Cell Physics Master Program

2016-2017

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. Facebook and Tweeter will be used for diffusing didactic news in the field.

In September, students have basics classes in the fields they do not know – with time in mountains with lecturers. From October to February, they attend lectures in classrooms in parallel to practicals. Once a week, they will meet me (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 2016

Basics : final exam

- **Basics in Biology : C. Gally (16 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 : G. Fuks (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 2016

Physics :

60 hours, final exam

K. Kruse : Active gels (16 hours)
Out-of-equilibrium physics : principles
Active gels : definitions, the cytoskeleton from a theory point of view
Stress generations
Active hydrodynamics
Oscillations
I. Kulic : Dynamics of the cytoskeleton (theory)

F. Graner : Physics of epithelial tissues (14 hours)
From cell to tissue
Structure and dynamics of tissues, *in vivo* and *in vitro*
Analogies and differences with cellular materials in physics
Experimental methods, from image analysis to force measurements
Models : strengths and limitations

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

R. Voituriez : Physics of Cell motility and Cell polarity (6 hours)
Active gel models of cytoskeleton dynamics: active transport and active stress
Minimal models of cell motility, from mesenchymal to amoeboid
From cell mechanics to cell trajectories

P. Didier : Biophotonics (10 hours)
Light-matter interaction (absorption, emission and diffusion)
Probing biomolecular interaction with fluorescence spectroscopy (Energy transfer, anisotropy, stop flow)
Optical microscopy (basics, diffraction limit, high-resolution imaging)
Quantitative fluorescence imaging (Fluorescence Lifetime Imaging Microscopy, single molecule experiments)

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

Biology :

60 hours, final exam.

Systems biology : G. Charvin/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. Schacherer (12 hours)
Yeast as a model system
Genome and its study
Model and experiments in the fields

Model systems / reconstituted systems (16 hours - 2 hours lectures)
C. elegans (S. Jarriault)
Mouse and epigenetics (M.E. Torres Padilla)
Zebrafish and the heart (J. Vermot)
Drosophila : dynamics (T. Lecuit/ P.F. Lenne)
Actin *in vitro* (L. Blanchoin)
Plants and development (O. Hamand)
Physics of fission (A. Roux)
To be completed

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, continuous control – 4 compuls.

Microfabrication in the clean room (IPCMS) H. Majjad : (15 hours)
Design of masks
Realization of replica
Preparation of chips

Microfluidics : M. Ryckelynck (15 hours)
Chips designs
Drops preparation
Directed evolution

Machine shop : INSA (15 hours)
Design of mechanical parts for manipulation and control
Fabrication of simple parts
Control with a PC

Numerical simulations : IPCMS/UFR Maths (15 hours)
Matlab and applets for living matter
SciLab
Code writing
Troubleshooting
Results

Molecular Biology/Cell Biology : ESBS (15 hours)
Design of primers
PCR
Preparation and characterization of a fluorescent construct
Transfection
Basics in cell biology : cultures and observations

Imaging : IGBMC (15 hours)
Optical microscopy : epifluorescence/spinning disk confocal
2 photon microscopy
FRAP/FRET
Super-resolution
Electron microscopy : basics

Electronics : INSA (15 hours)
Feedback loops
Op-Amp : basic logic circuits
Strategies for backward engineering in electronics
Links with systems biology

Administration and Patent meetings : meetings three times a year with students from **ENA** (National School of Administration located in Strasbourg) and from the **CEPI** (Patents School for Patents Engineers located in Strasbourg).

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.