Evolution of increasingly complex linear molecules — ÜPILIPP ZIMMER, EVA VOLLRAB, ALBRECHT OTT

Evolution of the size distribution of colloidal particles: focusing, breakdown of scaling, and asymptotic distributions — MARTIN ROHLOFF, JÜRGEN VOLLMER

Multi-Species Range Expansions; Frequency-Dependent Selection at Rough Fronts — JAN-TIM RUTHER and HOLGER STARK

The population. Since there are relatively few of these founders, rates of genetic drift are much higher, and the probability that a beneficial mutation will fixate in the population much lower. This is important as it will impact the speed with which such a population adapts to its environment, for example developing antibiotic resistance.

I will present my work using a fairly detailed agent-based biophysical simulation model of an expanding microbial colony to estimate probabilities of fixation of beneficial mutations, and how these depend on the fitness advantage and the properties of the cells, and compare these results to analytical theories of selection in expanding populations.

Darwinian evolution is based on variation and selection acting on mutations, reproduction, or the metabolism of a species. These processes can only take place when the underlying system is out of thermodynamical equilibrium. For natural evolution the species as well as their relation network has continuously been gaining complexity. The conditions necessary for a steady increase in complexity are not well understood. Performing stochastic simulations as well as experiments with DNA, we analyze a chemical system consisting of autocatalytically concatenating chains. We find that, despite its inherent stochastic nature, the system evolves along a reproducible path towards states of increasing complexity if the autocatalytic activity exceeds a critical value.

In many energetically driven systems non-linearities lead to pattern formation. Here we study the dynamics of a driven primordial broth, synthesized from a gas mixture of methane, ammonia and steam that is triggered by electric discharge and heat. Using real-time mass spectrometry, we observe the generation of many hundreds of different molecules in a mass range from 50 to 1000 Dalton. The temporal course of the primordial broth reveals the spontaneous emergence and disappearance of several oligomeric groups that consist primarily of polyethylene glycol (PEG) surfactants. These oligomers appear in aperiodic oscillations. This requires stronger non-linearities than a simple autocatalytic reaction. PEG and surfactants are well known phase-transfer catalysts, able to favour biochemical reactions by inhibiting hydrolysis. We suggest that autocatalytic phase-transfer leads to self-organizing processes in a primordial broth and enables the production of relevant biomolecules.

Mechanisms underlying the synthesis of mono-disperse colloids and nanocrystals are under vivid discussion. A common feature of the recipies is the growth of an assembly of particles subjected to a flux of material, provided e.g. by a chemical reaction like the decomposition of precursor.

We present analytical and numerical studies on diffusion dominated growth of particles with a constant overall volumetric growth rate. The resulting particle growth is qualitatively different from Ostwald ripening, and it leads to narrow and non-universal asymptotic size distributions.

In an expanding population, such as a bacterial colony growing on a surface in the laboratory or in nature, evolution proceeds very differently to in a well-mixed population with a static population size. This is mostly due to the so-called founder effect, where individuals close to the expanding front of the population have a much better chance of passing their genes on to future generations than those deep within the expanding front of the population have a much better chance

The interdependence of evolutionary and growth dynamics shapes the relation network has continuously been gaining complexity. The conditions necessary for a steady increase in complexity are not well understood. Performing stochastic simulations as well as experiments with DNA, we analyze a chemical system consisting of autocatalytically concatenating chains. We find that, despite its inherent stochastic nature, the system evolves along a reproducible path towards states of increasing complexity if the autocatalytic activity exceeds a critical value.

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Clonal interference and Muller's ratchet in spatial habitats

— Jakub Otwinowski1 and Joachim Krug2 — 1Biology Depart-
ment, University of Pennsylvania, Philadelphia, USA — 2Institute for
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Competition between independently arising beneficial mutations is en-
hanced in spatial populations due to the linear rather than exponential
growth of the clones. The resulting fitness dynamics is analogous to a
surface growth process, where new layers nucleate and spread stochas-
tically, leading to the build up of scale-invariant roughness. This sce-
nario differs qualitatively from the standard view of adaptation in that
the speed of adaptation becomes independent of population size while
the fitness variance does not, in apparent violation of Fisher’s funda-
mental theorem. Here we exploit recent progress in the understanding
of surface growth processes to obtain precise results for the univer-
sal, non-Gaussian shape of the fitness distribution for one-dimensional
habitats. We then consider a version of the model where all mutations
are deleterious, that is, a spatial version of Muller’s ratchet. Based
on an analogy to models of nonequilibrium wetting, we show that the
system displays a phase transition related to directed percolation. The
transition is governed by the ratio $U/s^2$, where $U$ denotes the dele-
terious mutation rate and $s$ the selection coefficient of mutations. For
$U/s^2 > 1$ the speed of the ratchet remains finite in the limit of infinite
habitats.

A Non-Equilibrium Phase Transition in a Biofilm Growth Model in a Fluctuating Environment — Florentine Mayer and Erwin Frey — Arnold Sommerfeld Center for Theoretical Physics (ASC) and Center for NanoScience (CeNS), Department of Physics, Ludwig-Maximilians-Universität München, Germany

Bacterial communities represent complex and dynamic ecological sys-
tems. They appear in the form of free-floating bacteria and biofilms in
nearly all parts of our environment. They are highly relevant for human
health and disease. Spatial patterns arise from heterogeneities of the
underlying landscape or are self-organized by the bacterial interactions,
and play an important role in maintaining species diversity. Bacteria
must rapidly adapt to fluctuating environments in order to survive. In
biofilms this is often achieved by phenotypic diversity, where bacteria
can switch between different phenotypic states. Survival of the popu-
lation can increase if each of these phenotypes is adapted to different
environmental conditions. To analyze biofilm growth we set up a two-
species automaton model in which growth, death and switching rates
depend on the environmental conditions. These fluctuate, resulting in
periodically interchanged reaction rates. Depending on the rates we
find either fast extinction or thriving biofilms with intriguing spatio-
temporal patterns. Close to the region of extinction patterns become
self-affine, which is typical for a phase transition to an absorbing state.
Employing extensive stochastic simulations we measure critical expo-
nents of our non-equilibrium phase transition and find universal scaling
behaviour characterising the universality class of our model.