SSCP2022 PROGRAM

The University of California San Diego, the University of Oslo,

and Simula Research Laboratory welcome you to the joint

2022 Summer School in Computational Physiology

Models, Tools, and Techniques for Excitable Tissues

Course website: www.simula.no/sscp

Oslo, Norway 20 June- 1 July 2022

Simula Research Laboratory: Oslo, Norway

General Schedule:

Theory (June 20-29):

   09:00 - 12:00 – lectures
   12:00 - 13:00 – lunch break
   13:00 - 17:00 – lectures, programming lab work

Project (June 30- July 1):

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.

SSCP2022 lectures will take place in the "Storstua" auditorium at Simula.

Sunday June 19

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

Monday June 20

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, 20 June: SSCP2022 Opening Dinner

Tuesday June 21

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 (Andy Edwards)
- 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 (Andy Edwards)
- Tissue-specific cell models (model lineages)
- Building an AP model by combining channel models – code-based exercise

Wednesday June 22

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: The EMI Model (TBD)
- Building the EMI model
- Applications in cardiac tissue
- Applications in neuroscience

Thursday June 23

Morning session

L10: Quantitative aspects of calcium handling (Jonas van den Brink)
- *Calcium in excitation-contraction coupling*
- *The sarco-endoplasmic reticulum calcium ATPase*
- *The sarcolemmal Na^+-Ca^{2+} exchanger*
- *Calcium flux balance – code-based exercise*
- *Coupled ion channel and calcium handling model - code-based exercise*

Afternoon session

L11: Fundamental cardiac mechanics (Andrew McCulloch)
- *Subcellular Cardiac Mechanics*
  - *Troponin C binding dynamics*
  - *Micro-structure of force development*
  - *Cross-bridge cycling*
  - *Regulation of force development*
- *Continuum Mechanics*

Friday June 24

Morning session

L12: 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*

Afternoon session

L13: The Finite Element Method (Cécile Daversin-Catty)
- *Introduction to the finite element method — code-based exercise*
- *Introduction to FEniCS – code-based exercise*

Monday June 27

Morning session

L14: Electrophysiology Applications in FEniCS (Hermenegild Arevalo)
- *Cable equation in FEniCS*
- *2-dimensional dynamics (spiral waves) – code-based exercise*

Afternoon session

L15: Mechanics Applications in FEniCS (Ingeborg Gjerde)
- *Diffusion — code-based exercise*
- *Darcy flow – code-based exercise*

Morning session

L17: Introduction to Machine Learning/ Data Mining (Gabriel Balaban)
- *Machine learning fundamentals*
- *Data mining fundamentals*
- *Principal Component Analysis — code-based exercise*
- *Applying PCA to ECG signals — demonstration*

Branched curriculum –
Tuesday June 28 (afternoon) - Wednesday June 29

Stream 1: Cardiac tissue mechanics and fluid dynamics *(Joakim Sundnes)*

Stream 2: Cardiac tissue electrophysiology *(Hermenegild Arevalo)*

Stream 3: Neural electrophysiology (*TBD*)

Thursday through Friday (June 30-July 1)

Supervised project work in teams 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 July 1st.

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

<u>**SOCIAL EVENT**</u>
Evening THURSDAY, 30 June: SSCP2022 Closing Dinner

University of California San Diego: La Jolla, USA

General Schedule:

Unless otherwise noted, the schedule for 8-16 August 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 6-6:45pm**

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/](#)

Required Materials:

Laptop computer and power outlet 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, 2022

Monday 8 August

Location: B003 Classroom (basement of bioengineering building)
   Time: 9:00 am – 4:30 pm
   Group project work with scientific advisors - compile results and finalise draft of paper abstract

Tuesday 9 August

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

Wednesday 10 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 Wednesday 12 August, students will be expected to have completed the Abstract and Introduction portions of their final paper.

Thursday – Monday (11-15 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 16 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, 16 August (after presentations are finished)
Farewell Beach Party