SSCP2023 PROGRAM

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

and Simula Research Laboratory welcome you to the joint

2023 Summer School in Computational Physiology

Models, Tools, and Techniques for Excitable Tissues

Course website: www.simula.no/sscp

Oslo, Norway 19 - 30 June 2023
Simula Research Laboratory: Kristian Augusts Gate 23

General Schedule:

Theory (June 19-28):

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

Project (June 29-30):

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 from 9:00-16:00 during this interval.

SSCP2023 lectures will take place in the HPL Lecture Hall (8th floor) at Simula.

Sunday June 18

Evening session (16:00 – 19:00)

Python Tutorial (Lena Myklebust and Oscar Odeigah)
- *Strongly encouraged for newcomers to Python and/or programming*
- *Pizza will be served for dinner*

Monday June 19

Morning session (9:00 – 12:00)

Course introduction and overview (Kimberly McCabe)
- *Preliminaries for software and overall course layout*
- *Expectations and assessment*

L1: Keynote (Andrew McCulloch)

L2: Physical chemistry and electrochemistry (Kimberly McCabe)
- *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 (Kimberly McCabe)
- *Diffusion and Fick's law*
- *Planck's equation and Nernst equilibrium*
- *Cell membrane*
- *Membrane potential*
- *The passive cell membrane – code-based exercise*

<u>***SOCIAL EVENT***</u>
17:00 MONDAY, 19 June: SSCP2023 Opening Dinner

Tuesday June 20

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 21

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 (Maria Hernández Mesa and Kimberly McCabe)
- *Calcium in excitation-contraction coupling*
- *The sarco-endoplasmic reticulum calcium ATPase*
- *The sarcolemmal Na^+-Ca^{2+} exchanger*
- *Calcium flux balance – code-based exercise*

Thursday June 22

Morning session

L10: 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*

Afternoon session

L11: Myofilament Dynamics (Kimberly 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 23

Morning session

L12: The Finite Element Method (Jørgen Dokken)
- *Introduction to the finite element method — code-based exercise*
- *Introduction to FEniCS – code-based exercise*

Afternoon session

L13: Electrophysiology Applications in FEniCS (Hermenegild Arevalo)
- *Cable equation in FEniCS*
- *2-dimensional dynamics (spiral waves) – code-based exercise*

Monday June 26

Morning session

L14: Mechanics Applications in FEniCS (Joakim Sundnes)
- *Continuum mechanics — code-based exercise*

Afternoon session

Guest Lecture: Bernardo Rocha, Professor, Juiz de Fora Federal University, Brazil
L15: The EMI Model (Aslak Tveito and Pietro Benedusi)
- *Building the EMI model*
- *Applications in cardiac tissue & neuroscience*
- *EMI in practice — code-based exercise*

Tuesday June 27

Morning session

L16: Introduction to Machine Learning (Mikkel Lepperød/V. Schøyen/K. Holzhausen)
- *Lecture 1: Real and artificial neurons*
- *Lecture 2: Reverse mode automatic differentiation (code based exercise)*
- *Lecture 3: Deep learning (code based exercise)*

Branched curriculum –

Tuesday June 28 (afternoon) - Wednesday June 28

Stream 1: Modeling cardiac tissue *(Hermenegild Arevalo, Joakim Sundnes)*

Stream 2: NeuroAI *(Mikkel Lepperød, Vemund Schøyen, Konstantin Holzhausen)*

Thursday through Friday (June 29-30)

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 30 June.

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
18:00 THURSDAY, 29 June: SSCP2023 Closing Dinner
ASIA Aker Brygge

San Diego, USA 7-15 August 2023

University of California San Diego: La Jolla, USA

General Schedule:
Unless otherwise noted, the schedule for 7-15 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 Pines dining facility (just south of the housing location) at the following times:
> **Breakfast 8:15-9:00am**
> **Dinner 6:30-7:15pm**

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 16th 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 (8-12 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, 2023

Monday 7 August

Location: B003 Classroom (basement of bioengineering building)
> *Time*: 9:00 am – 9:30 am
> Welcome and expectations for part 2 (Kimberly McCabe)

> *Time*: 9:30 am – 4:30 pm
> Group project work with scientific advisors - compile results and finalise draft of paper abstract. *Boxed lunches will be provided.*

SOCIAL EVENT
Evening MONDAY, 7 August: Welcome Reception

Tuesday 8 August

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

Wednesday – Monday (9 -14 August)

In general these three days will be used for project work in assigned workspaces at UC San Diego from 9:00-16:00. There will be guest lectures and workshops scheduled during this time:

- Examples from previous schools:
    - Francisco Contijoch, Assistant Professor, Bioengineering, UCSD
    - Wayne Giles, Professor Emeritus of Physiology and Pharmacology, University of Calgary
    - Daniela Valdez-Jasso, Associate Professor, Bioengineering, UCSD

Tuesday 15 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

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<u>*SOCIAL EVENT*</u>
13:00 TUESDAY, 15 August (after presentations are finished)
Farewell Beach Party - La Jolla Shores

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