Special Issue of *BioSystems* on The Physics and Evolution of Symbols and Codes

Reflections on the Work of Howard Pattee

Guest Editor: Luis Mateus Rocha
Computer Research and Applications Group
Complex Systems Modeling Team
Los Alamos National Laboratory, MS P990
Los Alamos, NM 87545, U.S.A.
E-mail: rocha@lanl.gov or rocha@santafe.edu
WWW: http://www.c3.lanl.gov/~rocha

Co-managing Editor: Michael Conrad
Department of Computer Science
Wayne State University
Detroit, Michigan 48202 USA
E-Mail: conrad@cs.wayne.edu
WWW: http://www.cs.wayne.edu/biolab/

To mark the occasion of the retirement of Prof. Howard Pattee, we are preparing a special issue of the journal *BioSystems* (http://www.elsevier.nl:80/inca/publications/store/5/0/6/0/1/7/) that can do justice to the interdisciplinary nature of his work, while maintaining a directed focus to the area that Pattee considers his most relevant contribution to science: *The Physics and Evolution of Symbols and Codes*. This theme encompasses theoretical and modeling aspects of biological and evolutionary systems. Indeed, at the core of the definition of biological and evolutionary systems lies the notion of codes used to construct organisms from inherited information. The study and modeling of the origin, physical constraints, evolutionary potential, and taxonomy of natural symbols and codes is extremely relevant for the disciplines of Biology (particularly for the origin of life problem), Complex Systems Research, Artificial Life, Cognitive Science, and Artificial Intelligence. Authors wishing to submit articles to this special issue, are requested to relate their work to Pattee's own description of the problem area:

"The two great scientific disciplines of physics and evolution theory have traditionally been taught as disjoint subjects. Yet some billions of years ago, certain collections of physical molecules reached a level of complexity that began open-ended evolution by heritable (symbolic memory-based) variation and natural selection.

Von Neumann was the first to propose explicitly why this "threshold" of complexity requires description-based reproduction (taken for granted by biologists), but his argument was focused on the logical, not the physical requirements. He did not discuss the organizational requirements that would allow normal physical molecules to function as descriptions, nor was he clear about his logical distinction between "active" physical dynamics and "quiescent" symbolic descriptions. He did not mention the origin problem except to say it was "a miracle of the first magnitude."

Even if we still do not have a clear picture of the origin of life, the significance of this fundamental distinction between descriptions and constructions, that is, between semiotic processes (rules, codes, languages, information, control) and physical systems (laws, dynamics, energy, forces, matter) reaches to all levels of evolution. This is an essential distinction from the earliest genetic control of the synthesis of proteins, to the codes and languages of the brain, to the distinction between the mind and the brain (the knower and the known, the epistemic cut), and even to physical theory itself that requires a clear distinction between universal physical laws and the local semiotic process of measurement - an area in which there is still no consensus. This distinction between laws and semiosis, as well as how they are related, needs to be made more clearly at all levels if we are to fully understand evolution, physical laws, and the languages of the brain.

In biology, the basic physics and chemistry of elementary life processes as they exist on earth is well-developed. However, our knowledge of the semiotic controls and interactions within and between organisms and in some cases even in single cells is far from complete. In evolution theory it is still not clear that blind variation in a virtually infinite semiotic search space is adequate to explain so many successful species.

Howard H. Pattee

Authors may also wish to address the following list of related topics:

1. COMPLEMENTARITY: Laws are universal, unchangeable, and essentially space, time and rate-dependent. By contrast, languages are defined by local rules that can evolve and often appear arbitrary. Languages are not related directly to physical time and space (displacement). How can these disjoint aspects be related? How can we study the law/rule distinction in computer simulations?
2. CONTROL: Physical laws were not changed by the origin of life, but life exists by virtue of its control of laws (i.e., control of the rates of chemical reactions). What types of control need to be distinguished? Is semiotic control necessary for evolution?
3. COMPUTATION: Computation is a universal semiotic process that has no intrinsic reference to physical laws (i.e., programs have complete control). In what sense can computers model evolution without contact with physical systems?

4. SELF-ORGANIZATION VS. NATURAL SELECTION. How much do physical laws (including statistical laws and possible new "laws of complexity") effectively limit the domain of variation and natural selection or guide the course of evolution?
5. BLIND VARIATION VS. RULE-BASED SEARCH. How much genetic learning (i.e., model-based or intelligent search) takes place in the course of evolution that improves on blind search? Are there other levels of biological organization that can improve on blind search? How important is the language grammar in efficient search? Computational experiments using genetic algorithms to deal with these issues are welcomed.
6. THE ORIGIN OF CODES. If the origin of life marks the origin of codes, how can we study this problem experimentally and computationally? Are biological codes relevant for the study of language and codes in the brain?
7. OPEN-ENDED EVOLUTION. What is meant by open-ended? Is description/symbolic-based reproduction necessary for open-endedness? How can we study constraints on evolutionary processes?
8. SEMANTIC CLOSURE. What kinds of closure are essential to understand the living organization? What can de said about epistemic autonomy from an environment? How can we detect it and simulate it?

Selected suggested reading (some can be found in electronic format in Pattee's web page http://ssie.binghamton.edu/~pattee):

Pattee, Howard H. (Ed.) [1973]. *Hierarchy Theory: The Challenge of Complex Systems.* George Braziller, New York.

Pattee, Howard H. [1978]."The complementary principle in biological and social structures." *Journal of Social and Biological Structures.* Vol. 1, pp. 191-200.

Pattee, H. H. (1980). "Clues from molecular symbol systems". In *Signed and Spoken Language: Biological Constraints on Linguistic Form*, U. Bellugi and M. Studdart-Kennedy (Eds.), Dahlem Konferenzen, Verlag-Chemie GmbH, pp.261-274.

Pattee, Howard H. [1982]."Cell psychology: an evolutionary approach to the symbol-matter problem." *Cognition and Brain Theory.* Vol. 5, no. 4, pp. 191-200.

Pattee, H. H. (1985). "Universal principles of measurement and language function in evolving systems". In J. Casti and A. Karlqvist (Eds.), *Complexity, language, and life: Mathematical approaches* (pp. 268-281). Heidelberg: Springer-Verlag.

Pattee, H. H. (1988). "Instabilities and information in biological self-organization". In F.E. Yates (Ed.), *Self-organizing Systems: The Emergence of Order* (pp. 325-338). New York: Plenum.

Pattee, H. H. (1989). The measurement problem in artificial world models. *BioSystems* 23, 281-290.

Pattee, Howard H. [1989]."Simulations, realizations, and theories of life." In: *Artificial Life*. C. Langton (ed.). SFI Series in the Sciences of Complexisty. Addison-Wesley, pp. 63-77.

Pattee, Howard H. [1995]."Artificial life needs a real epistemology." In: *Advances in Artificial Life*. F. Moran, et al. Springer-Verlag. pp 23-38.

Pattee, Howard H. [1995]."Evolving self-reference: matter, symbols, and semantic closure." *Communication and Cognition - Artificial Intelligence.* Vol. 12, nos. 1-2, pp. 9-27.

Pattee, H.H. (1996), "The problem of observables in models of biological organizations". *From Evolution, Order, and Complexity*, Elias L. Khalil and Kenneth E. Boulding, eds., London: Routledge, 1996.

Pattee, H.H. (1997), "Causation, Control, and the Evolution of Complexity". *Downward Causation*, P.B. Anderson, P.V Christiansen, C. Emmeche, and N.O. Finnemann.

SCHEDULE FOR SUBMISSIONS

Deadline for abstracts: March 31st, 1999

Deadline for papers: June 30th, 1999

REVIEWING PROCEDURE

Each research article will be reviewed by two referees. For each article, one referee will be chosen from the list of contributors to the issue, and another one will be chosen from the usual list of *BioSystems* referees, or from other relevant areas of research.

The deadline for reviews will be October 31st, 1999, and the deadline for revisions will be December 31st, 1999. The issue is expected to be published in 2000.

Updates to the special issue will be posted regularly at:

http://www.c3.lanl.gov/~rocha/pattee

INSTRUCTIONS FOR AUTHORS

Regular articles are limited to 10 journal papers. This corresponds to a limit of 5000 words plus a 50-100 word abstract. Figures and references are included in the word limit. One page of figures corresponds to 600 words. Twenty references corresponds to 300 words. Section headings correspond to about 20 words (three lines). A good guideline is: eight pages double space (1 inch margins) in Times 12pt. corresponds to 4 journal pages.

Electronic manuscripts have the advantage that there is no need for the re-keying of text, thereby avoiding the possibility of introducing errors and resulting in reliable and fast delivery of proofs. For the initial submission of manuscripts for consideration (i.e. if your paper has been accepted subject to changes or it has not yet gone through the refereeing process), four (4) hardcopies or electronically submitted files (disk or e-mail) are sufficient. For the processing of accepted papers, electronic versions are preferred. After final acceptance (as in the case of papers unconditionally accepted or accepted with some changes), your disk plus three (3) final and exactly matching printed versions should be submitted together. Double density (DD) or high density (HD) diskettes (3 1/2 inch) are acceptable. It is important that the filed saved is in the native format of the wordprocessor program used (WordPerfect, Word, Latex, etc.). Label the disk with the name of the computer and word processing package used, your name, and the name of the file on your disk.

The following instructions for the preparation of manuscripts should be adhered to:

1. The title page should state the full address of the author, including academic or professional affiliation. Where possible it should include FAX, email, and URL, of the corresponding author, and any special instructions about communicating proofs to the corresponding author. The title page should state that the paper has been prepared for the "Physics and Evolution of Symbols and Codes" special issue. The main delay with special issues is in retrieving proofs. Any author who expects to have trouble with this should make special arrangements.
2. Papers should include a short abstract, as specified above.
3. Papers should include 3-5 keywords, placed after the abstract.
4. Papers should be typewritten and double-spaced with 1 inch margin.
5. The first copy of the paper with original figures (on separate pages) should be clearly specified. Clean, well prepared figures are essential. If revision is necessary the originals will be retained by the editor and attached to the final manuscript. Tables should bear a short descriptive title and should also be double-spaced and typed on separate sheets.
6. The references should be cited in the text by giving the name of the author followed by the year of publication in brackets, e.g., Ebeling (1983) or (Ebeling 1983). Do not use the number system. All references should be listed alphabetically on a separate sheet.

   Examples:

   For periodicals:

   Capstick, M.H., Marnane, W.P., and Pethig, R., 1992, "Biologic computational blocks". *Computer* 25(11), 22-29.

   For books:

   Bohm, D., 1951, *Quantum Theory* (Prentice-Hall, Englewood Cliffs, N.J.) pp. 219-223.

   Ebeling, W., 1983, "Stochastic aspects of the evolution of macromolecules", in: *Darwin Today*, E.Geissler and W.Scheler (eds.) (Academie-Verlag) pp.1-30.

A guide for authors can be found on the Journal's website.