“Artificial Life” (ALife) is a name given to theoretical, mathematical, and computationally “empirical” studies of phenomena commonly associated with “life,” such as replication, metabolism, morphogenesis, learning, adaptation, and evolution. It focuses on the materiality-independent, i.e., abstract, bases of such phenomena. As such, it overlaps extensively with “theoretical biology” and, less extensively, with certain areas of physics and chemistry and the social sciences. It also raises important philosophical questions. It is part of a larger research program into “complex adaptive systems,” one stream of contemporary systems theory.

In its intersection with computer science, ALife is the newest example of “the sciences of the artificial” (Herbert Simon). ALife is to life what AI is to intelligence. Christopher Langton writes that “Artificial Life ... complements the traditional biological sciences ... by attempting to synthesize life-like behaviors within computers and other artificial media.” The purpose is twofold: to understand these phenomena better and to develop new computational technologies.

The course will sample the research literature in this field. Topics to be emphasized are: (1) discrete dynamics: cellular automata and random networks, (2) ecological & evolutionary dynamics, (3) genetic algorithm optimization and adaptation, (4) agent-based simulation. Other topics include: “complex adaptive systems,” NK and self-organized criticality models, artificial and real chemistry (metabolism, reproduction), and philosophical issues. See the SySc ALife web page: [http://www.pdx.edu/sysc/research_alife.html](http://www.pdx.edu/sysc/research_alife.html).

**TEXTS**


2. Xeroxed articles reader (obtain at Smart Copy, 1915 SW 6th Ave, 227-6137)

**PREREQUISITES:** Graduate status or consent of instructor

**COURSE WORK:** Project or term paper; class participation.

&Guest presentations by Dr. Jeffrey Fletcher, SySc; Professor Melanie Mitchell, Computer Science; Professor Wayne Wakeland, SySc; Professor Niles Lehman, Chemistry.
## COURSE OUTLINE: (the font indicates the source: Overview, Reader) {} = optional

### 4/1 \hspace{1cm} INTRODUCTION \hspace{1cm} {Taylor, Langton\textsuperscript{a,b}, Kim\textsuperscript{a,b}}

Main topics:

**AUTOMATA DYNAMICS & COMPLEXITY**

4/3  
*EDGE OF CHAOS; CHAOS & RECONSTRUCTABILITY*  \(\text{Langton}\textsuperscript{c}, \text{Zwick}\textsuperscript{a,b})*

4/8  
*COMPUTING IN CAs*  \*Guest presentation: Prof. M. Mitchell, CS*  
\{Wolfram, \} Mitchell\textsuperscript{a}

4/10  
*GENE NETWORKS*  \(\text{Kauffman}\textsuperscript{a,b}, \text{Shmulevich}\{\text{Leemput}\})*

**EVOLUTIONARY & ECOLOGICAL DYNAMICS; GAMES**

4/15  
\(\text{Lindgren, Lindgren, Hillis, Kaneko})*

4/17  
*Guest presentation: Dr. J. Fletcher*  \(\text{Fletcher}\textsuperscript{a,b})*

**AGENT-BASED SIMULATION**

4/22  
*Guest presentation: Prof. W. Wakeland, SySc*  \(\text{Epstein\&Axtell})*

4/24  
\(\text{Resnick, Bonabeau, Langton\textsuperscript{a}, Carlson}\{\text{Loengarov}\})*

**GENETIC ALGORITHMS**

4/29  
*GA BASICS; ORDERING GENOMES*  \(\text{Mitchell, Holland}\textsuperscript{a}, \text{Mitchell}\textsuperscript{b}; \text{Shervais}\{\text{Knibbe}\})*

5/1  
*GENETIC PROGRAMMING, GAS & NEURAL NETS*  \(\text{Koza, Belew})*

Other topics:

5/6  
**COMPLEX ADAPTIVE SYSTEMS; ALIFE & AI**  
\(\text{Steels, Gell-Mann, Maes})*

*** Project/paper mini-proposals due; declarations to class ***

5/8  
**COMPUTER LIFE (TIERRA, VIRUSES).**  
\(\text{Ray, Ray}\{\text{Spafford}\})*

5/13, 15  
**NK MODELS; SELF-ORGANIZED CRITICALITY**  
\(\text{Kauffman}\textsuperscript{b,c}, \text{Bak}\textsuperscript{a,b})*

**CHEMISTRY**

5/20  
*REAL CHEMISTRY & WET ALIFE. Guest presentation: Prof. N. Lehman, Chemistry*  
\(\text{Breaker, Szostak, Rasmussen}\{\text{Schuster}\})*

5/22  
*ARTIFICIAL CHEMISTRY: AUTOCATALYTIC NETWORKS, METABOLISM, REPLICATION*  
\(\text{Fontana, Kauffman}\textsuperscript{b}, \text{Bagley})*

5/27, 5/29  
**GENERAL DISCUSSION; PHILOSOPHICAL ISSUES**  
\{Taylor, Langton\textsuperscript{a,b}, Kim\textsuperscript{a,b}\}  \(\text{Dennett, Harnad, Bonabeau})*

6/3  
*** Projects/papers due ***

6/3, 5  
**PROJECT/PAPER PRESENTATIONS**  \(\text{No class during finals week.})**
Abbreviations for sources for xeroxed articles


**DISTRIBUTED SEPARATELY**


**READER**

*INTRODUCTION*


*AUTOMATA DYNAMICS & COMPLEXITY*

Leemput, Koenraad; Bulcke, Tim Van den; Dhollander, Thomas; De Moor, Bart; Marchal, Kathleen; Remortel, Piet van, *Exploring the Operational Characteristics of Inference Algorithms for Transcriptional Networks by Means of Synthetic Data, Artificial Life 14*: 49-63 (2008).

*EVOLUTIONARY & ECOLOGICAL DYNAMICS; GAMES*

AGENT-BASED SIMULATION
Langton\(^a\): read 30-33; reference is above in INTRODUCTION

GENETIC ALGORITHMS
Knibbe, Carole; Fayard, Jean-Michel; Beslon, Guillaume, The Topology of the Protein Network Influences the Dynamics of Gene Order: From Systems Biology to a Systemic Understanding of Evolution, Artificial Life 14: 149-156 (2008).

COMPLEX ADAPTIVE SYSTEMS; ALIFE & AI

COMPUTER LIFE

NK MODELS; SELF-ORGANIZED CRITICALITY
Kauffman\(^a\): see reference above in AUTOMATA
Kauffman\(^a\), S. and Johnsen, S., Coevolution to the Edge of Chaos: Coupled Fitness Landscapes, Poised States, and Co-Evolutionary Avalanches. ALife II, 1991.

CHEMISTRY
Kauffman\(^b\): read 87-100; reference is above in AUTOMATA