

SYDE 750 Topic 37 / ECE 750 Topic 32 / SYDE 599

Abbreviated title: **Biology & Computation**

Full course title: **Artificial Life: Biology and Computation**

Fall 2021 – University of Waterloo

Instructors:

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Readings: Articles, journal papers, book chapters will be made available to students, assigned weekly. These should be read before the next class meeting. We also use sections of the book *Introduction to the Modeling and Analysis of Complex Systems* by Hiroki Sayama, which is free to download in pdf: <http://bingweb.binghamton.edu/~sayama/textbook/>

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Class Times: [REDACTED]

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 in artificial life as the foundation for artificial intelligence and biological modelling.

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; Origins of Life and Exobiology.

Course Grading for Graduate Students:

- 25% 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 instructors. 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.

- 15% Seminar Notes: Students will attend at least external 4 research seminars during the semester on topics related to Artificial Life, Biology & Computation, and submit a 1-2 page seminar summary and reflection document. Suitable seminars will be announced by the professors in the course of the seminar. Due dates to be announced.

Course Grading for Undergraduate Students:

- 50% Problem Worksheets. Frequent weekly worksheets (including several involving programming) will check and develop student understanding of concepts covered in-class.
- 50% 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 instructors. 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.

Expectations: Students are expected to attend all lectures, take detailed notes, and participate in class discussions online. We will endeavor to complete all this synchronously online, though we understand that may not always be possible due to Covid-19 and will adapt as needed.

Students should be able to program well in at least one high-level computer language. M.Eng. students wishing to enroll should have achieved a strong mark 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 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, 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 and student ID. Please include include the course code ECE750, SYDE750, SYDE599 in the subject line to indicate which you are enrolled in. We endeavor to respond within 24 hours during Monday-Friday.

Important Dates:

Friday	8 October 2021	– Individual Project Proposals Due by 5 p.m.
Friday	3 December 2021	– Final Project Reports Due by 5 p.m.
Monday	6 December 2021	– Project Demo presentations in class from 10 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 used (e.g. text, figures, diagrams, tables, pictures, code, etc.).

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.

Seminar Notes (Graduate Students Only). During the semester graduate students (those in enrolled in ECE/SYDE 750) will attend 4-6 relevant research seminars related to Artificial Life (details to be provided) and for each one write a 1-2 pp summary and reflection document). These will be marked for quality and content of scientific writing, and the top 4 scores will count toward the grade.

All coursework and software code is 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.

Privacy and Remote Teaching and Learning:

<https://uwaterloo.ca/privacy/about-information-and-privacy/guidelines-frequently-asked-questions/privacy-and-remote-teaching-and-learning>

Notice of Recording: In order to make lectures available for students in the event some are unable to attend synchronously, these will be recorded. The URL of an event or an event session recording or copies of recording are not permitted to be shared 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.

Course materials and 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 instructors if you have concerns.

SYDE/ECE Comment on Accommodation:

We respect that our graduate and undergraduate students are independent adult decision-makers, with many opportunities to partake in activities that might be in time conflict with academic deadlines and deliverables. Along with the right to make adult decisions comes the responsibility and accountability for those decisions and any outcomes.

The University of Waterloo's policy on accommodation for missed deliverables pertains to verifiable health matters, and highly unfortunate events (for example: family tragedies). The Faculty of Engineering follows University of Waterloo's general policy: students who self-elect to forgo a deliverable receive a "0" for that deliverable. It is preferred practice so that fairness is maintained for members of the same class/course by avoiding preferential treatment, and so that instructors are not burdened with having to create extra quizzes, deliverables, etc. It also reflects professional practice, as failing to show up to work and missing deadlines can be very costly to the company and individual (for example: not submitting a contract proposal, or design review on time). Please read the policy here: [Link [Accommodation due to illness](#)]

Academic priorities over Co-op interviews (Undergraduates):

With asynchronous schedules, undergraduate students should be able to arrange co-op interviews that do not conflict with major deliverables (for example: timed course midterms, final exams). For deliverables with longer time windows (for example: 24-48 hours or more), students must manage their time for deliverables and coop interviews accordingly. If a co-op interview conflicts with a short deliverable time window (for example: 1-3 hours), then students MUST follow the CECA procedure for rescheduling the interview: [Link [CECA rescheduling co-op interviews](#)]

Compassionate Accommodation:

If you are facing challenges that are affecting more than one course contact your Associate Chair Undergraduate, or 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/Graduate Studies Committee, Department Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

Academic Integrity, Grievance, Discipline, Appeals and Note for Students with Disabilities:

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: uwaterloo.ca/academic-integrity

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm When in doubt please contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity [check uwaterloo.ca/academic-integrity], to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course instructor, or the undergraduate or graduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm.

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 he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

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.