Emergent Order in Biology

International Summer School, Cargèse, France, July 23 - Aug 3 2012

Final Report

Organisers: Pierre Sens — ESPCI, Paris, France.
Matthew Turner — University of Warwick, UK.
Massimo Vergassola — Institut Pasteur, Paris, France.

1. Summary

There has been much recent interest in the emergence of order in complex systems from academic communities based in Physics, Mathematics, the Social Sciences and Biology. There is, simultaneously, great interest in bringing quantitative techniques to bear to understand the function of Biological systems. This school sits at the intersection of these two interests.

The school was focussed on providing a stimulated learning environment for PhD students and junior scientists. There was also be a strong focus on current research in general and the research interests of all participants in particular.

1.1 Composition of participants

The school had 3 organisers, 7 lecturers and 54 other participants. Of these participants a small fraction were postdocs and masters students, while the vast majority were PhD students. 9 participants and one lecturer were female while a number of the a number of the participants either originated in developing countries or were currently studying there. Roughly half of the remaining participants were from Europe (UK, France, Germany, Italy, Spain and Finland) with the rest originating from the USA together with a small number from other countries, notably India and Israel.

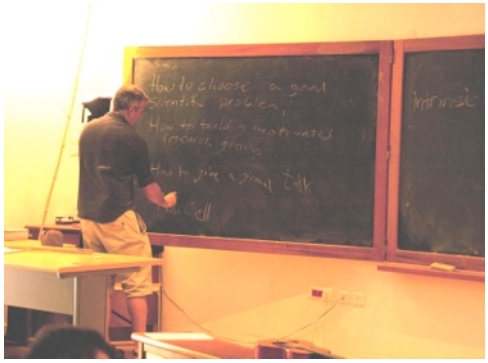
2. Scientific content, lecture format and discussion

2.1 Lecture format and problem classes

We chose a number of lecturers specifically for their expertise and approved the lecture syllabi with them in advance. See pages 7-13 for a complete listing of the school

lecturers and associated syllabi. The topics for the lectures were chosen to represent conceptually important and vibrant subjects that could be presented within the time constraints available. The lecturers were also made aware of the varied backgrounds of the participants. While most were familiar with basic physics,, a few of the participants had stronger backgrounds in Biology. Some of the lecturers chose to use the blackboard while others chose to present slides. We will not include these in this report but they will continue to be made available, together with other supporting material, at http://homepages.warwick.ac.uk/~phscz/cargese2012/

Lecturers were typically assigned five, 60 minute time-slots in which to present a coherent series of lectures on a specific research field (see photo, right). These lectures were supported by one 90 minute problem class which was used by the different lecturers in a number of different ways. Some lecturers chose to look at worked problems while others chose to set group assignments in which groups of students were assigned different papers. In this model typically 1/3 of the school were in each group and the papers that they were asked to read were considered by the lecturer to convey a particularly important concept, result or technique. The individual groups were then invited to report on their analysis of the paper. All participants were then invited to participate in a question-and-answer session, moderated by the lecturer. One special short lecture course was offered by Prof David Nelson (Harvard) who presented three different research problems. These presentations were particularly popular with the students.



Questions from participants were invited at any stage throughout the school. There was a pleasing level of engagement with a regular stream of questions during lectures. Questions were explicitly invited at the conclusion of each lecture and these sessions were often particularly stimulating. The formal questions sometimes had to be cut short for the program to remain on schedule but the timetable was designed to incorporate regular discussion sessions, at which coffee was provided (see photo, right). Vigorous informal discussions between the participants and both the lecturers and school organisers, as well as between the participants themselves, developed spontaneously at these sessions. An atmosphere of scholarly interaction and exchange was regularly present at these sessions.

With the approval of the lecturers the lectures were all recorded on video. We understand that this footage will be edited and later disseminated via the ICAM website http://icam-i2cam.org

2.2 Additional personal development sessions

We were extremely fortunate to have one of the school's lecturers, Prof Uri Alon, offer to run two informal sessions with the participants on the subject of the psychology and dynamics of being a scientific researcher and on the social dynamics within research groups. The first session was accompanied by songs of Prof Alon's own composition, accompanied by the guitar (photo, right). Many of the participants found these sessions uplifting and helpful.

2.3 Participant presentations

Participants were given the opportunity to chose to present their research interests in two different formats. The first of these was in timetabled, oral seminar presentations to the whole school lasting 20 mins (15 mins + 5 minutes for questions). A number of students chose this format (see detailed information on these presentations on pages 35-39 and the time table for the presentations circulated to the students on page 14). The vast majority of students also participated in one of the two timetabled poster sessions, which were held outdoors and accompanied by wine and snacks. These proved extremely popular, overrunning their scheduled end times on both occasions.

3. Assessment of the results

The organisers continually assessed the success of the school while it was in progress and regularly conferred on minor schedule changes and approved slot-swapping between students.

We also received a number of comments to an email questionaire conducted by us. These are appended on pages 19-21. A summary of these is that they were overwhelmingly positive. The school environment in general was popular and the lectures and general organisation were praised, as well as the poster sessions in particular. The rare negative comments included a minority who felt that the delivery of one of the lecture courses was rather fast and one individual who made some criticisms of the local travel arrangements on arrival. All students did arrive safely and on time. In spite of these rare negative comments the overall tone of the feedback was extremely positive

We believe that the school was a resounding success. The organisers felt that the quality of student presentations was exceptionally high.

4. Contents

The following pages contain supporting material from the school itself that was made available to the students as well as material posted to the website and information on student presentations. This is indexed as follows:

5. Course outline

Complex, non-equilibrium phenomena in living systems are currently of great interest to researchers with backgrounds in a number of traditional and non-traditional disciplines. These include soft matter physics, quantitative and systems biology, mathematical biology and the experimental biosciences, amongst others. To understand the way in which complex behaviour and order typically emerges from a large number of smaller interacting subsystems we need to make progress both on solving (and posing) formal problems and on understanding experiments. The present workshop will focus on this question under the title emergent order in biology. The aim of the workshop will be to present the state of the art of our understanding of a number of rapidly evolving fields and to promote discussions and interactions between participants.

PROGRAM

Timetable: EMERGENT ORDER IN BIOLOGY - Cargèse July 23 - August 4 2012

Week #1

	Monday 23	Tuesday 24	Wednesday 25	Thursday 26	Friday 27	Saturday 28	Sunday 29
8h45 - 9h45	**Arrival**	Shraiman 1	Cavagna 2	Cavagna 3	Shraiman 4	Cavagna 4	**Free Day**
9h45 - 10h45		Cavagna 1	Shraiman 2	Altan-Bonnet 3	Altan-Bonnet 4	Shraiman 5	
10h45 - 11h15		Coffee	Coffee	Coffee	Coffee	Coffee	
11h15 - 12h15		Altan-Bonnet 1	Altan-Bonnet 2	Shraiman 3	Altan-Bonnet 5	Cavagna 5	
12h15 - 2h		Lunch	Lunch	Lunch	Lunch	Lunch	
2h - 3h		Sem	Sem	Sem	Sem	**Free 1/2 day**	
3h - 3h30		Coffee	Coffee	Coffee	Coffee		
3h30 - 5h	Welcome	Sem	Shraiman	Cavagna	Altan-Bonnet		
Evening		Apéritif	Poster	Student's BBQ		Boat Cruise	

Week #2

	Monday 30	Tuesday 31	Wednesday 1	Thursday 2	Friday 3	Saturday 4
8h45 - 9h45	Prost 1	Alon 2	Dogterom 3	Prost 4	Alon 5	**Departure**
9h45 - 10h45	Dogterom 1	Prost 2	Prost 3	Dogterom 4	Prost 5	
10h45 - 11h15	Coffee	Coffee	Coffee	Coffee	Coffee	
11h15 - 12h15	Alon 1	Dogterom 2	Alon 3	Alon 4	Dogterom 5	
12h15 - 2h	Lunch	Lunch	Lunch	Lunch	Lunch	
2h - 3h	Nelson 1	Sem	Nelson 2	Nelson 3	Sem	
3h - 3h30	Coffee	Coffee	Coffee	Coffee	Coffee	
3h30 - 5h	Sem Alon's special	Sem	Dogterom	Prost	Alon	
Evening		Poster	Prost - Public	Dinner in town	Closing	

X i	ith lecture of speaker L
X	Problem/research class supporting the lecture course of speaker X
Sem	Seminar by students

Boris Shraiman - UCSB (Santa Barbara)

STATISTICAL GENETICS

◊ lecture 1: Basic Elements of Evolutionary Dynamics:

* Natural selection and the sources of genetic variation
* The Wright-Fisher model of evolutionary dynamics
* Kimura's Diffusion theory of genetic “drift”
* Evolution as a stochastic branching process

◊ lecture 2: Genealogy:

* Coalescent theory description of population history
* Statistical properties of Kingman’s neutral coalescent
* Parameter inference via coalescent.
* Effect of selection on the structure of the coalescent.

◊ lecture 3: Natural selection in asexual populations:

* Purifying selection: Mutation-selection balance
* Muller’s Ratchet.
* Rate of asexual adaptation.
* Clonal interference.

◊ lecture 4: Adaptation in recombining populations:

* How to model recombination.
* Extinction and long-term survival.
* Benefit of sex: reduction of clonal interference.
* Genetic hitch-hiking and quasi-neutrality

◊ lecture 5: Alleles vs Genotypes: a theory of multi-locus selection:

* Epistasis,recombination and heritability of quantitative traits.
* Quasi-linkage equilibrium in the frequent recombination regime.
* Fisher’s “Fundamental Theorem” and additive genetic variance.
* Breakdown of quasi-linkage equilibrium and clonal condensation.

Andrea Cavagna - ISC-CNR (Roma)

COLLECTIVE BEHAVIOUR IN BIOLOGICAL SYSTEMS

◊ lecture 1: introduction

* examples: a phenomenon on many scales
* fundamental questions
* physics vs biology
* how the get information from the data

◊ lecture 2: Structure

* relevant observables
* radial correlation function
* anisotropy of the neighbours
* topological vs metric interaction
* the problem of the border

◊ lecture 3: correlation

* relevance of fluctuations
* velocity correlation function
* correlation length
* scaling relations and scale-free correlations
* orientation vs speed: soft vs hard modes

◊ lecture 4: inference and maximum entropy method

* general Bayesian framework
* the problem of the prior
* the minimal model compatible with the data: maximum entropy
* caveats

◊ lecture 5: maximum entropy for flocks

* how to cope with motion: spins vs birds
* spin wave approximation
* maximum entropy for orientation
* maximum entropy for speed
* near the critical point?

Grégoire Altan-Bonnet - MSKCC (New York)

SYSTEMS IMMUNOLOGY: bottom-up approaches to model the immune response

◊ lecture 1: introduction to the immune system: main players and quantitative challenges.

◊ lecture 2: self/non-self discrimination, from the molecular to the cellular level (part 1)

◊ lecture 3: self/non-self discrimination, from the molecular to the cellular level (part 2)

◊ lecture 4: emerging dynamics of a collection of lymphocytes: phenotypic variability, differentiation, synchronization (part 1)

◊ lecture 5: emerging dynamics of a collection of lymphocytes: phenotypic variability, differentiation, synchronization (part 2)

Jacques Prost - ESPCI (Paris)

PHYSICS OF CELLS AND TISSUES

◊ lecture 1: Active Gels

* Generic equations: active nematic gel, active polar nematic gel, active isotropic close to nematic ordering
* Comparison of gradient expansion with generalized hydrodynamics
* Density fluctuations
* Comparison between one component and multicomponent expansion

◊ lecture 2: Active Gels

* Cell oscillations
* Cell wound healing: orientation field, flow field, healing speed
* Cytokinesis: small amplitude deformations, flow and orientation fields; large amplitude, separation threshold, closure dynamics

◊ lecture 3: Tissue Dynamics

* Homeostatic stress
* Competition for space
* Simulations: importance of homeostatic stress
* One component description: fluidification on long time scale
* Cell diffusion
* Simulations : fluidification in silico

◊ lecture 4: Tissue dynamics

* Two fluid description: equations, experimental significance of the hydrodynamic screening length, effect of gravity
* Diffuse interface: link with Fisher Kolmogorov-Petrovskii-Piscounov equation
* Cell spheroids: growth experiments under controlled stress

◊ lecture 5: Tissue Dynamics

* Intestinal Villi: small intestine, colon and more
* Tubular Pathologies: arteries and trachea
* Thick Epithelia: steady state and instability

Marileen Dogterom - AMOLF (Amsterdam)

ASSEMBLY AND ORGANIZATION OF THE CYTOSKELETON

◊ lecture 1: The cytoskeleton in vivo:

- Introduction and biological background
- Microtubule and actin organization in vivo
- Role of microtubule dynamics and force generation in vivo
- Overview of the lectures

◊ lecture 2: Theoretical models:

- Dynamic instability
- Polymerization ratchets
- Positioning strategies in cells of different size and shape

◊ lecture 3: Cytoskeletal dynamics and force generation in vitro:

- Measurements of pushing and pulling forces in vitro
- Microtubule assembly at the nano-scale
- End-binding proteins and the regulation of microtubule dynamics

◊ lecture 4: Cytoskeletal organization in vitro:

- Self-organization of microtubules and motors
- Positioning strategies based on pushing and pulling forces

◊ lecture 5: Microtubule-actin crosstalk and cell polarity:

- Linear transport and the establishment of cell polarity
- Co-organization of actin and microtubules in vitro
- Cytoskeletal links to the membrane
- Towards an artificial cell?

Uri Alon - Weizmann Institute (Rehovot)

GENETIC NETWORKS

◊ lecture 1: Network motifs:

* Complex gene networks are made of a small set of recurring circuit patterns called network motifs. well discuss these recurring circuits for gene control and their dynamical functions.

◊ lecture 2: Robustness:

* biological circuits have special design so they can work precisely with noisy component. We'll discuss mechanisms for robustness that recur in different systems such as use of paradoxical components.

◊ lecture 3: Robustness (part 2):

* biological circuits have special design so they can work precisely with noisy component. We'll discuss mechanisms for robustness that recur in different systems such as use of paradoxical components.

◊ lecture 4: Optimality:

* natural selection as multi-objective optimization , leading to simple patterns in the shape space of animals.

◊ lecture 5: Modularity:

* how does modular design arise in biology on many scales by natural selection.

◊ Special lecture: Love and fear in the lab:

* guitar and discussion of the importance if the subjective and emotional aspects of doing science.

David Nelson (Harvard)

ASSORTED TOPICS

◊ lecture 1: Competition and Cooperation at Frontiers

* Species often expand from where they first evolved, invade into favorable habitats or move in response to climate changes, or gradients in nutrients, salinity, ambient temperature, etc., in the case of biofilms. Recent microbial experiments on bacteria and yeast have uncovered a remarkable genetic demixing phenomenon at the frontier of a two-dimensional range expansion. Simple models of asexual biological evolution at expanding frontiers can explain both the spatio-genetic correlations that develop for neutral competitions and the effect of natural selection. However, new questions arise when two or more species (or genetic variants of the same species) display cooperative or antagonistic growth strategies. For example, can mutualism prevent demixing? Evidence for a phase transition at a critical degree of cooperativity for mutualists will be presented in a one dimensional stepping stone model.

◊ lecture 2: Life at High Reynolds Number:

* Microorganisms living in the ocean can be subject to strong turbulence with cell division times in the middle of a Kolmogorov-like cascade of eddy turnover times. We explore the dynamics of a Fisher equation describing cell proliferation in one and two dimensions, as well as turbulent advection and diffusion. Because of inertial effects and cell buoyancy, we argue that the effective advecting velocity field is compressible. For strong enough compressible turbulence, bacteria, for example, can track, in a quasilocalized fashion (with remarkably long persistence times), sinks in the turbulent field. An important consequence is a large reduction in the carrying capacity of the fluid medium.

◊ lecture 3: Dislocation Mediated Elongation of Bacteria

* Recent experiments have revealed a remarkable growth mechanism for rod-shaped bacteria: specialized proteins associated with cell wall elongation move at constant velocity in clockwise and counterclockwise directions on circles around the cell circumference. We argue that this machinery attaches to dislocations in the ordered peptidoglycan cell wall, and study theoretically the dynamics of these interacting defects on the surface of a cylinder. Unlike the dislocations typical in materials science, the motion is predominantly climb (glycan strand extension) instead of glide. The activated motion of these dislocations and the resulting dynamics within a simple kinetic model show surprising effects arising from the cylindrical geometry, with important implications for bacterial growth.

SEMINARS

1	Tue 24th	14.00	1. Tikhonov	Mikhail
2		14.20	2. Vucelja	Marija
3		14.40	3. David Oriola	Santandreu
4		15.30	4. Greulich	Philip
5		15.50	5. Pragya	Srivastava
6		16.10	6. Bradde	Serena
7		16.30	7. Court	Steven
8	Wed 25th	14.00	8. Biancalani	Tommaso
9		14.20	9. Butler	Tom
10		14.40	10. Asti	Lorenzo
11	Thu 26th	14.00	11. Bottinelli	Arianna
12		14.20	12. Melbinger	Anna
13		14.40	13. Seminara	Agnese
14	Fri 27th	14.00	14. Meyer	Bob
15		14.20	15 Mcfarland	Christopher
16		14.40	16. Vulin	Clément
17	Mon 30th	15.30	17 .Banigan	Edward
18		15.50	18. Tjhung	Elsen
19	Tue 31st	14.00	19. Karschau	Jens
20		14.20	20. Masson	Jean-Baptiste
21		14.40	21. Oppenheim	Jacob
22		15.30	22. Zou	James
23		15.50	23. Drescher	Knut
24		16.10	24. Ciandrini	Luca
25		16.30	25. Mohapatra	Lishibanya
26	Fri 3rd	14.00	26. Cohen	Daniel
27		14.20	27. Singh	Vijay
28		14.40	28. Chachra	Ricky

6. Website

Material for the school

Updated programme

Dogterom lectures, supporting matrial

Slides from lectures: **1, 2, 3, 4, 5**

Problem class: Article to read and associated problems.

Prost lectures, supporting matrial

Problem class: Articles to read and report on for group 1 (Asti-Farrell), group 2 (Foret-Oppenheim) and group 3 (Oriola-Zou). "Please consider the virtues of these descriptions & caveats, criticisms, limitations, extent of universality..."

Nelson lectures, supporting matrial

Slides from lectures: 1, 2, 3

Altan-Bonnet lectures; supporting material

Document in lieu of lecture notes

Two classical papers

Systems Immunology circa 1958 (first proof of single-receptor expression on lymphocytes): Nosal & Lederberg Nature, 1958

Kinetic proofreading applied to TCR signaling: McKeithan PNAS, 1995.

Shraiman lectures, supporting matrial

Problem class: Articles to read and report on for group 1 (Asti-Farrell), group 2 (Foret-Oppenheim) and group 3 (Oriola-Zou)

Cavagna lectures, supporting matrial

Slides from lectures: 1, 2, 3

Problem class "Border effects in collective behaviour": 1. What is r_1(N) at fixed density? 2. What is \gamma(1) near the edge of a flock with the mean velocity *normal* to the interface? 3. What is \gamma(1) near the edge of a flock with the mean velocity *tangential* to the interface?

Updated timetable

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	Alon's special				Closing	
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X i — ith lecture of speaker L

X — Problem/research class supporting the lecture course of speaker X

Sem — Seminar by students

Emergent order in Biology 2011

Complex, non-equilibrium phenomena in living systems are currently of great interest to researchers with backgrounds in a number of traditional and non-traditional disciplines. These include soft matter physics, quantitative and systems biology, mathematical biology and the experimental biosciences, amongst others. To understand the way in which complex behaviour and order typically emerges from a large number of smaller interacting subsystems we need to make progress both on solving (and posing) formal problems and on understanding experiments. The present workshop will focus on this question under the title *emergent order in biology*. The aim of the workshop will be to present the state of the art of our understanding of a number of rapidly evolving fields and to promote discussions and interactions between participants. Details of the program are now available.

Workshop Venue and Format

The school will be held at the Institute d'Etudes Scientifiques de Cargèse, an Institute specially constructed for this type of meeting.

The institute is located on the seashore of the island of Corsica, 50 km north of Ajaccio. It is located close to the beach at walking distance (20 min. via the main road, 15 min. via a 'goat path', bring good shoes) from the village of Cargèse. Lunch for all participants will be served at the Institute.

Sessions will start on the morning of Tuesday, July 24th and end in the afternoon of Friday, August 3rd. Participants are expected to arrive on Monday, July 23rd and leave Cargèse late on Friday, August 3rd (or on Saturday morning).

Participation

The objective of this summer school is to bring together PhD students and young scientists whose research aims at understanding emergent order in complex biological systems. We would like to provide them the opportunity to attend focused courses starting at a tutorial level but allowing to reach the state of the art in this field, both on theoretical and experimental aspects. The format of the school will also give attendees the opportunity to present their research, hopefully providing useful feedback and advice, including on possible future directions for their research. We also aim to offer young scientists the opportunity to promote and discuss their work and exchange views with experts. We envision approximately 60 to 80 participants from the international community, including lecturers and guest speakers.

Information

- Home
- Important dates
- Registration & Fees

7. Student presentations

name	presentation title	type	additional information
Arianna Bottinelli	How do fish use the movement of other fish to make decisions	talk	abstract on p 36
Elsen Tjhung	Hydrodynamic modelling of cell cytoskeleton and cell motility	both	abstract on p 37
Edward Banigan	The title of the talk was Effector CD8+ T cells migrate via chemokine-enhanced generalized Lévy walks	both	abstract on p 36
Geoffrey Fudenberg	Polymer Models of Yeast S. Cerivisae Chromosome Organization	poster	
Jacob Oppenheim	Human Time-Frequency Acuity Beats the Fourier Uncertainty Principle	both	poster on p 33
Jakub Otwinowski	Inference of a large fitness landscape of the E. coli lac promoter	talk	abstract on p 37
Knut Drescher	Bacterial biofilm morphogenesis and rapid clogging of flow systems	talk	abstract on p 38
Christopher McFarland	Deleterious Passengers in Cancer	talk	abstract on p 38
Ricky Chachra	Your model is sloppy! Multiparameter fits to data: connections to emergence is scientific theories	talk poster	 poster on p 26
Mikhail Tikhonov	Stochasticity and precision of transcriptional control	both	poster on p 27
Vijay Singh	Continuum dynamics model of primary visual cortex	poster	
Marija Vucelja	Emergence of clones in sexual populations	talk	
Stefano Bo	Anomalous thermodynamics at the microscale	poster	

name	presentation title	type	additional information
Tommaso Biancalani	Noise-induced metastability in biochemical networks	both	poster on p 25
Jens Karschau	Living in the fast lane: optimal origin placement for DNA replication	talk	abstract on p 39
Beth Marshall	Coping with nonsense: Modelling the degradation of aberrant mRNAs	poster	poster on p 23
Alexandre Lazarescu	Current Fluctuations in the open ASEP	poster	poster on p 29
Serena Bradde	Dynamics of intestinal microbiota perturbed Social interaction, noise and antibiotic-mediated switches in the intestinal microbiota	talk poster	 poster on p 28
Guido Uguzzoni	The true reinforced random walk with bias	poster	poster on p 34
Carles Blanch-Mercader	A nonlinear mechanism of cell motility in lamellar actomyosin fragments	poster	poster on p 30
Lorenzo Asti	Statistical Mechanics of the Immune System Organization and Evolution of Synthetic Idiotypic Networks	talk poster	abstract on p 35 poster on p 25
David Oriola	The role of hydrolysis kinetics on the collective performance of single-headed kinesin	both	poster on p 24
Jamie Luo	Functionality and Speciation in Boolean Networks	poster	poster on p 22
Jean-Baptiste Masson	Non invasive inference of chemotaxis responses from bacterial trajectories The diffusion and energy landscapes of transmembrane proteins in cultured neurons	talk poster	abstract on p 37 poster on p 26

name	presentation title	type	additional information
Sam Ocko	Thermoregulation and adaptation in honeybee swarm clusters	both	poster on p 33
Brian Lee	Tubule Formation as a Mechanism for Vesicle Replication	poster	
Tom Butler	Collective effects allow T cells to discriminate between self and non-self	talk	
Clément Vulin	Controlling the growth and shape of yeast colonies	both	poster on p 31
Luca Caniparoli	Synonymous but not the same: extracting information from codon bias	poster	

8.Participants comments

The comments are listed anonymously. This list is (i) complete (ii) unmoderated and (iii) unedited

- The school was very well organised and the quality of lectures, talks and extra-curricular activities were all excellent. I would recommend a repeat or follow on most definetely.

- I really enjoyed this school. The lectures were, for the most part, very well presented. The Institute is an ideal place to isolate yourself and become immersed in science, and the "extra-curricular" events that were put on were excellent opportunities for networking; I made many beneficial contacts during my time there. The timetable was well balanced, allowing for discussions to take place around the lectures, talks and tutorials.

- I found the seminars very profitable since it was a very good opportunity to present your research to the whole audience. Also, I think it was a good choice to split the poster session in two since everybody had the chance to look calmly each other's work.

- It was bloody cool.

- I think that for a grad student the best thing would be courses made of real lessons with chalk and blackboard (with the help of the computer if needed). Not every course was that way and that would be the best way to learn something about topic for a young researcher.

- I think that the arrival in Cargese could have been better organized: when we arrived at the airport on Monday we did not have clear indications about where the bus would have been and no

one in charge of giving us indication, people managed to find it anyway, but the bus driver did not have a list of people and left without checking if everyone was on the bus. We had to make ourself the check and make him drive back to the airport to pick up more people. Then in Cargese we were expecting some kind of welcome, as written on the program, instead we just got our apartments and the people at the Institute did not have any further indication/information to give us about the organization of the school. Also, the apartment I got in town did not have an internet connection, which is quite uncomfortable (other apartments had it). About lectures, I think the topics that were presented were all very interesting in principle, but in a couple of cases the choice of speakers made it very difficult not only to enjoy classes but also to understand them. I think this was quite clear from the drop in attendance at some lectures. Except for these points, I think the institute had very good facilities and a kind personal, and that all the other activities had been well organized. The larger part of lectures had been interesting and well taught by speakers. Lunches and snacks during poster sessions were very good, coffee breaks could have been improved but were ok anyway. And the location of the school was awesome! I personally enjoyed a lot the summer school and if you plan to organize another one next year please keep me informed that I surely would like to participate.

- The school was very well organized, both logistically and academically as well. Most of the lectures were interesting and useful (although sometimes a bit too fast and with a "very steep learning curve" as those given by Altan-Bonnet), the discussion with many of the colleagues has been really stimulating, providing the grounds for future collaborations.

- Excellent workshop! The location was excellent, and the people there as well. Very good learning experience to see what people around the world are doing in biophysics.

- I loved it. I have both learned a lot and was in its great, beautiful and relaxing place.

- I enjoyed the science and the scenery very much. I learned a lot and met many great people. Name tags would have been helpful for the first few days.

- The school was a good experience and most of the lectures were very interesting

- The summer school at Cargèse was excellent! Very well-organized, great selection of topics, lecturers, location, and activities.

- As for general comments about the lectures or school, I've already left some feedback on the form that was provided at the end of the school, but overall, I'd say I got a lot out of it: in particular, I've had several very interesting discussions with Prof. Alon and Prof Shraiman, and thoroughly enjoyed lectures of both of them as well as the lectures of Prof. Cavagna.

- It was a very well organized school both in terms of topics covered and hospitality. The lectures had the right balance of theory and experiment. It covered a good range of topics in biological physics. I look forward to attending similar schools and would suggest to include a few lectures from theoretical/experimental neuroscience.

- The school was really nice and interesting. Thanks for organizing it.

- I enjoyed the school a lot and overall the lectures, food and people were great. I should however mention that not all of the lecturers met my standards for lectures worth attending.

- The course was an idyllic mix of lectures, research, theory, experiments, and sun. Thank you!

- Overall, I found the lectures interesting. The only (very minor) criticism I could make, if I had to, is about some of the problem classes, for which I think problem solving would have been more profitable than paper reading, especially for such a diverse audience (understanding a paper from outside of one's field takes much more time and energy than we had available there and then).

- Thank you again for organising this brilliant summer school. Please find the report below. I enjoyed this summer school very much. It has a good variety of lectures and I had some very good discussions. Even though I am a physicist, I did not feel overwhelmed by the biological content of the lectures. I think the balance between biology and physics is about right. I will definitely look forward to any future summer schools of similar theme.

- In my opinion the school in general was excellent. It is not worth discussing which things may be improved since the majority of the events in the school, such as lectures or social events, were beyond my initial expectations.

- Had a great time! Thanks

- Fantastic school; my only wish is that Prof. Dogterom had given more general lectures - her work is fascinating, however, the specific focus solely on experiments on "catastrophes" in the elongation of microtubules, seemed overly specific and targeted for a general school in physics and biology. A more general overview of the questions she and her group have addressed and the types of experimental techniques involved would have been more useful and better for the nonspecialist.

- I appreciate a lot the lessons and of course the location too, in particular i found very interesting the lessons of Altan-Bonnet and Cavagna.

- I thought the research talks were great, and it as good to have a mixture of talks from PhD students, postdocs, and faculty. The teaching lectures given by faculty were overall very good, and it was useful to get an insight into new topics I didn't have on my radar before I came to the summer school. The organization was great, and the school provided many opportunities to meet and talk to other participants.

- The lectures were mostly excellent.