Slime Molds – Social Amoebae

In this document I make the case for keeping slime molds in the future Biolab in Calafou, and outline my perspective on them.

Slime molds raised to attention in the last years, mainly since the turn of the century, and went viral with videos such as this and this. They were even featured in XKCD, the acme of geek fame. They have interesting properties that warrant scientific attention and they are simple enough to study without an expensive laboratory.

Why slime molds are awesome?

1. They are the most intelligent brainless creatures!
2. They can be used to build computers – OK, at least logic gates. :)
3. They calculate shortest routes and build networks.
4. They are one of the first organisms which lived on land.
5. They are not animals, plants or mushrooms.
6. They sport funny shapes and colours.

What can be done (in Calafou) with slime molds?

1. We can keep them safely in petri dishes, etc.
2. We can build mazes, make stop motion photos and show to visitors.
3. We can make software to recognise and track slime molds on images.
4. We can reproduce experiments done in prestigious universities.
5. We may make mazes with 3d printers for them algorithmically.
6. We might develop neural networks which simulate their behaviour.
7. We might develop software which builds mazes for specific problems.
8. We might collaborate with the HAROSA research network to solve logistics problems with them.

Notably, according to some sources they can be interesting for measuring metal toxicity and even for biological reclamation of heavy metal contamination, especially zinc, etc. This can be potentially relevant for dealing with the contamination of the Anoia river. Even if we cannot save the river this way, it may be possible to contribute to scientific research by making and documenting some experiments.

How can we get some slime molds?

There are three ways to get slime molds:

1. buying them in kits,
2. getting them from somebody who has them,
3. or harvesting them from the forest.

The last option seems good but there seems to be a lack of documentation on how to do it. The second option could work if we make some more research online, find the right people and ask them. However, for a start, the first option is the most straightforward. I can invest in ordering a few different kits and we can see where to go on from there.

In addition to the slime molds themselves, the rest of the necessary equipment is trivial. Most howtos suggest oat meal flakes to feed them and petri dishes to keep them. They do have a complex life cycle, but at the moment I am not aware of any difficulties with keeping them alive and multiplying for an extended period of time.

My motivation and research programme

As it will quickly become apparent, my interest in slime molds is bound up with my interest in the ideological and historical issues of cybernetics, and it is largely theoretical.

Slime molds embody several large scale changes in society and technology which I study from the perspective of a critical history of ideas. They stand at the intersection where metaphors are operationalised and translated from one realm of reality to another (an ontological shift):

1. Networks: networked creatures – master metaphor for everything?
2. Computers: biological computers – computation as phenomena?
3. Societies: social amoebae – the social body?

Networks: How a simulation replaced reality

At the same time as computers really happened, i.e. when the von Neumann Architecture – which defines a computer as the combination of a (a) processing unit, (b) a storage device and (c) a memory between the two – crystallised (Neumann 1945), neural networks – an alternative computing paradigm – were being developed by McCulloch and Pitts (1943), and successfully implemented by (1958). Even the founding father of cybernetics, the mathematician Norbert Wiener, developed a similar model during the same period, in cooperation with the Mexican physician and physiologist Arturo Rosenblueth (Wiener and Rosenblueth 1946). These people were all adepts of cybernetics, an ambitious research program which originally aimed at building a functional model of the brain. (Pickering 2010) Cyberneticians abstracted away the biological qualities of living organisms (especially the brain) in exchange for a mechanistic, calculative model – an approach that quickly turned into an avant-garde scientific paradigm, redefining in those logico-mechanistic terms such categories as life, purpose, reason and subjectivity. (Dupuy 2000) Therefore, from base research in the hard sciences, in a few decades it became an ontological-metaphysical project, the effective deployment of an ideology through the whole territory of social life. (Tiqqun 2012)

To summarise, the key movement was comprised of two parts: first, the abstraction of biological phenomena into a logico-mechanistic model; and second, its reification from model to the very blueprint of reality. The idea of networks in particular was drawn from the image of the interconnected neurons in the brain, which was turned into an abstract logical model, and finally reified to nothing less than an actual law of nature. The idea of the network is thus interesting for its intellectual trajectory from an observed biological phenomena through a scientific model which aimed at understanding it to a concrete metaphor treated as the nature of almost everything: a veritable ideal.

A principal example of how cybernetics shaped the intellectual history of the second part of the twentieth century is Actor Network Theory, a sociological research program developed by Bruno Latour primarily in the 1990s. (Latour 1993; Latour 1996; Latour 2005) At the moment the hegemonic theoretical framework in the sociology of technology, it presents itself as a "practical metaphysics" (Latour 2005, 50f), granting equal attention and equal powers to both human and non-human entities. The network of actors is the principal metaphor of its sociological imagination. While it seeks to give an impartial account of how networks are formed, function or fail, its ontological operation restricts everything that exists – and *can* exist – in reality to these same networks. If analytically actors are considered black boxes, ultimately they too can be decomposed into networks. Thus nothing else can exist in the world but networks – everything else proves to be an illusion.

Of course the power of networks does not stop at the level of intellectual reflection. We do not simply understand the world this or that way – we also act based on such and such an understanding. When everything can be seen as a network of networks, everything has to be reorganised to become a network of networks. Communication infrastructures, computer architectures, the global firms of capital, its markets and the geopolitical strategies of imperialist nation states – in conjunction with the very social movements which oppose them. Humans start to live in the context of social networks and networking becomes the principal professional activity, while liberal capitalism is rebuilt according to *The Wealth of Networks* (Benkler 2006) (a book playing on the title of Adam Smith's *The Wealth of Nations*). In Manuel Castells' *The Network Society*, nothing else is allowed to live but networks. When all problems are posed in the categories of network ontology, all solutions are posed as network ontologies. Being a network becomes the ultimate recipe for success – since everything else is just a badly functioning network anyway.

The moral of the story is that cyberneticians started working on a model which would correspond to reality more than the models before, and ended up with a reality which *has to correspond* to its own models more than before.

Obviously, slime mold research touches upon many of the issues outlined above. Slime molds are living biological organisms which (are made to) look and act like a network, and in turn used to model other networks in the real world, with the idea of eventually generating a system which can compute these networks on a logical level. The foundational notion of slime mold research is that there is no ontological difference between biological networks and logical networks, or any other networks such as transportation infrastructures like railroads, the interaction of the neurons in the brain, the collective behaviour of certain animal populations, etc.

"In the province of connected minds, what the network believes to be true, either is true or becomes true within certain limits to be found experientially and experimentally." – John Lilly, *The Human Biocomputer* (1974)

Computing: Happens in the Brain, in Nature, and in Machines

As Dupuy (2000) explains, computers were not the material inspiration for the cybernetic conception of the brain. In fact the cybernetic conception of the brain was formulated before, and computers came to be the material expression of it. However, in the history of cybernetics there were many other research directions open. Thanks to the organisation of cybernetics as a general science, and the involvement of a high number of physicians in the movement (on both sides of the Atlantic), especially biology, logics and computing were highly related.

Let me recount a few examples. Stafford Beer was one of the three fathers of cybernetics in the United Kingdom (along with Ross Ashby and Grey Walter). His life trajectory – from the chief consultant to the British Steel Industry, through the architect of the Cybersyn project to reorganise the economy of Allende's Chile to yoga guru – could itself fill a novel. His first forays into cybernetics, however, had to do with biological computers. In fact not even biological computers. He was firmly against computers. He was saying that it is really stupid and selfish to build sophisticated machines that can count. Such a mistake derives from the hubris of humanity, that we go around thinking that we are the only creatures that can think. But every living organism is a complex ecosystem which balances its inputs and outputs according to well defined requirements: the requirements of its environment. Therefore, we just have to look around and find the ecosystem we need for our calculations.

In line with his ideas, he proposed to replace the management of steel factories with… a pond. The pond would do the calculations necessary to run the factory better than the human management. The main difficulty in this endeavour was bridging the gap between humans and natural ecosystems: how to do input and output? His best idea for input was saturating the pond water with steel powder, and using magnetic fields to give instructions to the ecosystem. However, as much as natural ecosystems automatically tend towards equilibrium, most of them cannot strive against a high concentration of metals – so soon everything died in his pond. [ˆ It is interesting that slime mold research even touches upon this difficulty, albeit slightly. Note the section above on the resistance of slime molds to high concentration of metals. Additionally, there are even aquatic slime molds. Maybe Stafford Beer could go on with his experiment if he used slime molds.]

His second idea was a living tissue arranged in a film which was pierced at intervals with electric wires. He noticed that once the wires are in place, paths form connecting the wires. Beer concluded that it was evidently an example of adaptation, and eventually communication between the human and the organism. Soon he prophetised that if confronted by noise, the organism will develop an ear. In order to test his theory at some point he was holding out the poor creature of his living room window, so that it would pick up the noise of the passing cars in the street. This second idea was not more successful then the first one. However, Beer had good reasons to concentrate on biological computing and therefore he refused the help offered by Alan Turing several times. Turing was building a pioneering mainframe computer at the time, and thought that the calculations Beer had in mind could be run as simulations on the new machine. Towards the end of his life, Beer returned to the idea of the biological computer and wrote a book – accompanied by photographs of Hans Blohm – admiring the computing capacity of the Atlantic ocean. (Beer 1986)

On the other side of the Atlantic, a hotbed of cybernetics, – in fact virtually the only serious institution explicitly devoted to cybernetics – has been the Biological Computer Laboratory, founded in 1958 by Heinz von Foerster. Many key cyberneticians were visiting scholars there. For instance the aforementioned ideas of McCulloch and Pitts were worked out in that milieu. (Müller 2007) Inspired by the Mexican physician Arturo Rosenblueth (Arturo Rosenblueth and Bigelow 1943) and the Chilean biologists Humberto Maturana and Francisco Varela (Maturana and Varela 1980 [1972]), they believed that certain problems cannot be solved by mere calculating machines like computers. However, they held on to the idea that thinking is a logical operation which can be implemented in various media, be it biological material, mechanics or electronics. The first step in the realisation of this thesis was created by the engineering student Paul Weston. His contraption, the Numarete, could recognise the number of objects (or rather, shadows) placed in front of it. According to Müller, "The Numarete was a computer that was not built according to the (reductionistic) von Neumann architecture, but rather was in a sense 'oblique' to this architecture: it was based on the parallel operations of its modules." It was a custom-built electronic box operating according to the principles of the aforementioned neural networks. The whole laboratory draw its inspiration from the idea that it is possible to build machines with capabilities of living creatures, and the way to do it is following the logical operation of observed natural phenomena.

Interestingly, the current epicentre of slime mold research is a very similar institution, the International Center of Unconventional Computing in Bristol, operated by the University of the West of England, where its mastermind Andrew Adamatzky is building the slime mould computers (Adamatzky 2010). The academic study biological computers became virtually extinct following the spectacular success of the von Neumann architecture, and even the development of neural networks was put on hold for more than a decade after the publication of a book by the adherents of the rival school of symbolic artificial intelligence (Minsky and Papert 1969). As a result, bionicians around the turn of the millennium picked up the threads close to the point where the cyberneticians left them off. What changed, however, is the scientific climate which is not ideal for base research any more, so that novel efforts are not couched in the same level of epistemic-contextual reflection as before, but more narrowly focused on narrow practical applications. While some of the avant-garde idealism which drive cybernetics withered away, many of the dangerous assumptions behind such work continue to linger on without a critical evaluation. Such critique is only possible from a perspective where two disjunct lines of inquiry meet: the history of ideas conducted with a hermeneutics of doubt, and the sympathetic anthropological field work which appreciates the complexities of contemporary scientific practice.

Societies: Social Laws from Natural Phenomena, and Back

Natural laws as observed in biological phenomena often inspired and even underpinned political thought. Hobbes' Leviathan as the philosophical imagery of the society as a unified social body is perhaps the most well established example. The discoveries of cybernetics have not been an exception. A logical order which can be abstracted from the behaviour of living organisms and which applies in a more – or less – metaphorical way to the world of human social affairs is a recurring theme in the history of ideas.

The idea of autopoiesis and the related concept of self-organisation and autonomy, (Maturana and Varela 1980 [1972]) as well as the idea of ecosystems that tend towards equilibrium through negative feedback, developed by cyberneticians, have been absorbed by the older tradition of anarchist collective organising, mainly as conceptual metaphors. (Curtis 2011) Anarchist ideologies depended for long on a positive anthropology which asserted that people are generally good, but their positive natural tendencies are short-circuited by the social conditions in an authoritarian society (Newman 2007 [2001]). The corollary is that when authoritarianism is not enforced by social structures, people start to act in a more positive way, described in the language of solidarity, mutual cooperation, and so on. (Graeber 2004) Anarchists found support for these propositions in the scientific results stated above. Moreover, another branch of cybernetics have also inspired anarchist theory and practice in a similar way, namely chaos theory and emergence. Chaos theory provided support for the idea that the actions of a small minority (or perhaps even an individual) can have far-ranging structural effects on society as a whole. On the other hand, emergence supported the claim that horizontal social order rises up naturally wherever people are left to organise themselves in the absence of oppressive authoritarian institutions like the state. Interestingly, these scientific trajectories have been developed most convincingly in the area of emergent evolutionary theories, which stated that evolutionary chains tended towards complexity and exhibited signs of spontaneous self-organisation – therefore refuting or at least complementing the idea of natural selection as the engine of biological history. (Wolfram 2002) These results are evidently useful in countering vulgar interpretations of socio-darwinism which take the "survival of the fittest" as their slogan.

Slime moulds entered this discussion once it has been realised that while they live their life mostly as single-cell organisms, when they face difficult environmental conditions such as the lack of nutrients, they flock and form a single organism, joining their cells into a single body. Recent results dubbed some species "social amoebae" – claiming that they actually form a society of the species comparable to an ant farm or a beehive. Since these animals have long been the subject of study inspiring social theories, such a line of inquiry opened up, offering great possibilities for ideological manipulation and misinterpretation. Interestingly, the first discoveries suggested that perhaps in contrast with ants and bees, there is "competition" and "cheating" between certain amoebae when the cells which meet to form a body have different genetic identity and materials. In these articles, the language usually applied to the analysis of society is transferred and applied to the understanding of micro-organisms. Observe the following sample from the abstract of a recent article on slime moulds:

Altruism and social cheating in the social amoeba Dictyostelium discoideum

The social amoeba, Dictyostelium discoideum, is widely used as a simple model organism for multicellular development, but its multicellular fruiting stage **is really a society**. Most of the time, D. discoideum lives as haploid, free-living, amoeboid cells that divide asexually. When starved, 104–105 of these cells aggregate into a slug. The anterior 20% of the slug altruistically differentiates into a non-viable stalk, supporting the remaining cells, most of which become viable spores. If aggregating cells come from multiple clones, there should be selection for clones to exploit other clones by **contributing less than their proportional share** to the sterile stalk. Here we use microsatellite markers to show that different clones collected from a field population readily mix to form chimaeras. **Half of the chimaeric mixtures show a clear cheater and victim.** Thus, unlike the clonal and highly cooperative development of most multicellular organisms, the development of D. discoideum is partly competitive, with conflicts of interests among cells. These conflicts complicate the use of D. discoideum as a model for some aspects of development, but they make it **highly attractive as a model system for social evolution**. (Strassmann, Zhu, and Queller 2000)

Methodology

While I am reading about theories and theorists, experiments and scientists, and so on and so forth, I'd like to try out these drifts of the imagination in which you get entangled when you engage concretely and practically with such creatures, experiments and phenomena. Beyond merely reading the documentation about how ideas developed, what about trying to recreate the existential and epistemological conditions which moved such developments? I believe that certain experiences have transformative have transformative power, and that a milieu can only be grasped properly through developing some actual contributions to it, however modest they may be.

maxigas, 2013-08-28→2013-09-02, Budapest

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