Cell Physics Master Program

2019-2020

Daniel Riveline

This short document gives the outline of the year with contents for the lectures. The website is http://www.cellphysics-master.com/, and it will be completed with the yearly schedule, names of lecturers, contents of lectures.

In September, students have basics classes – with a stay in mountains with lecturers. From October to February, they attend lectures in classrooms in parallel to practicals. Once a week, they will meet Daniel Riveline for 1 hour to address points such as 'translations' between fields/topics, the latest and the classical references, concrete questions of organisation about the program.

September 2019

Basics : final exam

- **Basics in Biology : C. Gally (24 hours)**

This course will allow the students from Physics/Chemistry/Biology backgrounds to be exposed to the basics in Biology.

- DNA/RNA/protein
- Prokaryotic cells/Eukaryotic cells : compartments and their functions
- Multicellular organisms and model systems/plants
- Signaling pathways : examples and meanings
- The cytoskeleton
- Basics in evolution
- Novelties in Biology

- **Basics in Physics : T. Charitat/ F. Thalmann (16 hours)**

This course will allow the students from Maths/Chemistry/Biology backgrounds to be exposed to the basics in Physics.

- Life at low Reynolds number
- Energy, minimization of energy
- Elasticity : examples with polymers and with simple visco-elastic materials
- Physics of membrane : examples with caveolae
- Hydrodynamics : the Navier-Stokes equation
- Scaling
- Phase transition
- Novelties in Physics

- **Basics in Chemistry : M. Mauro (16 hours)**

This course will allow the students from Maths/Physics/Biology backgrounds to be exposed to the basics in Chemistry.

- Basics in Chemical Biology : basic reactions
- Basic reasoning and strategies in synthesis
- Classical methods for characterisations
- Novelty in Chemical Biology

- **Basics in Maths : L. Navoret (16 hours)**

This course will allow the students from Chemistry/Physics/Biology backgrounds to be exposed to the basics in Maths.

- Differential Calculus
- Solving Partial Differential Equation
- Stochastic differential equation and Brownian motion
- Cell Displacements and collective effects : examples with Vicsek models and comparisons with experiments
- Novelties in Mathematical Biology

October-February 2020

Physics :

60 hours, final exam

K. Kruse : Introduction to active gel theory and applications on cellular scales (9 hours)
Out-of-equilibrium physics : principles
Active gels : definitions, the cytoskeleton from a theory point of view
Stress generations
Active hydrodynamics
Cell migration

F. Graner : From cell to tissue : multiscale physics of epithelial tissues (9 hours)
Models for cell monolayers : lists of approaches
Energy for tissues
Experimental methods
Strengths and limits in comparisons theory/experiments

G. Salbreux : Physics of biological tissues as active fluids (9 hours)
Continuum description of an active fluid
Examples of flows induced by tissue growth

T. Guyomar : Exercices on theory

I. Kulic : Dynamics of the cytoskeleton (theory)

A. Ott : Experimental biophysics (10 hours)
Rheology of active gels
Rheology of cells/monolayers
Origin of life

P. Didier : Biophotonics (10 hours)

M. Maaloum/ S. Harlepp : Forces and micromanipulations, AFM and optical tweezers **(4 hours)**

Biology

60 hours, final exam.
Systems biology : G. Charvin/N. Molina/A. Dejaegere (16 hours)
Noise in expressions and its consequences
Basic circuits in systems biology
Experimental design and models
Links with electronics
Omics and identification of networks/motifs

The biology of population : J. Schaecherer (12 hours)
Yeast as a model system
Genome and its study
Model and experiments in the fields

Model systems /reconstituted systems (16 hours)
C. elegans (A.C. Reymann)
Rho and optogenetics (O. Pertz)
Zebrafish and the heart (J. Vermot)
Drosophila : information processing (T. Gregor)
Actin *in vitro* (A.C. Reymann)
Mouse : Division and cell fate (J.L. Maître)
Physics of fission *in vitro* (S. Morlot)

Classics in Biological Physics : Daniel Riveline (16 hours)
Analysis of classical articles
Recent developments

Chemistry :

20 hours, final exam.

Strategies for surface engineering (L. Jierry , D. Vautier)
Strategies for screenings (A. Klymchenko, A. Reisch)

Maths :

20 hours, final exam.

Pierre Degond (ICL) : Maths for collective displacements
Marcela Szopos (UDS): Numerical methods for the Stokes/Navier-Stokes equation
Nicolas Meunier (Paris Descartes) : Models for cell interactions
Jean Bérard (UDS) : Probalistic model for genetics
Vincent Calvez (ENS Lyon): Maths for chemotactism

Practicals :

60 hours, final exam – 4 compuls.

Microfabrication in the clean room (IPCMS) H. Majjad : (16 hours)
Design of masks

Realization of replica
Preparation of chips

Microfluidics : M. Ryckelynck (16 hours)
Chips designs
Drops preparation
Directed evolution

Machine shop : INSA (16 hours)
Design of mechanical parts for manipulation and control
Fabrication of simple parts
Control with a PC

Numerical simulations : ESBS (16 hours)
Matlab and applets for living matter
SciLab
Code writing
Troubleshooting
Results

Molecular Biology/Cell Biology : ESBS/IGBMC (16 hours)
Design of primers
PCR
Preparation and characterization of a fluorescent construct
Transfection
Basics in cell biology : cultures and observations

Imaging : IGBMC (16 hours)
Optical microscopy : epifluorescence/spinning disk confocal
2 photon microscopy
FRAP/FRET
Super-resolution
Electron microscopy : basics

Electronics : INSA (16 hours)
Feedback loops
Op-Amp : basic logic circuits
Strategies for backward engineering in electronics
Links with systems biology

Editing/Patent meetings : Lectures on editorial activity from Editors and on patents from CEPI Engineers (Patents School for Patents Engineers located in Strasbourg)

Scientific writing : Lectures on writing a PRL, refereeing, re-submitting.

March-June

Internship in laboratories, defense in June (oral with written documents).

The year after : possibilities for three rotations of 4 months before selecting a Lab. for the PhD.