THE UNIVERSITY OF SYDNEY
MATH3888

| Semester 2 | Interdisciplinary Mathematics Project Unit | 2020 |
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# INFORMATION SHEET

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| **Coordinator:** | Martin Wechselberger | (martin.wechselberger@sydney.edu.au) | |
| **Lecturers:** | Georg Gottwald | (georg.gottwald@sydney.edu.au) | Project 1 |
| | Martin Wechselberger | (martin.wechselberger@sydney.edu.au) | Project 2 & 3 |
| **Mentors:** | Cathy Liu | (xliu0689@uni.sydney.edu.au) | Project 1 |
| | Ian Lizarraga | (ian.lizarraga@sydney.edu.au) | Project 2 |
| | Sam Jelbart | (sjel7292@uni.sydney.edu.au) | Project 3 |

**Course delivery:**

The whole unit (lectures & labs) will be delivered online!

**General outline:**
The focus of this interdisciplinary project unit is on biochemical/physiological problems. We offer three interdisciplinary project streams, and you will be introduced to 'real' lab data and/or experiments. The aim will be to understand the experimental observations by means of mathematical modelling and analysis.

Modelling can provide mechanistic understanding of a given system without having to perform large numbers of trial-and-error experiments. One can consider graphical models, such as cartoons of biochemical pathways, as simple examples of qualitative models. Qualitative models have inherent limitations because they rely on interpretations which are not amenable to analysis by mathematics and computer algorithms. For this reason, quantitative models will be the subject of interest in this unit. Students will analyse these models using maths software packages (e.g. Matlab & MatCont, Python,...) and perform numerical experiments.

**Learning outcomes:**
- learn about the biochemical/physiological problem application from biochemistry/physiology peers
- get a basic understanding of the methods of biochemical/physiological research. You will participate in the lab work (albeit mainly as an observer). It is important that you appreciate both the potential and the limitations of experimental work.
- conceptualise the problem in mathematical terms and develop mathematical models/ideas
- explain to the biochemistry/physiology peers how your modelling represents their system; learn new mathematics as required
- solve/analyse the model numerically using suitable software
- critically assess the modelling in light of experimental results and the experimental system
- work together with all other students in the group to produce outputs such as lab/project reports, posters or oral presentations

**Project 1: Protein-Protein Interaction Networks (together with BCMB3888):**
This project is concerned with *protein-protein interaction* (PPI) networks. Certain diseases are crucially linked to the interaction between certain proteins. Using yeast as a study set, which comprises more than 6,500 nodes with more than 1.8 million interactions between them, you will use sophisticated complex network theory and their algorithmic implementation to identify in close discussion with your biochemist colleagues particular proteins and their interactions related to certain diseases. Equipped with this information your biochemist colleagues will then explore experimental approaches to study the effects of regulation or deletion of the protein on the organism.

**Project 2: Planaria Regeneration (together with MEDS3888):**
You will be looking into *planarian* (a flatworm) which has this amazing ability to regenerate, i.e. when cut into pieces, each piece has the ability to regenerate into a fully formed individual. Understanding how morphology emerges from the activity of cellular pathways is a key goal of developmental and regenerative biology. Your physiology peers will design experiments that alter the planaria signalling pathways through specific drugs implicated in the treatment of Covid19. The outcome might be a different morphology (e.g. tail instead of a head), and your aim will be to understand the 'switching' mechanism of the morphology by means of mathematical modelling and analysis.

**Project 3: Cell Calcium Signalling (together with MEDS3888):**
This project focuses on the kinetics of *calcium signals*. This is an exciting topic since calcium is the main signal agent of life and death in our body. Cell calcium signals have the ability to create very different temporal rhythms – from milliseconds to minutes and even hours. The aim is to uncover the mechanisms of calcium oscillations from both the physiological and the mathematical point of view. You will be introduced to real lab experiments & data and see how calcium signals are actually measured (fluorescence imaging of cardio-myocytes). Your aim will be to understand the observed rhythms & signals by means of mathematical modelling and analysis.

**Assessment:**

Lab Reports: $4 \cdot 5\% = 20\%$, Presentations: $2 \cdot 10\% = 20\%$; Project reports: $20\% + 30\% = 50\%$

**Participation:**
Active participation is crucial and, hence, mandatory for this project unit (your participation will be recorded). 80% attendance required to pass this unit.

**Lab reports:**
You will document your lab experiments/findings and submit a written report after each lab session (weeks 6-9).

**Presentations:**
You and your group will give two presentations about the biochemistry/physiology, lab & modelling experience using Beamer (LaTex), Keynote (macOS) or Powerpoint (Windows). (week 5 and week 12)

**Project reports:**
- Your group will submit a final report about your interdisciplinary project (week 12, details TBA).
- You will also create a final individual (more mathematical specific) report (week 13, details TBA). This final report will be a Latex document which will consist of several chapters: (i) biochemistry/physiology of the problem under study (ii) modelling of the problem under study, (iii) numerical implementation of these models and (iv) analysis of these models. Submission (of a pdf file) will be via turnitin.