between the Continuum and the Discrete.* Special issue: **Mathematical Structures in Computer Science** 17(2), pp. 289-307,.

Barendregt H., Longo G. *Equality of lambda terms in the model T^{W}* In **To H.B. Curry: Essays in Combinatory Logic, Lambda-calculus and Formalism**, (Seldin, Hindley eds.) Academic Press, London, pp. 303-337, 1980.

Hoyrup M., Kolcak A., Longo G. *Computability and the Morphological Complexity of some dynamics on Continuous Domains*, *invited survey,* **TCS**, *to appear*.

Longo G., *Laplace, Turing and the "imitation game" impossible geometry: randomness, determinism and programs in Turing's test*. In Epstein, R., Roberts, G., & Beber, G. (Eds.). **The Turing Test Sourcebook**. Springer- Kluwer, 2007.

Longo G., Tendero P.-E., *The causal incompleteness of Programming Theory in Molecular Biology.* Under revision for publication. (A preliminary and longer french version A paraître dans **Evolution des concepts fondateurs de la biologie du XXIe siècle**, DeBoeck, Paris, 2007.)