



UNIVERSITÀ  
DEGLI STUDI  
DI TORINO

SUMMER SCHOOL 2019 SCUOLA DI  
DOTTORATO

# EMERGENCE AND ORGANIZATION OF LIFE

20 AND 21 JUNE 2019  
BARDONECCHIA

## **SPEAKERS**

**Maurizio Casiraghi:** *"The evolution of biological complexity: myths and truths"*

**Barbara Cavalazzi:** *"The relevance of microfossil studies in the early Earth contest"*

**Markus Egli:** *"Climate: the engine for soil formation and organisms"*

**Andrea Gamba:** *"Eukaryotic cell polarity and protein sorting"*

**Daniela Paolotti:** *"Digital traces and participation for forecasting the flu"*

**Michael J. Russel:** *"Why Does Life Start, What Does It Do, Where Will It Be, and How Might We Find It?"*



## BARDONECCHIA SUMMER SCHOOL 2019 SCUOLA DI DOTTORATO

On 20 and 21 June 2019

### ***Eukaryotic cell polarity and protein sorting***

**Andrea Gamba**, DISAT, Politecnico di Torino, & IIGM, Torino

Eukaryotic cells break their native symmetry and polarize in order to respond to signals coming from the environment. An essential driver of the process is the incessant spatial reorganization of membrane-bound proteins sustained by biochemical feedback loops that contrast the homogenizing effect of diffusion. A second driver is the coupling of protein and lipid dynamics: protein crowding induces the bending of lipid membranes and the nucleation of small lipid vesicles enriched in specific molecular factors that are targeted to appropriate destinations. This leads to an incessant distillation process controlled by the strength of protein-protein interactions. Physical modeling and simulations suggest the existence of an optimal distillation regime characterized by simple laws. Experiments suggest that living cells work close to this optimal regime, likely as the result of evolutionary pressure.

### ***Digital traces and participation for forecasting the flu***

**Daniela paolotti**, ISI Foundation

The ability to rapidly recognize and respond to both global and local health threats remains a critical public health priority. The ever-growing digital world represents an unprecedented opportunity to harvest for tools to face emerging and re-emerging public health issues. This digital means of disease detection and health-related information collection have been made possible by the growing influence of Internet technology, which has significantly changed the landscape of public health surveillance, epidemic intelligence gathering and forecasting of epidemic spreading. Informal digital channels (e.g. social networking sites, Web searches, local news media etc.) have been credited with providing health-related information that are not easily accessible by more traditional channels, such as census or traditional surveillance. More in particular, voluntarily provided self reports on health related matters can become a crucial tool in informing dynamical models for epidemic spreading on a national and global scale. In this talk we present Influenzanet, a European network of participatory systems for the monitoring of Influenza-Like Illnesses (ILI), established in 2009 and now comprising 11 countries.

The system relies on the voluntary participation of the general population through a dedicated national website in each country involved in the project. Several thousands of participants are engaged every year in Influenzanet, with about 50K volunteers in the 2017/18 season. After eight years of activity, Influenzanet has proven to be a reliable and flexible monitoring system that has become a complement to existing ILI monitoring infrastructures in several European countries. Its unique characteristics offer the possibility for a direct comparison of ILI rates across countries, for detecting non-medically attended ILI cases, for applying different case definition, and for facilitating individual-level epidemiological analyses generally not possible in standard systems. The timeliness and accuracy of the Influenzanet systems allow the detection of substantial changes in population health, making it a potential tool for a wide variety of applications in public health preparedness and control.

### ***Why Does Life Start, What Does It Do, Where Will It Be, and How Might We Find It?***

**Michael J. Russell**, Interim Employment Program, JPL, NASA

Life was driven into being on our planet to resolve the disequilibria between the fuels H<sub>2</sub> and CH<sub>4</sub> emanating from submarine hydrothermal alkaline springs (pH ~11), as against the CO<sub>2</sub> and NO<sub>x</sub> in the ancient atmosphere and dissolved in the acidulous ocean (pH ~5.5). The two fluids – one reduced and the other relatively oxidized – were kept at bay by the precipitation at the spring of iron minerals such as mackinawite (FeS) and the variable valence and pliable green rust ([FeII<sub>4</sub>FeIII<sub>2</sub>(OH)<sub>12</sub>][CO<sub>3</sub>]•3H<sub>2</sub>O). It was in these mineral barriers that this free energy (redox and pH) was first converted, via a proto-metabolism, to organic molecules. Thus, we can say that life hydrogenated, and still hydrogenates, carbon dioxide. Therefore, we may expect life to emerge on any wet and rocky world that has a partly CO<sub>2</sub>-rich ocean. It should reveal itself either as whole cells or as bioorganic molecules that themselves are far-from-thermodynamic equilibrium. A pedagogical analogy between the alkaline vent site for the emergence of life and rocketry is offered, in that fuels and oxidants in both are somewhat similar as figured below. It is clear, for example, that the rocket is driven by the high entropy exhaust gases generated in the low entropy environment of the combustion chamber. Likewise, it is the waste from the low entropy feeds to life that keep it sustained and working. Indeed, life also uses nano-engines such as Complex 1 and ATPase to couple exergonic reactions to endergonic ones. Thus, life can be said to transcend chemistry, i.e., it can react hydrogen (or the electrons therefrom), generated geochemically as in hydrothermal convection, or photolytically as in oxygenic photosynthesis to generate a small but ever continuous supply of very particular organic molecules on our planet.

## ***Climate: the engine for soil formation and organisms***

**Markus Egli**, Department of Geography, University of Zurich, Switzerland

Climate in general, and climate change in particular, and hydrologic conditions are expected to affect soil mass redistribution rates (erosion and sedimentation), chemical weathering and also biological processes. The presentation will explore the fundamental principle of water and energy for soil formation and, thus, life in Alpine ecosystems. It will show how soils and landscape evolve over time (e.g. in glacier forefields) and how temperature and particularly the water percolation drive this evolution. Weathering, soil formation, the establishment of vegetation, its decay and integration into the soil are all processes that are interconnected and driven by (solar) energy and moisture availability. Individual organisms, populations, community distributions and ecosystem composition and function strongly depend on water availability, the energy balance and organic matter.

Soil production, in the sense of pedogenesis, is closely related to chemical weathering. Recent modelling and comparison with field results showed that soil formation by chemical weathering, either from bedrock or unconsolidated material, is more often limited by solute transport than by reaction kinetics. Predicting what drives the transition from 'non-soil' to a soil-mantled landscape (or from bedrock to a 'developed' soil mantle) is, therefore, a significant challenge for models of landscape evolution and for 'critical zone' studies. If predictions for the rates of soil formation and vegetation growth, at both regional and global scales, can be made accurately, future climate change effects on alpine systems can be assessed more reliably.

## ***The relevance of microfossil studies in the early Earth context***

**Barbara Cavalazzi**, University of Bologna, University of Johannesburg

The earliest evidences for life come from studies of the rock record. Biosignatures (buried in rocks) indicate that Earth became a biological planet long before 3.5 billion years ago, making most of life's history microbial. Based on our current knowledge on requirements needed to support life, our planet could have been already potentially habitable 4.4 billion years ago when the most resistant extremophiles might had chance to originate and adapt in protected ecological niches. However, the known sedimentary record only begins with highly metamorphosed sedimentary rocks deposited ~3.8 billion years ago, and the biosignatures could be hardly recognised because non-biological chemical reactions or physical processes could mimic them. Despite the significant advances in our understanding of the evolving early biosphere over the last few decades, many question remains over the extent to when and how Earth becomes home for life. Here we will explore the fossil record and the recent discovery in the origins field as well as the early Earth environment conditions covering the first billion years of the earth's history.

## ***The evolution of biological complexity: myths and truths***

**Maurizio Casiraghi**, Zoologist, University of Milan-Bicocca, Italy

There are many things that biologists do not really know, that are not easy to define or to measure. Biological complexity is such a case. It seems simple to observe that 3 billions years ago, on the Earth, there were prokaryotes only, while today there are humans and "we are much more complex than a bacterium"!

However, if you plot any kinds of complexity measure vs the relative abundance you can observe that it exists a minimum level of complexity, the so-called "left wall", under which the life simply does not exist. In this context, complexity could be considered no more than a passive consequence of evolutionary processes, with a progressive sequence of steps in which the complexity increased: eukaryogenesis, pluricellularity, phyla macroevolution and so on. The existence of an "irremediable complexity" is nowadays considered a misunderstanding since it is clear that we are still living in a world in which prokaryotes dominate the biodiversity and consequently the complexity. One of the most promising and interesting challenges is related to the possibility to identify some kind of universal measures for complexity. The best candidate appears to be genomic complexity. In the talk, I will also analyze pros and cons of such a possibility.

### ***DAYS PROGRAM***

*20 June*

H 15.00: "The relevance of microfossil studies in the early Earth contest" - Barbara Cavalazzi

H 16.00: "Digital traces and participation for forecasting the flu" - Daniela Paolotti

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*17.00 - Coffee Break*

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H 17.30: " Why Does Life Start, What Does It Do, Where Will It Be, and How Might We Find It?" - Michael J. Russel

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*20.00 - Dinner*

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*21 June*

H 9.00: "The evolution of biological complexity: myths and truths" - Maurizio Casiraghi

H 10.00: "Eukaryotic cell polarity and protein sorting" - Andrea Gamba

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*11.00 - Coffee Break*

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H 11.30: "Climate: the engine for soil formation and organisms" - Markus Egli

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*12.30 - Lunch*

# **THE SUMMER SCHOOL IS FREE OF CHARGE FOR STEM DOCTORAL STUDENTS**

## **Accommodation:**

Villaggio Olimpico ([www.villaggiobardonecchia.it](http://www.villaggiobardonecchia.it)), which is located in the Alps, about 100 km from Turin, and can be reached from there by train, car or bus.