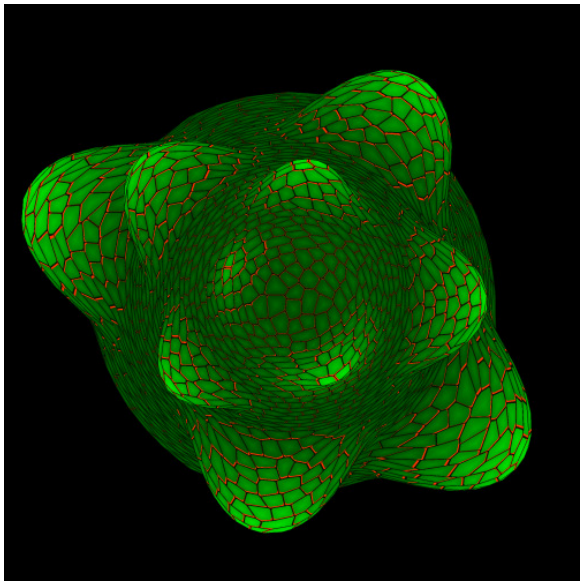
Courses in Systems Biology at the University of Bern



A computational model of pattern formation in the plant shoot
(Smith et al. PNAS 2006)

In 2008, the Swiss Federal Government initiated SystemsX.ch, a new research program in the area of Systems Biology. The University of Bern participates in two large RTD projects:
Plant Growth in a Changing Environment,
http://www.systemsx.ch/index.php?id=150;
Principal Investigator: Prof. Cris Kuhlemeier
and
NeuroChoice
http://www.systemsx.ch/projects/systemsxch-projekte/rtd-projekte/neurochoice/
Bern representative: Prof. Walter Senn

A major goal of SystemsX.ch is to promote education in systems biology at all levels. As part of this effort, we have collected data on systems-biology-related courses presently taught at the University of Bern. It is our hope that this brochure will expand rapidly and serve to promote teaching in systems biology.

Cris Kuhlemeier

What is Systems Biology

Systems biologists aim to understand living things as a function of their various interactions; not simply as a sum of all their individual parts. This more holistic approach to living systems culminates in being able to model them in a predictive fashion. Consequently a large part of this new approach to studying biological systems depends on interactions with computer scientists and other quantitative and theoretical scientists for it to succeed. Getting biologists to work with scientists from the more quantitative and theoretical, non-life science orientated disciplines, is one of the major challenges of this shift. However, the formation of these new relationships and interactions is exactly what the success of Systems Biology relies on. In sum, Biology should become a more quantitative and predictive natural science; and no longer a simple descriptive science of the world around us.

From:
SystemsX.ch The Swiss Initiative in Systems Biology

http://www.systemsx.ch/

Courses in Systems Biology at the University of Bern

1. Course on plant modeling

Plant modeling with L-studio, L-systems, and VV

Prof. Richard S. Smith

The aim of this course is to introduce students to plant modeling techniques, with an emphasis on hands-on work. Even without any prior programming experience, students will be able to learn how to program simple models of growing plants. This requires a formalism that can easily represent a dynamic system with a growing structure. The course will focus on a technique widely used for the one dimensional case (L-systems) and a relatively new method which is suitable for modeling sheets of cells in two dimensions (VV).

Course Type
Block Course (4 days): Lectures and hands-on student projects

Courses contents:
The course covers the basics of L-systems, including rewriting rules, turtle geometry, branching, parameters, context sensitivity, and fast information transfer. These concepts are used by sample models to demonstrate how to implement growth and development, signal propagation, and the solution to differential equations with L-systems. A variety of geometrical constructs useful in the visualization of plants are also presented, such as Bezier surfaces, and generalized cylinders.

Vertex-vertex (VV) systems are then introduced, building on topics covered in the L-systems section. The application of VV to two dimensional structures, such as sheets of cells and tip growth is presented. The course will demonstrate how to implement simple genetic regulatory networks, diffusion, transport, and physically based (mass-spring) simulations on these structures. Some techniques for implementing growth, such as radially symmetric growth and key-framing with Bezier surfaces are also presented briefly.

The course is hands-on, and everyone is requested to bring a PC laptop. The L-studio software environment and simulators will be installed on the students' laptops, as well as over 45 sample models. The sample models will be run by the students during the course lectures, and are designed to build on the students' knowledge in a stepwise manner as new concepts are introduced. As the lectures proceed, the students will be able to explore the effect of parameter and model code changes as new topics are presented. No previous programming experience is required.

https://wiki.systemsx.ch/display/PGRTDproj/Course+on+plant+modeling+in+Bern%2C+June+8-11th%2C+2010%2C+Dr.+Richard+Smith

Level: Masters and Ph.D. Students and PostDocs

ECTS: 1

Next Course dates: June 2011

Where: Bern, Institute of Plant Sciences

Contact: Richard.Smith@ips.unibe.ch

Webpage: http://www.botany.unibe.ch/associated/systemsx/index.php

Developmental Biology: from experiments to models

Profs Richard S. Smith and Cris Kuhlemeier

The aim of this course is to integrate classical developmental biology with computational approaches. It is explicitly directed at students both from biology and mathematics/computer sciences. Each topic will be discussed by the two lecturers who will connect biology with quantitative approaches. Student projects involve simple experiments for math students and introductory modeling for biology students.

Course Type
Lectures and hands-on student projects

Courses contents
Several topics in development will be covered in detail. The relevant biology and key experimental work will be introduced first, followed by the application of modeling techniques used to develop a greater understanding of the systems under study. Topics include: cellular differentiation in filamentous cyanobacteria, specification of leaf angles in plants (phyllotaxis), vein formation in leaves, flowering signals, and circadian rhythms. Modeling approaches applied to these areas include: one and two dimensional models of growth and development, signal propagation, the kinetics of chemical reactions and transport, genetic regulatory networks, reaction-diffusion and transport-based patterning and models of cells and cell division.

Level
Part of the Masters Program in Molecular Life Sciences

ECTS: 3

Next Course dates:
Fall semester 2010, Tuesdays 11.00-13.00

Where:
Institute of Plant Sciences

Contact:
Richard.Smith@ips.unibe.ch
Cris.Kuhlemeier@ips.unibe.ch

Webpage:
http://www.botany.unibe.ch/deve/index.php
http://www.botany.unibe.ch/associated/systemsx/index.php
http://evub.unibe.ch/pievub/n_index.asp?KursID=4106063&KursNr=W6350&UeberschriftID=682685&page=detail

Mathematical Modeling in Biology

Profs. Walter Senn und Thomas Wihler

The aim of this seminar is to expose students to the field of mathematical modeling in biology, with a special focus to models in ecology and neuroscience. In particular, the development of such models as well as their analytical, numerical and computational investigation will be focused on.

Course Type
Student seminar, 2h/week.

Courses contents
- Neural computation: models of single neurons, coding strategies of neurons, theory of learning and memory, theory of neuronal decision making
- population models in bounded habitats, modeling of different reproduction mechanisms by discrete and continuous models.
- understanding and investigation of models by means of analytical and numerical tools.

Level
Master students in mathematics, biology. physics

ECTS: 3

Next Course dates:
Spring semester 2011, time to be announced

Where:
Exakte Wissenschaften (EwWi)

Contact:
Prof. Dr. Walter Senn, senn@pyl.unibe.ch
Prof. Dr. Thomas Wihler, wihler@math.unibe.ch

Webpage:
http://www.math-stat.unibe.ch/content/lehrveranstaltungen/master_mathematik/fruehjahrssemester_2011/index_ger.html

Mathematical Modeling in Biomedical Sciences

Prof. Jean-Pierre Montani, PD. Jan Kucera, Prof. Walter Senn

Based on selected topics, the course gives an introduction into the technique of mathematical modeling in biomedical sciences. The topics cover control theory of organs in the human body, computer modeling of the heart electrophysiology, and the biophysics and computational theory of neurons and neuronal networks. Lectures are complemented with hands-on computer practicals.

Course Type
Block course with 12 lectures and 12 lessons computer practicals.
Lessons in English, exam with 18 Multiple Choice questions.

Courses contents
- Regulation of organ function in the human body by control circuitries, with a special focus to the kidney and the heart.
- Cardiac modeling: biophysics of the membrane, single receptors, and propagation of electrical waves across cardiac tissue.
- Computational neuroscience: mathematical models of neurons and networks, and the neuronal theory of learning and memory.

Level
Master students in biomedical sciences, mathematics, biology

ECTS: 2.04

Next Course dates:
Block course, first half of December 2010, time to be announced

Where:
Institut für Physiologie (Seminarraum, Bühlplatz 5, 3012 Bern)

Contact:
Prof. Dr. Walter Senn, senn@pyl.unibe.ch

Webpage:
http://studmed.unibe.ch/bmsc/
http://www.physio.unibe.ch/

Population genetics

Prof. Laurent Excoffier

Course Type
The course on population genetics is about 20 hours long and consists in a mixture of formal lectures (Tuesday, 10-12) and exercises (Thursday, 12-13).

Courses contents
1. Introduction to population genetics concepts. Wright-Fisher model of populations. Hardy-Weinberg equilibrium. Computation of allele frequencies from genotype frequencies
2. Inbreeding. Estimation of inbreeding from pedigrees.
3. Genetic drift and its consequences within and between populations.
4. Population subdivision, genetic structure of populations, migration models, F-statistics.
5. Fitness, deterministic models of selection (directional, balancing and disruptive selection models). Interaction between selection and genetic drift.
6. Mutation models.
7. Selection at the molecular level. Effect of selective sweeps on molecular diversity. MacDonald-Kreitman test.
8. Neutral theory of evolution. Concept of molecular clock.
9. Effect of recombination on genetic diversity, linkage disequilibrium.

Level
Biology, Bachelor in Biology (3, Semester)

ECTS: 1.5

Next Course dates:
Fall semester 2010

Where:
Institute of Ecology and Evolution (Haller-Auditorium, Baltzerstrasse 1, 3012 Bern)

Contact:
Prof. Dr. Laurent Excoffier, laurent.excoffier@iee.unibe.ch

Webpage:
http://evub.unibe.ch/pievub/n_index.asp?KursID=3552209&KursNr=W6275&UeberschriftID=624379&page=detail

R-Programming

Prof. Dr. Lutz Dümbgen

Course Type
Block course. According to special program.

Courses contents
Programming and data analysis with R

Level
Biology
- Bachelor in Biology, Specialisation in Ecology and Evolution (5th semester), and Master in Ecology and Evolution
- Biostatistics and quantitative ecology

ECTS: 2

Next Course dates:
Fall semester 2010

Where:
Institut für mathematische Statistik & VersicherungslehreAlpeneggstrasse 22, 3012 Bern

Contact:
Prof. Dr. Lutz Dümbgen, lutz.duembgen@stat.unibe.ch

Webpage:
http://www.math-stat.unibe.ch/content/lehrveranstaltungen/bachelor_mathematik/herbstsemester_2010/programming_and_data_analysis_with_r/index_ger.html

Cellular and genetic networks

Dr. Emi Nagoshi , and guestspeakers

Course Type
2 hours / week FS. Part of MSc BeFri project Neuro- and Developmental Biology

Courses contents
Genes and cells function in a complex web of networks to regulate any biological systems. Opposite to the reductionist approach to understand life sciences, the systems level approach is much needed and has been emphasized in recent years. In this course, we will primarily use "circadian rhythms" as an example of such complex systems and review the mechanisms of circadian clocks in organisms from bacteria to mammals (Emi Nagoshi, Urs Albrecht). In addition, the mathematical modeling approach (Christian Mazza) and another example of the cellular regulatory networks in yeast and flies (e.g. gene regulatory networks controlling cellular growth and cell cycle regulation; Claudio de Virgilio, Beat Suter) will be presented. External guests will be presenting their topics as well.

Level

Biologie
Bachelor in Biology, Specialisation in Cell Biology (5th semester) and Master in Molecular Life Sciences
Electives Bachelor in Cell Biology (B) and Master in Molecular Life Sciences (M)

ECTS: 3

Next Course dates:
Tuesday, 20.9.2010 - 24.12.2010, 13:00 - 15:00

Where:
Institut für Zellbiologie

Contact:
Prof. Dr Beat Suter, beat.suter@izb.unibe.ch
Dr. Emi Nagoshi, emi.nagoshi@izb.unibe.ch

Webpage:
http://evub.unibe.ch/pievub/n_index.asp?KursID=4181068&KursNr=W6381&UeberschriftID=682682&page=detail