ECE 750 Topic 32   **Artificial Life: Biology and Computation**
Fall 2022 – University of Waterloo
Instructor: Prof. Chrystopher L. Nehaniv   E7-6322   chrystopher.nehaniv@uwaterloo.ca
    with guest lectures by Prof. Kerstin Dautenhahn
Class Times: Tuesdays and Thursdays 11:30 am-12:50 pm in EIT 3151/3.

Text: Required and optional readings (articles, journal papers, book chapters) are assigned
weekly to students, and accessible on Course Reserves via Learn, or via links on the course
website on Learn. Required readings are to be read before the next class meeting.
There is no required textbook.

Course Grading:
- 30% Problem Worksheets. Frequent weekly worksheets (including several involving
  programming) will check and develop student understanding of concepts covered in-
  class.
- 60% Individual Term Project: Students first propose and then carry out an individual
  experimental project using artificial life techniques in a particular application area
  and critically evaluate the results. This is written-up as an 8-page IEEE-style
  formatted report to which all code and additional appendices must be added. All
  projects must be demoed to the instructor. The report has to demonstrate motivating
  background review, research questions and/or research hypotheses, software/system
  development, experimental results and analysis, and critical evaluation.
  NB: The written report (**not** the demo) will serve as the main basis of assessment.
- 10% Lecture Notes. Students will take turns on a rota to transcribe and typeset notes
  (in LaTeX) on the lectures to be shared with the class.

Artificial Life is the study of the simulation and synthesis of living or life-like systems. This
course treats the basic principles of biology and computation in nature that underpin the
organization of living systems in life as we know it, as it might exist elsewhere in the universe,
and in digital or artificial media. We explore the mechanisms within living individuals that
grow and change in a complex environment. This provides a variety of methods for
understanding, modeling, and designing complex adaptive systems, whether naturally
occurring or engineered, in simulation, in physical systems, with a view to applications of
artificial life as the foundation for artificial intelligence.

Course Topics Outline. (*order of topics will vary, with some topics interleaved and returned
to several times during the semester; content is subject to change):
1. Origins of Artificial Life, Cybernetics and AI: Simulation & Synthesis of Living and
   Life-like Systems, Properties of Life.
2. Biological Background for Engineers – Evolution of Life on Earth, Molecular
   Genetics, Genetic Code (and its digital aspects), Protein Biosynthesis & Darwinian
   Evolution. Digital Organisms.
3. Cellular Automata, Synchronous/Asynchronous Automata Networks, Genetic
   Regulatory Networks
4. Swarm Intelligence & Stigmergy
5. Self-Reproducing Systems
6. Evolutionary Systems, Sex, and Nature-Inspired Optimization
7. Models of Growth and Morphogenesis
8. Ethical issues for Artificial Life
9. Selected topics chosen from the following (if time allows):
   Theory and Applications of Differentiated Multicellularity as a computational
   paradigm; Evolution of Individuality; Evolution of Evolvability; Evo-Devo;
   Symbiogenesis; Major Transitions; Open-ended Evolution; Complexity and
   Interaction Machines; Nanomedicine; Artificial Cells; Origins of Life & Exobiology.

Students are expected to attend all lectures, take detailed their own notes, and participate in class discussions.

Students should be able to program well in at least one high-level computer language.

ECE M.Eng. students wishing to enroll should have achieved a mark of 80+ in ECE 650, or be able to present evidence of equivalent strong programming ability.

It is expected that students understand the university position on copying (in terms of assignments) and plagiarism (in terms of the project). All work / figures / code which are not your own must be explicitly identified.

Students enrolling agree to have their work checked on Turn-It-In to guard against plagiarism and collusion. (If you enroll but do not agree, please contact Prof. Nehaniv to discuss within the first two weeks of term.)

Auditors (those not enrolling for credit), if any, must register as auditors and are required complete all course elements (including project proposal) except for the final project report.

Email Policy: Only emails from a valid uwaterloo email address will be responded to. The email must contain the **full student name, student ID and course number**.
I endeavor to respond within 24 to 48 hours during working hours.

Important Dates:

Friday	**7 October 2022**	–	Individual Project Proposals Due by 5 p.m.
	(8-16 October 2022 is Reading Week – No Lectures)		
Monday	**28 November 2022**	–	Final Project Reports Due by 5 p.m.
Tuesday/Thurs	**29 Nov /1 Dec 2022**	–	Project Demo presentations in class from 11 a.m.
Tuesday	6 December 2022	–	[Reserve day for demos in class from 11 a.m.]

Worksheet assignments are open book in the sense that you may consult your readings, course notes, and materials posted in, or directly linked from, the course LEARN site, and also online materials. Inclusion of other material is permitted, but if this is done without proper citation, you may be subject to academic discipline. Use of any other resource without citation (including file-sharing services such as chegg.com, coursehero.com, stackexchange.com, ...) is prohibited. Assignments need to be completed on an individual basis; you must write up your text and solutions yourself in your own words. You must fully cite any material (e.g. text, figures, diagrams, tables, pictures etc.).

LaTeX lecture notes: When it is your turn to take notes for the class, log into https://www.overleaf.com using your University of Waterloo credentials to create your notes document. When finished, share the document allowing editing by the course instructor. Include only material presented in the lecture *and no external material.*

Individual Project Reports. Make sure to carefully cite the sources of all assertions made in your report, writing *in your own words* and using *quotation marks* around any direct quotes. Cite sources and authors of all software code you use or modify in your project. Paraphrasing or quoting long sections of text (more than one sentence), even with citations, from other sources is generally not appropriate, and may constitute academic misconduct.

All coursework and software code are subject to checking for collusion and plagiarism using Turn-It-In.

Turnitin.com: Text matching software may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

Course materials and any videos provided by the instructors must not be shared on social media or otherwise distributed in any form (including sharing links to them).
They are for your own personal use while studying at the University of Waterloo only, and are subject to copyright and intellectual property laws, and university privacy policies.
By taking part in the course, *you agree not to share this material or any links to it to anyone outside the course without instructor agreement.*

Please discuss with the instructor if you have concerns.

Compassionate Accommodation: If you are facing challenges that are affecting more than one course contact the Associate Chair Graduate Studies. They will review your case and coordinate a reasonable and fair plan in consultation with appropriate others (for example: instructors, Department Undergraduate Studies Committee, Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

Privacy and Remote Teaching and Learning. We expect this term to be taught in-person only, synchronously. In case this changes, the guidelines at the following URL will apply: https://uwaterloo.ca/privacy/policies-guidelines/privacy-and-remote-teaching-and-learning

Notice of Recording: In case we are forced to go online in the event of a pandemic lockdown, online lectures would be recorded. The URL of an event or an event session recording or copies of recording are not permitted to be disclosed to anyone, without the permission of the course instructor or event organizer. The URL should be available only to authorized participants who have been directly provided the link. Generally, we intend that only the instructors or TAs will be recorded, but the online platforms used may potentially record your audio or video. Student demos will not be recorded.

FACULTY OF ENGINEERING – MORE FINE PRINT

Faculty of Engineering website: *[Link* Academic Support and Policies *]*.

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect, and responsibility.
[Check Academic Integrity website for more information. Link Office of Academic Integrity].

Discipline: A student is expected to know what constitutes academic integrity (see link above) to avoid committing an academic offence, and to take responsibility for their actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example: plagiarism, cheating) or about expectations for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. Relevant documents include:
- University of Waterloo Policy 71 [Link Policy 71 Student Discipline].
- Academic Penalty Guidelines [Link Policy 71 Penalty Guidelines].
- Assessment of Unauthorized Collaboration: [Link Assessment of Unauthorized Collaboration].

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt please be certain to contact the **Associate Chair for Graduate Studies** who will provide further assistance.
[Link Policy 70 Petitions & Grievance.]

Appeals: A decision made, or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72 (Student Appeals)**.**

Note for Students with Disabilities: AccessAbility Services (AS), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require accommodations to lessen the impact of your disability, please register with AS at the beginning of each academic term.