

# Lecture Notes in Artificial Intelligence

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# Advances in Artificial Life

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# Preface

No matter what your perspective is, what your goals are, or how experienced you are, Artificial Life research is always a learning experience. The variety of phenomena that the people who gathered in Lausanne reported and discussed for the fifth time since 1991 at the European Conference on Artificial Life (ECAL) has not been programmed, crafted, or assembled by analytic design. It has evolved, emerged, or appeared spontaneously from a process of artificial evolution, self-organisation, or development.

Artificial Life is a field where biological and artificial sciences meet and blend together, where the dynamics of biological life are reproduced in the memory of computers, where machines evolve, behave, and communicate like living organisms, where complex life-like entities are synthesised from electronic chromosomes and artificial chemistries. The impact of Artificial Life in science, philosophy, and technology is tremendous. Over the years the synthetic approach has established itself as a powerful method for investigating several complex phenomena of life. From a philosophical standpoint, the notion of life and of intelligence is continuously reformulated in relation to the dynamics of the system under observation and to the embedding environment, no longer a privilege of carbon-based entities with brains and eyes. At the same time, the possibility of engineering machines and software with life-like properties such as evolvability, self-repair, and self-maintenance is gradually becoming reality, bringing new perspectives in engineering and applications.

All these aspects, and many more, are reflected in the 90 papers presented at ECAL'99 from 13 to 17 September 1999 and collected in this volume. Each paper has been carefully reviewed by three members of the scientific committee (see list following the Preface) and selected from among 150 submissions. Of the selected and revised papers, 50 have been accepted as long oral contributions and the remaining 40 as short poster contributions. In both cases, the overriding selection criteria have been scientific and methodological soundness, novelty, and potential for future developments. In addition to the contributed papers, this volume includes the abstracts of four keynote lectures (H. Meinhardt, W. D. Hamilton, L. Steels, and T. Lenton) and two invited talks (D. Mange and D. Thalmann). At the end of each abstract, the reader will find a list of the most relevant references for these talks.

In addition to single-track presentations, demonstrations, and satellite workshops, the first day of the conference was dedicated to a series of tutorials covering genotype-phenotype mappings, collective intelligence, cellular automata and complex systems, synthetic actors, evolutionary robotics, and artificial chemistry.

Contributed and invited papers have been classified according to the following broad categories.

*Epistemology* is concerned with the philosophical aspects of Artificial Life. The two selected papers address two key concepts in Artificial Life: what an emergent phenomenon could be and when an entity may be defined as alive.

*Evolutionary Dynamics* (17 papers) addresses a number of fundamental issues in natural and artificial evolution. These include the interactions between evolution and other forms of ontogenetic dynamics, the role and effect of mutations, development of synthetic organisms, and measures of diversity and complexity in evolving systems.

*Evolutionary Cybernetics* (12 papers) is artificial evolution of mechanisms and structures that support behavior of biological and artificial organisms with a sensory motor system. The papers included in this section employ this methodology for both understanding the development and functioning of biological brains and for synthesising control systems of autonomous robots and of other artificial creatures.

*Bio-Inspired Robotics and Autonomous Agents* (15 papers) is a collection of contributions describing recent efforts in building physical and virtual agents with life-like properties, such as bio-inspired control, adaptation, human and animal morphologies, and behavioural autonomy. Some of these papers go as far as addressing motivation, emotions, and economic behaviour.

*Self-Replication, Self-Maintenance, and Gene Expression* (16 papers) includes papers that investigate some fundamental properties of micro-entities such as RNA, DNA, cells, and cellular aggregates. These micro-entities are capable of self-replication, self-maintenance, evolution, and development into full organisms from a set of genetic instructions. While some of the authors attempt to understand these principles with mathematical models and computer simulations, others incorporate them into a new generation of bio-inspired electronic circuits capable of complex behaviours.

*Societies and Collective Behaviours* (17 papers) display complex dynamics that cannot be understood by looking at single individuals in isolation. Sex, cooperation, selfishness, teaching, cultural transmission, distributed problem solving, or simple interference are some of the phenomena that one observes in assemblies of natural and artificial organisms. The papers in this section attempt to understand under which conditions these phenomena arise, when they develop, and how one could exploit them to create societies of artificial agents and robots capable of performing complex tasks.

*Communication and Language* (13 papers) goes one step further and investigates the emergence and role of communication in societies of organisms and intelligent machines. In most cases communication is considered a dynamic phenomenon arising in populations of organisms that evolve, learn, and dynamically form temporal aggregations. Within this conceptual framework, some papers address the origin of language in its many manifestations, ranging from speech to lexicon and syntax.

ECAL'99 was selected as the *1999 International EPFL-Latsis Foundation Conference*. Generous sponsorship by the Latsis Foundation allowed us to invite high-quality keynote lecturers, offer several student fellowships, and make

sure that the necessary resources were available for a successful organisation. Additional sponsors are listed on the next page.

The organisers thank very much Monique Dubois and Joseba Urzelai for their assistance. Monique ensured a smooth and professional organisation from day 1, taking care of every single detail with precision and patience, while Joseba managed all bits and tricks of electronic submissions and e-mails. Marie-Jo Pelaud kindly helped out whenever it was necessary. Our thanks also go to Luigi Pagliarini for the cover art and to Mark Peden for the caterpillar depicted in it.

Lausanne, June 1999

Dario Floreano  
Jean-Daniel Nicoud  
Francesco Mondada

## Organisation

ECAL'99 has been organised by LAMI-Mantra at EPFL in Lausanne.

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