SSCP2020 PROGRAM

The University of California San Diego, the University of Oslo, and Simula Research Laboratory welcome you to the joint

2020 Summer School in Computational Physiology
Models, Tools, and Techniques for Excitable Tissues

Course website: www.simula.no/sscp

Oslo, Norway 15-26 June 2020
Simula Research Laboratory: Oslo, Norway

General Schedule:
Theory (June 15-24):
09:00 - 12:00 – lectures
12:00 - 13:00 – lunch break
13:00 - 17:00 – lectures, programming lab work

Project (June 25-26):
There is no set schedule for project work. It is, however, expected that project teams take full advantage of this time. At least one advisor for each project will be available on site from 9:00-16:00 during this interval, and always via email.

Most SSCP2020 lectures will take place in “Storstua” auditorium at Simula Research Laboratory.

Sunday June 14

Evening session (16:00 – 19:00)
Python Tutorial (Jonas van den Brink)
• Strongly encouraged for newcomers to Python and/or programming

Monday June 15

Morning session (9:00 – 12:00)
Welcome to Simula (Managing Director Aslak Tveito)
Course introduction and overview (Kim McCabe)
• Preliminaries for software and overall course layout
• Expectations and assessment
L1: Keynote
L2: Physical chemistry and electrochemistry (Jonas van den Brink)
• Mass action
• Gibbs energy
• Enzyme kinetics and cooperativity
• Reaction rates and equilibria – code-based exercise

Afternoon session (13:00 – 17:00)

L3: Mass transport and membrane biophysics (Jonas van den Brink)
  • Diffusion and Fick's law
  • Planck's equation and Nernst equilibrium
  • Cell membrane
  • Membrane potential
  • The passive cell membrane – code-based exercise

SOCIAL EVENT
Evening MONDAY, 15 June: SSCP2020 Opening Dinner

Tuesday June 16

Morning session

L4: Ion channel gating (Glenn Lines)
  • Two-state channels
  • Channels with multiple subunits
  • Rate constants as probabilities
  • Waiting time and channel dynamics
  • Modelling sodium channel gating properties – code-based exercise
  • Stochastic and deterministic ion channel behavior – code-based exercise

Afternoon session

L5: Building modern ion channel models (Hermenegild Arevalo)
  • Markov models of ion channel function
  • Incorporating experimental recordings to build ion channel models
  • Parameterizing ion channel models to experimental data – code-based exercise
  • Major ion current formulations in the heart

L6: Combining ion transporter models to simulate the action potential (Hermenegild Arevalo)
  • Tissue-specific cell models (model lineages)
  • Building an AP model by combining channel models – code-based exercise

Wednesday June 17

Morning session

L7: Electrical conduction in biology (Joakim Sundnes)
  • Derivation of the cable equation
  • Passive flow in neurons
  • Active flow in excitable cells

L8: Modelling electrical conduction in cardiac tissue (Joakim Sundnes)
  • Simulating an excitable cable – code-based exercise
  • Simulating reentry – code-based exercise
  • Refractoriness and restitution

Afternoon session

L9: Quantitative aspects of calcium handling (Kim McCabe)
  • Calcium in excitation-contraction coupling
  • The sarco-endoplasmic reticulum calcium ATPase
  • The sarcolemmal Na⁺-Ca²⁺ exchanger
  • Calcium flux balance – code-based exercise
• Coupled ion channel and calcium handling model - code-based exercise

Thursday June 18

Morning session

L10: Fundamental cardiac mechanics (Andrew McCulloch)
  • Subcellular Cardiac Mechanics
    o Troponin C binding dynamics
    o Micro-structure of force development
    o Cross-bridge cycling
    o Regulation of force development
  • Continuum Mechanics

Afternoon session

L11: Myofilament dynamics (Kim McCabe)
  • Models of myofilament mechanics
  • Building a simple crossbridge model - code-based exercise
  • Exploring more complex models of myofilament mechanics - code-based exercise

Friday June 19

Morning session

L12: Continuum methods for biological systems (Alban Souche)
  • Introduction to the finite element method
  • Introduction to FEniCS – code-based exercise
  • Numerical error quantification

Afternoon session

L13: Mechanics Applications in FEniCS (Alex Diem)
  • Continuum mechanics in FEniCS
  • Darcy flow and soft tissue contraction – code-based exercise

L14: Week 1 summary (Kim McCabe)

Monday June 22

Morning session

L15: Electrophysiology Applications in FEniCS (Hermenegild Arevalo)
  • Cable equation in FEniCS
  • 2-dimensional dynamics (spiral waves) – code-based exercise

Afternoon session

L16: Model robustness and Optimization (Valeriya Naumova)
  • Derivative-free optimization methods
  • Derivative-based optimization methods
  • Sensitivity analysis – importance and approaches
  • Concepts in uncertainty analysis
Tuesday June 23

Morning session
L17: Introduction to Machine Learning (Valeriya Naumova)
- Machine learning fundamentals
- Local models, parameter selection

L18: Introduction to Data Mining (Evrim Acar Ataman)
- Data Mining fundamentals
- Principal Component Analysis — code-based exercise
- Applying PCA to ECG signals — demonstration

Branched curriculum – see below (continues Wednesday)

Tuesday afternoon and Wednesday (June 23-24)

Stream 1: Cardiac tissue mechanics and fluid dynamics (Joakim Sundnes, Alex Diem)
Stream 2: Cardiac tissue electrophysiology (Hermenegild Arevalo)
Stream 3: Neural electrophysiology (Tuomo Mäki-Marttunen)
Stream 4: Machine learning in physiological systems (Valeriya Naumova, Evrim Acar Ataman)

Thursday through Friday (June 25-26)

Supervised project work in teams June 25-26 will take place in assigned workspaces. Please note that there may be some guest lectures during this period. The school will finish at 2 pm on Friday June 26th.

Example Projects:
Project 1: Arrhythmia generation and maintenance in an ischemic pig heart
Project 2: Computational models of cardiac microtissues for drug side effects
Project 3: Modelling the role of glial cells in cortical spreading depression
Project 4: Describing brain dynamics with neural fields
Project 5: Mechanisms of tissue perfusion under strain
Project 6: Mechanisms of cardiac contraction and mechanics
Project 7: Effects of ventricular properties on systolic mechanics in simulated populations
Project 8: Characterization of neuroscience data through simulations and data mining
Project 9: Machine learning tools to uncover ischemic markers in a population of image-based virtual hearts

SOCIAL EVENT
Evening THURSDAY, 25 June: SSCP2020 Closing Dinner
San Diego, USA 10-18 August 2020
University of California San Diego: La Jolla, USA

General Schedule:
Unless otherwise noted, the schedule for August 10-18 will generally run from 9:00 am to 5:00 pm.
All lectures and workshops will take place in the Powell-Focht Bioengineering building.

Meals:
*Breakfast* and dinner are served at the Café Ventanas dining facility (near the Village Apartments) at the following times:
  - Breakfast 8-8:45
  - Dinner 6-6:45 pm
Students are responsible for their own lunches and are free to decide where to eat. The cost of lunch will not be reimbursed by the summer school.

Map:
Interactive map available here: [act.ucsd.edu/maps/](http://act.ucsd.edu/maps/)

Required Materials:
Laptop computer and power adaptors.

Assessment:
All students will be required to present their project work in journal club format on the 18th of August at UCSD. Following the presentation will be a Q&A session, in which professors, examiners and other students can ask about the project.

Students will additionally be required to submit a final report (4-5 pages) detailing their project work. This report should take the form of brief scientific paper (Background, Methods, Results, Discussion and Conclusions), and is to be submitted no later than midnight (CET) September 1, 2020

**Monday 10 August**
Location: B003 Classroom (basement of bioengineering building)
  - Time: 9:00 am – 4:30 pm
  - Workshop: “Scientific Writing and Publishing” - Nature Masterclass

**Tuesday 11 August**
Location: B003 Classroom (basement of bioengineering building)
  - Time: 9:00 – 4:30 pm
  - Workshop: “Scientific Writing and Publishing” - Nature Masterclass

By the end of Tuesday, August 11, students will be expected to have completed the Abstract and Introduction portions of their final paper.
**Wednesday – Monday (12-17 August)**

In general these three days will be used for project work in assigned workspaces at UC San Diego from 9-4. There will be guest lectures and workshops scheduled during this time, and one day will be dedicated to peer review between groups.

Example Lectures/workshops:
- Lab tours, Powell-Focht Bioengineering Hall (PFBH)
- "Simulating dynamics of second messengers in realistic geometries of dendritic spines" - Dr. Padmini Rangamani, Mechanical and Aerospace Engineering, UCSD
- "Tales from the fringe: succeeding as an academic in the Institute sector" - Dr. Molly Maleckar, Computational Physiology, Simula Research Laboratory
- “Ethics of Scientific Authorship” - Dr. Michael Kalichman, Research Ethics, UCSD
- Tips and Tricks for Effective Reviewing: An Editor’s Perspective” - Dr. Andrew McCulloch, Bioengineering, UCSD

**Tuesday 18 August**

*Location: Fung auditorium, bioengineering building*

*Time: 9:00 - finished*

Final exam in the form of journal club-style presentations with approximately 10 minutes per project team plus questions

**SOCIAL EVENT**

13:00 TUESDAY, August 18th (after presentations are finished)

Farewell Beach Party