SynthEthics

An Ethical and Socialogical analysis
on Synthetic Biology

By Sara Aguiton,
Student in Social Studies of Science at Ecole des Hautes Etudes en Sciences Sociales of Paris,
Member of iGEM Paris Team 2009

Contact: synthethics@igem-paris.org

Summary

Preface : Why wonder about ethics in a biological engineering competition?

The International Genetically Engineered Machine competition (iGEM) is an undergraduate competition begun at the MIT in 2004. In four years the competition grew up exponentially from 5 teams in 2004 to 110 teams in 2009. Within the context of its participation in IGEM 09 competition, the Paris team (iGEM Paris) proposes a reflexion about ethical stakes in synthetic biology, in order to exercise our critical reflexion. Our “disciplinary” motivations to lead that ethical reflexion will be developed in a more formal introduction. We propose to wonder, in that preface, about the several “causes” of the necessity of that reflexion, mainly by wondering about the way interdisciplinarity encourages reflexivity. We wish to establish the fact that ethical reflexion is necessarily linked to a critical perspective, a point will be enlighten in the introduction.

Synthetic biology can be read as an encouragement to interdisciplinarity, as a disciplinary challenge by bringing together, in a unique life science, perspectives from engineering and practices from molecular biology. That interdisciplinarity stimulates researchers the necessity to change from their initial “disciplinary standpoint” in order to come up to synthetic biology specifications, requiring them to change position, to become alternatively insider and outsider towards their own science formation. That change sometimes permits the development of a critical perception, or, at least, makes it more attainable. That critical perspective permitted by reflexivity is one of the ways to get to ethical reflexion.

Among the large field of synthetic biology, the IGEM competition invites young scientists, future researchers to interdisciplinary experimentation. Heterogeneous teams focus on freedom, innovation and motivation can lead teams to perform that disciplinary “insider/outsider” team standing. The specifications of the competition encourage to this reflexive position. In other word, the point is how exploration and experimentation in the way to build up an IGEM project can lead teams to that critical reflexion. Freedom and experimentation, encouraged by the structure of the competition, make the ethical reflexion both relevant and accessible to the teams' mind.

If we go ahead with our inquiry, crossing several institutional or disciplinary structures which promote a critical standpoint and ethical reflexion, we have to examine our own structure of participation in the competition : our team. We can find two “original” explanations to that reflexivity of the team. The Parisian team is build by volunteers to the “IGEM call” made by the Center for Research and Interdisciplinary (CRI) not only because of the student's membership of a certain university. Therefore, the team(iGEM Paris Team) is hybrid both socially and disciplinarily. Students come from high school or undergraduated programs, and differences in disciplines and specializations are large and various. At first, we had to make an effort to understand each other's different backgrounds. In the course of the project development, that “different regard” of the members was transformed, becoming a “shared regard” by building up our project and knowledge, in the process of building a team.

These differences between members, understood as a wealth, were already in the mind of the researchers of the Center for Research and Interdisciplinarity (CRI). The CRI was founded in

2005 at the Medical University of Paris Descartes and defines itself as a convivial place at the crossroad between Life Sciences and exact, natural, cognitive and social sciences. New ways of teaching and learning are daily practices at the CRI, for graduate students, post-doctoral fellows and researchers. The originality of the collaborative, non-hierarchical interactions between students and teachers can be found in the autonomy of the student (they collectively choose the content of the classes) but also in the main research's themes and perspectives. The CRI "call for participation" to IGEM has to be understood in that perspective of giving to students critical tools, understood as a wealth in the scientific approach.

Several effects and new questions will rise of that interdisciplinarity, reflexivity and critical perspectives. What are the effects of those institutional and disciplinary causes of the ethical questions? Why and how can we enlighten what is "new" in biological engineering and in the IGEM competition through ethical reflexion? As we will analyze it in the introduction, we will have to consider the ethical reflexion as necessary, once we have admitted the social responsibilities of science and scientists regarding the social effects of their theoretical and material production. Our work will be lead by another imperative of the ethical reflexion, in order to make it concrete and not to give up to that intellectual temptation to go through concepts and methods without actually "doing something" about it. That imperative is making that ethical reflexion "practical" and so, to see who, where and when the decision process is made and how we can operate on it. Beside our aim, a rapid check on the institutional literature about synthetic biology, such as (CRI), make us consider the fact that reflexion is shared between different kinds of actors of that scientific field, especially States, international organizations and national agencies. The ethical questions about synthetic biology are also and mainly about questioning the governance of the field. How, as a first step, will we manage the debate? Then, how will we supply the decision making? In other words, who is going to decide? Who, after putting stakes into light, will deal and manage the tensions linked to that stakes? That tension is inherent to what could be the definition of "scientific ethics" : the coexistence, the "harmony" between a free scientific research, both in theories and practices, and the social responsibilities of those scientific theories and practices. The necessity of the ethical question can now be seen as "viral", once accepted, it leads us necessarily to the question of the governance, of the decision making, of the action and regulation, from now, each seen as something necessary too.

Methods

The theoretical approach in this report can be regarded as quite “singular”, and that singularity has to be explained. I am student in Science and Technology Studies in the Ecole des Hautes Etudes en Science Sociales of Paris (EHESS) and my thesis focus on practices in the field of synthetic biology. Before participating in IGEM, I worked on collaborative projects with the Center for Research and Interdisciplinarity which sponsored the creation of the inter-institute Paris IGEM team, I wanted to be part of the Paris IGEM team in order to observe the team in the 2009 competition and to see how the team engineered biology and how they dealt with and interpreted the ethical aspects of synthetic biology. This participation was a very good way for me to enlighten knowledge and productions process of a team of student in synthetic biology and for the other students to reflect on ethical issues, which we were able to build on together.

With this perspective, and I am to avoid the conceit “sociological” in my observation, nevertheless this report has to be understood from the perspective “science and technology studies”, with references and concepts that are situated in that academic context. My primary goal in precisely situating my point of view is to be precise what it is not : this report is not the reflexion of a scientist about his/her own practices, but the look of a student of science and technology studies about what students of science are saying about their work.

In my daily work with the IGEM team, some important methodological questions had to be answered : I decided to use a qualitative and participant-based approach, preferring collective experience of reflexion of ethical reflexion to data. This report won't have any graphics with team-members-answers to pre-set questionnaires, instead our meetings and talks were dynamic and I decided not to constrain the scope of the discussion by my up stream reflexions. That process also permitted discussions were coexisted sociological and scientific stakes, when everyone of us were trying to find answers to our own research programs. That was, for me, the greatest benefit to my privileged access to a scientific field, having the opportunity to discussed these questions with the team.

My discussions with the team started with a series of individual conversations with almost all students of the team. Depending on student, these discussions were all very different and at the end of the first round of conversation, I sought to bring together all the different stakes and questions brought by the individual team members in a collective and dynamic reflexion process. We decided to schedule collective talks, each about one hour long and focusing an pre decided themes, in order to delimit stakes. For certain discussions, I had to make a presentation, to put into light the history of a concept, to share with the team my reading on the subject or to highlight what seemed important to me, as a sociologist. That way, I shared with the team my own system of references, they were able to know through what “regard” I appreciated their words and reflexions.

After that talks, and in keeping with the IGEM' spirit, I decided to fill the ethical part of our wiki with an abstract of the discussion blended with my analysis on them. These posts had the form of blog's posts, as a individual, local and situated analysis. This report is more formal, but I propose it to be read in parallel with those informal posts. Both of these types of writing were important to the process of creating a dynamic reflexion of the ethics of synthetic biology. While formal essays are still valuable as a way to express our analysis of any topic, social studies sometimes miss the advantages of informal reflexion (fluidity, experimentation in the writing process, different kind of discourses, vocabulary or lexicon). Both styles were a good exercise, permitting me to scour, to search different ways to explore and uncover the stakes of synthetic biology.

Introduction

Synthetic biology is a young branch of contemporary biology, which aims to design functional modules in an organism, taking the advantages of different methods to develop the capacity of that organism to “do” and to “be” something new, something that isn't naturally in its own capacity. Synthetic biology embodies the meeting of two assembled elements : the manipulation of organisms modified by man (technologies already developed by molecular biology) and an engineering approach through the aim of standardization.

By using an engineering approach, synthetic biologists hope to discover underlying design principles in genetic networks and to develop new standards for how biologists manipulate genes. Tim Gardner and Jim Collins' biological toggle switch (Gardner, Cantor, and Collins 2000) is a good example of this engineering approach. Using simple, standardizable genetic modules, they were able to build a switch in E coli that controls its behavior. Thus, knowledge from genetics is transformed to work for engineering purposes. Through standardization, it is hoped that discoveries and progress in synthetic biology will be usable at a large scale, will be included in a common reference and could create a harmonious and protocolar ensemble.

The emergence of a new discipline, of new forms of knowledge, new sets of practices and handling is “socially” accompanied by new discourses, tales, hopes, anguishes, etc. That new “whole” will have built-in stakes, references and paradigms that affect our regard of the world. Our reflexion is about ethics in synthetic biology. Thus, we will poll, question those hopes, anguishes and promises linked to that new discipline in that ethical perspective.

The ethical reflexion has some intellectual constraints : we will have to take account of and challenge the abstraction of the moral and normative while facing the complexity of the social world it is trying to rule. Ethics in science is quite difficult to define, I decide to consider it as the challenge of the coexistence of a free scientific research, both in theory and practices, and the social responsibilities of those scientific theories and practices. In this introduction, we will have to consider two sets of stakes, two dimensions relevant to that challenge. At first, in the field of ethics : how and for what aim was the ethical reflexion on the sciences built? Then, in the field of science : why do scientists have to consider, through the concept of risk, the social world?

A. Perspectives from the field of ethics : polyphony and the moral imperative.

Deontology in science (as a professional ethical code or a code of professional responsibility), since Hippocrates, was gradually twisted, invested, questioned by a series of social actors and disciplines. It no longer belongs to doctors and, largely, to scientists, on their own and in a “corporatist” way, traditional and endogenous, to rule the moral implications of their works and productions. It is an ethics “by doctors, for doctors”.

The main rupture which leads us from medical ethics to bioethics happened after World War II, with collective reflexions about human rights and science, coming to us from the “by doctors, for doctors" perspective. During the 60's, two kinds of events happened that shaped the development of bioethics : some scandalous cases (for example the Thalidomide (Cerhr), the Brooklyn and Willowbrook cases) and the emergence of new critical and political discourses claiming individual rights, autonomy and contesting authority, and, through that criticism, medical and scientific authority.

The singularity of bioethics comes from this plurality of legitimate social actors, disciplines and discourses about "good practices in science". Among these, medical and scientific discourses are joined with discourses from the theological and juridical fields, as well as discourses from activists, ecologists, citizens, consumers, patient, etc. That singularity comes with a enlargement of the scale of the object of the ethical thought : from medicine to life science. In the United States of America during the 70's, that movement came with a polarization of the ethical concerns : some specialized sectors of ethics were rising (bioethics, business ethics, environmental ethics, etc), showing that the point is now both about building a system of ethical references and a rational procedure of decision-making. It enlightens the pragmatical concern at work in that new ethical perspective.

Legitimacy seems quite hard to attain : the one who detains scientific knowledge is no longer the only one who "can" and "must" express the social ins and outs about a scientific discovery or progress. There is dissociation between modes of legitimacy of bioethical discourse and forms of "traditional" scientific gratitude. We can notice that new participants of the debate are "uninitiated" persons or a "mixed group", expressing themselves in new structures (institutional or not), new moment of expression, and new recommendations. Temporality, form and dynamics of discourses are now numerous, hybrid and non rivalled. Exteriority from the scientific field is now a criterion of legitimacy, regarding the fact that internal motivations of the speakers are not involved in the moral imperative expressed.

These new expressions of "good practices in science" lead us to a new problem : it reveals a new and complex prescriptive dimension to the bioethical discourses. Actually, the pragmatical objective of that ethical reflexion is to prescribe. It makes use of an imperative, a "good practices manual" as tools, expressing its genealogy and cultural history : universalism of moral principles from the modern philosophy.

Both elements, one from the historical construction of bioethics and the other from that philosophical tradition, are intention. Plurality of discourses about good practices in science is becoming a productive polyphony, both considered as complex and as new wealth of our democratic societies. That polyphony seemed quite contradictory to the quest of unity and simplicity of moral principle, built on the idea that a moral imperative has to be one, simple and necessary to be operational and, above all, to be valid.

How are we to deal with both, quite contradictory dynamics in the bioethical perspective? How are we to build normative principles in order to guide and to control practices? Every disciplinary paradigm, every social actor, every regard seem legitimate to express in their own way but are still trying to fulfill a unique moral imperative. Bioethics has the interest to embody that tension between a polyphony of legitimate discourses and and a moral imperative quest, between the multiple and the unique, the hybrid and the pure.

B. Perspectives from the scientific field : considering the social world.

As we find out in our previous reflexions, the look of the outsiders of the scientific field on scientific practices and productions is now perceived as a richness and is progressively admitted and legitimate.

Citizens, jurists, sociologists, economists, politicians, people from consumers or patients' associations, NGO's are now entitled to claim a visibility on scientific practices and motivations. That claim came with discourses, recommendations and alerts.

My own presence in the Paris team in the IGEM competition is representative of that phenomenon : being a science studies sociologist on the team, having a “anthropological approach”, trying to enlighten ethical stakes. Scientists accept the presence of observers. What will be the feedback of that acceptance? Of that opening to the other, the outsider of the scientific community, the uninitiated?

We first have to come back to an a priori that will be only mentioned here because of its importance even if it is not at the heart of our reflexions : the historical influence of the uninitiated, the non scientists on the constitution of scientific knowledge, has always been important, even if invisible. In the pubs of London in the modern period (Information 1999, vol. 32,) or in the salon of the “Blue stockings” movement of the British aristocracy (EHESS), many invisible places and people are left out of the History of science but were active contributors in the production of knowledge. That contribution in invisibility is a way for us to perceive the broadness, the irregularity and the divergence of the multiple front line of science, creating a multiplicity of places, people, kind of expertise and practices to look at (Pestre 2006).

According to Marie-Angèle Hermitte (Hermitte 2007), in the 1970‘s, a "society of science and technology" (referring to any society where science and technology are the primary production resource) developed between the economy of knowledge under construction (weighing up knowledge, technology and sustainability as a new motor of the contemporary capitalism) and the risk society, considering that “we can't have one without the other”. That culture of science also has a new component, separating it from the idea of priceless progress, making its rise “spectacular” for the analyst : that society rests on “consent”. It is now admitted, encouraged and normalized to expose difficulties and risks linked to technological society, to admit that technological progress is not exempt from negative effects. That element will be important in our approach, because it culturally built up a new objective of the ethical perspective, adding to the objective of prevention (regarding established risks) an objective of precaution (adding the “probable” risks to its concerns). The new aspect of “consent” in our technological society regarding crisis, risks and the global consensus about the necessity to exit lead to the creation of a new people, composed of manufacturers, scientists, politicians, and citizens keeping their differences of opinion in order to create “social pact” to answer the new social and environmental imperatives. The risks associated with emerging technologies could reconfigure the social world, putting the promises, responsibilities and expertise of science and scientists at its centre. The ethical questions in sciences and the new relations that it “imposes” between social actors can have some large effect and reconfigurations on the social world and democracy.

We have to take into consideration those uninitiated in the social debates, controversies and polemics nowadays about the technical and scientific decisions facing risks (nuclear waste, GMOs, infected blood). Controversies are special moments and situations where both uncertainty and divergences between actors are perceptible. These situations call scientists' monopoly into questions about what is the best way to resolve the “local” problem, leading to a more “global and conceptual challenge” by reopening the question of the “neutrality of science”. The legitimacy of the scientific decision about risks, and so the technical choice of politics usually based on these scientific decisions, are now disputed. Scientific and social controversies are a way to put into light the democratic aspects of the scientific decision-making process, focused on the question of the good way to “live together” (including the environmental question), that new social pact, where ethical perspective is at the center. We can also notice, referring to the work of Callon, Lascoumes and Barthe's (Callon, Lascoumes, and Barthe 2001), that controversies are also regarded as a new way to practice a “dialogical democracy” in the decision making process, in some new “open spaces where groups can mobilize themselves to debate technical choices in which the public is involved”. As already proposed, the question of governementality, the scientific decision making process and democratic experimentation have to be considered in our reflexion.

As evidenced by our emphasis on the words “look” and“regard”, ethics is mainly about observation, looking before assessing. Importantly, in order to judge a situation, one needs to have access to it. That “look” on scientific production can be the look of the scientific community, the look of the outsider, the look of the judge, etc. Building ethical tools is also about building that observation, that special way to look at scientific production. I intend to create a dialogue between the “look”, the “regard” and the “speech” as the next step of this ethical perspective. That way, speech has to be thought almost as “action”, referring to the performative utterance, allowing us to consider it also in a critical perspective, by observing what kind of power, tensions and strategies are involved in a scientific debate that covers a multiplicity of social stakes.

I. Biosafety and biosecurity concerns

In the first part of our analysis, we will focus on biosafety and biosecurity problems, a primary concern surrounding synthetic biology. Our analysis is based on the synthesis of arguments from a heterogeneous literature. Thus, as stated in the introduction, we must try to take into account the polyphony of ethical discourses. By reading these papers, we can find a homogeneous ensemble of arguments and warnings, showing that homogeneity could happen even in polyphony, when every social actor has the same interest, creating an invisible and informal consensus. We will use the evaluations of Vivagora (Vivagora), a French intellectual association that studies the stakes of biotechnologies, the ethical report Life to Lego of the Delft University of Technology (Flipse 2008) in Netherlands for IGEM 08, two monitoring strategical reports from French State (Note de veille stratégique (Suet 2009)) and the European Union (through the Synbiosafe initiative (Synbiosafe)) and the paper A Synthetic Biohazard Non-proliferation Proposal by George M. Church, professor of genetics at the Harvard Medical School (Church 2004).

Biosafety and biosecurity are neologisms build to express new forms of alerts against risks linked to technologies of contemporary life sciences. Biosecurity's reflexions focus on “biologic accidents”, involuntaries, and unexpected consequences of certain scientific handling. Through these “bioerrors”, for example, we can think about the involuntary release of a synthetic organism into the environment, or the unexpected production of toxins or pathogenic agents by an organism that was thought to be under control. Biosecurity is about risks posed by a malicious mind, a person who wants to harm. That threat is embodied in the “social part” of the bioterrorist. The “subjects”, centers of interest of biosecurity and biosafety are also what justified their common analysis. Health, regarding human, and environmental concerns, regarding “non human”, are at the heart of the ethical perspective we will perform. Biosecurity and biosafety are very present in the synthetic biology literature and that presence can be read under the light of M. A. Hermitte’s explanations about the fact that, in our society of science and technologies, both promises and anguishes are formulated at the same time (Hermitte 2007).

Both kind of risks can be divided and connected through two concepts : malice and failure. In the texts we studied, we found the main distinction between these concepts to be the identification of the person who is at the origin of the action (the scientist and the terrorist) and the nature of his intentions, his wills. We have to notice that failure is attached to scientific work and is opposed to the malice of the terrorist will. Intentions, errors or “harming will”, in ethical reflexion, are substitutes for other concepts that we usually use to distinguish “terrorist” and “scientist”. Thus, “knowledge”, “work” or other social aspects are not present here. We do not distinguish these cases by their intellectual and handling capacities but by their intentions. Even worst, the scientist seems to undergo, in that portrait, natural unpredictability and errors while voluntary procedure of the terrorist seems to confer him a better relation to knowledge, at least more efficient. Failure is related to the scientific handling while success is related to the terrorist perspective. That point is quite risky for the social perception of synthetic biology, “essentializing” the discipline in a dangerous light, success being easier when you want to hurt others. It also leads us to consider the democratization of knowledge in new disciplines of life science. That kind of insignificance of knowledge represents the fact that is not the main distinction anymore : everyone can have knowledge of the life sciences, it is not a principle of distinction anymore. That point entertain the risks perception : for example, the fact that Roger Brent, Director of Molecular Science Institute of Berkeley, estimates that 100,000 people are able to create their own anthrax is a very frightening argument, encouraging critics of that democratization process. The last element we can get from that analysis is the new mythical construction of the social aspects of our protagonists, the scientist and the terrorist. I use the "mythical" word to refer to the cultural influence of sciences in the construction of the way we perceive the world and the social agent. Thus, in the theoretical perspective of philosophers such as Donna Haraway (Balmer and Martin 2009), we can draw the mythical figures that seem to embody a part of western culture frightened about the uncontrolled holder of knowledge. The social figure of the terrorist and the scientist can be considered under that light. That new cyborg figures, hybrids of promises and threats, products of our techno-scientific, post-industrial and western societies.

C. Biosafety

1. Questions

a) Questioning biosafety matters?

In parallel with that new cultural construction of the protagonists of knowledge, as Synbiosafe points out, an ethical perspective will have to succeed in a new challenge for risks perception.

« In traditional genetic engineering the risk assessment is based on the donor organisms. Most transgenic organisms so far contain genes from relatively few parental organisms. In synthetic biology, however, the situation changes because organisms can be created with a large number of genetic donors or even without any natural templates at all. Also instead of changing only few genes, with synthetic biology we will be able to create completely new genetic networks without known counterparts in nature. Given the absence of natural templates as a basis for solid evaluation, how can a risk assessment be carried out under such circumstances? »[1]

Is other words, are we able to integrate the techniques and technologies that are performed in synthetic biology with our social devices of risks prevention?

b) What are the biosafety problems?

What are these problems? How are they formulated in our lectures? A set of problems can be drawn, we'll try to justify it in the more complete and concise way.

To introduce our point, we will refer to a question asked by the Synbiosafe report, wondering about risks in the perspective of the "rejection of novelty". The Synbiosafe report wonders about reliance on new protocols in order to answer to the new risks when some people say that nothing is new in synthetic biology, referring to risks in life science in general. The European initiative retaliates to those critics, underlining the contradiction of their purpose : how can we promote such "novelties" in synthetic biology and, in the same time, claim that nothing new is happening about risks?

[1] Synbiosafe, Background Document Pages 5-6

Discourses we are about to analyze, in the preventive dynamic of the ethical reflexion, have to be thought of in the stages upstream of the incident and challenged to find “efficient answers” even if problems are not yet present to us.

c) How to evaluate risks?

As already mentioned, risk evaluation seems to be a necessary preliminary step to any satisfying ethical reflexion. Are we able to understand the stakes? Through what means and what formulations?

One of the new ways to perceive ethical stakes can be find in the TU Delft ethical report, by mathematizing the analysis of the risks.

« When making a decision, like the decision whether or not to use Synthetic Biology in an application, one balances the risks against the benefits. But is actually meant by “risk” isn’t always clear. Textbooks state that the Risk is the magnitude of the Hazard when it takes place, multiplied by the Frequency in which these hazards actually occur ($R = H * F$). These risks are partially factual risks, which can be scientifically assessed, like assessing the chance that an organism will share DNA with surrounding organisms upon deliberate release into the environment. There are also virtual risks, like exploring the probability of creating a biological weapon with open source BioBricks. When the future impact of a certain decision, like in the case of using Synthetic Biology in increasing levels of artificialness, risk assessment actually becomes risk perception: the response of the public, NGOs or consumers are unknown, as well as the scientific possibilities and application areas. If the risk is “low enough” (and one has to wonder who decides that), a certain action can be justified. Some would calculate the Justification of a decision as the Impact of something going well, times the Chance of it going well, minus the actual risk ($J = I * C – H * F$). » [2]

That pragmatical perspective create a balance between possible risks and benefits of an application, putting that balance in the moment of the design of that application. After that demonstration, the author of the report has to concede its limits, mainly in the arbitrary choice of the variables. Degrees of certainty and strategical variability in the position of the social actor through the evaluation of risks also has to be taken into account. Thus, an NGO working on biotech risks will develop a more alerted position than a genomic laboratory. It can be interesting to notice, through this light, the importance of the variability of defended positions about risks and solutions, depending on the strategies of actors.

d) The intuition of “nature”

The work of the french association Vivagora enriched our approach about discourses on biosafety by referring to nature. What can we do about unexpected mutation of an organism in the environment? What can we do if a laboratory fails in containment and that a pathogenic

[2] Flipse, Steven. “LIFE to LEGO,” 2008. http://2008.igem.org/wiki/images/5/56/TUDelft_iGEM_Ethics_StevenF.pdf.

agent escapes? Before that, Synbiosafe alerts us about the fact that environmental propagation is, sometimes, the main aim of an application, in particular about green and depollution application. Environmental biosensors need to be deliberately introduced into environment. Facing the weak capacities to evaluate risks, how can we be assured that the synthetic organism will succeed in the task it was designed for and no others? How can we control its behavior?

Through that variability that handicap us, Vivagora adds a fixed element, something solid we can hang on to : the natural dynamics that determines all organisms, evolution. The theoretical and paradigmatical base of the theory of evolution in life science seems to impart it with enough authority to be the element needed to fix risk evaluation. Thus, we can be sure that any organism is about to mutate and propagate in an adaptation process to its environment. Precaution linked to that point is then attached to the concept of control. Development, mutations and other kinds of evolutions of a synthetic organism has to be controlled. That control, however, has to be done through means of synthetic biology. Synthetic biology is thus able to answer autonomously to its own stakes. That control has to be faced from the beginning of a project, in the design of the application, to prevent the match with environment. Thus, precaution is at the heart of that process : from the formulation of the ethical risks to its material and biological answer.

2. Answers

What kind of answers are proposed or brought by our actors?

a) Biological answers with social faces

Vivagora doesn't defend any position but portray proposals from different researchers. Thus radical modification of organisms is proposed to make them unable to survive into the wilds and to cross with other species. It is the idea that “the less natural will be our production, the less they will be risky”. How to perceive that proposal? The internal logic of that idea, that more synthesis will lead to more security isn't a refuge in denial of risks? Regarding unknown evaluation of risks about the reaction of a mutated organism in a natural environment, can we trust our intuition about the security of a parallel system? How can we be ensured of the non-reaction of the organism, even the “less” natural? What if the mutation, despite all, happens, what will be our means of action? The prevention and “upstream” alerts of ethical perspectives don't seem to be satisfied by the same adjectives. Thus, uncertainty about risks coming with a preventive approach is reassuring but, that reassurance isn't coming with the uncertainty of answers.

Synbiosafe mentions the proposal of a parallel biological system which won't interact or exchange with other organisms. The European initiative refers to a “unconventional” biosafety system, through the idea of “high external control” in which the conditions and possibilities of existence of the organism will be controlled and determined by man.

A recent article of Philippe Marlière precises a new framework for biosafety for synthetic genomes (Marliere 2009) based on :

- Physical containment,

- Trophical containment,
- Evolutional containment,
- Semantic containment.

At the opposite of Genetically Modified Organisms GMO, the author wants to design Genetically Secured or Safed Organisms, e.g. GSO.

(1) « Physical containment »

The most basic containment for GMO is "physical containment". Even if the GMO strains are in a secure laboratory, it is imaginable that these strains could escape, as it was the case with Foot and Mouth Virus Released from Government laboratory in august 2007.[3]
New kinds of barrier have to be set-up.

(2) "Trophical containment"

Trophic containment would prevent metabolic cross-feed. The GSO needs rare or naturally unknown substances to survive (artificial vitamins).

(3) "Evolutional containment"

In Wikipedia : "it is about creating modified organisms, recombinant (for example, "reprogrammed" bacteria conceived to be unadapted to autonomous survival in nature. In order to reduce production costs, it is already easy to produce massively new recombinant and reprogrammed organisms with no natural equivalent. If they are very different and highly altered, they have little viability in a natural environment. Using that type of organism, said loser (for example "weaker" bacteria so few are competitive against "natural" forms, so that they survive only if they are cultivated in optimal conditions and artificially maintained by man). This is a form of security of the device, but it implies maintenance costs of the habitat and of the colony. Philippe Marlière notices that it is enough, then, to submit that mass of organisms to a new kind of natural selection process in order to select individuals and strains more suited to survive (which is possible with some bacterias because of their high rates of reproduction). But, that solution asks once again the question of risk of escape in the natural strain of an organism or of an genomic part which became competitive, even "supercompetitive" (said winner)."

We have to stop here for a while, certifying that evolutionary containment corresponds to that "fail fast" solution already mentioned. Remarks made in wikipedia to that device are close to ours. It is also interesting to notice that, into the light of natural selection and the theory of evolution, a new surprising lexicon is entering the game. Synthetic organisms are qualified as winner and loser depending on their capacities of adaptation. The notion of competitiveness enlightens the application of a manager to biological phenomena. Moreover, it is important to note that our preventative approach leads us to fear for that competitiveness. Thus, the winner bacteria causes us to fear, while the loser bacteria stays within our ethical specifications. Vocabulary and lexicon used seem to be both ethically problematic and socially representative of new criteria of evaluation and the way to express it in contemporary life sciences. Like the liberal manager without a qualm in a system of concurrency (the social winner), bacteria will scare us but, through that lexicon, also becoming something that

[3] http://www.prisonplanet.com/articles/august2007/050807_foot_and_mouth.htm

deserves our respect, because of the development of its aptitude. The use of a socially situated lexicon is no novel in life science, as shown in Evelyn Fox Keller and Emily Martin's works about the influence of explanatory metaphors in biology. Emily Martin focused about how metaphors about egg and sperm roles in the reproduction process have an important social impact about our perception of man and women.

(4) Semantic containment

Finally, a new challenge will be to be able to design organisms that implement a semantic containment, for preventing genetic cross-talk. We also consider with classical GMOs to build organisms programmed to commit suicide or to not be able to reproduce (for example, terminator genes or inhibition of reproduction).” Semantic containment will allow to be sure that the synthetic genome/organism is not any more able to share its genetic data with the Nature. Implementations of semantic containment could be to design a different genetic code that could reside in using

- new codons,
- new amino acids,
- new nucleotides,
- new DNA backbone,
- New DNA polymerases,
- New ribosomes

The French page of wikipedia remind us that noon of the four “bolts” offer “certain, definitive or complete protection”, but that has to be considered all together to get to a high level of security. These new framework has to be setup at world level. Industry could use Extreme Genetically Organisms, if and only if, they implement these 4-level procedures, which could be defined in a future ISO norm[4].

b) Protocols to fight hazard

George M Church’s article, A Synthetic Biohazard Non-proliferation Proposal (Church 2004), is surprising in its aim and representative of a certain spirit of synthetic biology. This more academic source does not go through material modes of containment and biological systems of security. It proposes, in a very precise way, to set up an ensemble of procedures of control that are more or less institutional, to create a series of agencies, administrative protocols and organisms of regulation in order to “decrease risks while minimizing impact on legitimate research”. Thus, a licensing system of reagent and instrument is proposed, as “non-profit or government DNA Instrument & Reagent Registry (DIRR) database and web site would allow manufacturers and customers to register their instruments”. A chain of checking and responsibilities is described, from the seller to the customers, through entities as States, manufacturers and distributors of agents, shipping companies, etc. Registers, websites and databases are also presented as needed to manage “existing machines, the resale of used machines and confirmed destruction of machines.” Checking methods as developed by the Drug Enforcement Agency are promoted. That precision and proceduralization in the aim to answer to security imperatives is well described in the article and we won't reproduce it in detail here. But, we must wonder about that proceduralization. Two explanations seemed

[4] http://www.iso.org/iso/home.htm

important to us. The first is about the structure of production in modern life science. Scientists in that field, especially Americans, have to answer to strict security specifications about biological materials needed for their research and handling. Thus administrative "machinery" is admitted as legitimate, integrated in the scientific process andused daily by researchers. That habits of scientists, in their ordering of biological materials or in their conceptions of necessary conditions of security, will determine their ethical discourses and recommendations. The other explanatory element I found in that article is the reassuring fact which can be found in the procedural, even bureaucratic, conditions to make synthetic biology. Thus, we can see here the expression of a "engineering mind", expressed in rationality in that procedural form of the system of production and exchange in life science.

Biosafety stakes will have numerous effects on the way we will treat biosecurity problems. We won't take back all the containment proposals already mentioned and we will focus on new arguments, new discourses which are expressed when actors have to face "bioterror". The proposals mentioned here also have to be considered as answers to some risks in biosecurity concerns.

2. Biosafety and biosecurity : a differentiated focus.

In reference to its institutional membership with the European Commission and in a strategic perspective, the Synbiosafe report relates an interesting element about the formulated ethical stakes in synthetic biology. The report draws a gap between American and European interests about ethical stakes about biosafety and biosecurity. Europe is said to be more interested in biosafety matters and that the USA is more concerned about biosecurity problems. The report asked, in that reflexion, the more strategical and political question of it : "Will synthetic biology deepen the transatlantic divide opened up during past biotech debates?". We won't go deeper into that point but we can notice the geopolitical stakes of biotechnologies that can come with ethical questions. Governance and political strategies that occur with the precautionary approach has to alert us about different motivations of the ethical debates on biosafety and biosecurity.

D. Biosecurity

1. Overview

Vivagora refers to the democratization of access to synthetic biology as a cause of new risks. Thus the "important volume" and "low prices" of genetic elements are presented as possible causes of biosecurity risks. The internet, even if not directly mentioned, is considered as a new way of circulation for factors of risks, permitting visibility and large scale access to that genetic materials.

The question of internet (which will be more developed later) lead us to wonder about the nature of the goods of synthetic biology and about the risks it could contain. The immaterial nature of the goods of synthetic biology finds its origins in the field of genomics, discussed from an illuminating point of view in the works of Kaushik Sunder Rajan (Rajan 2006). He doesn't actually write about synthetic biology but about genomics, but as synthetic biology is based on genomic technologies, we can rely on Rajan's thesis. In Biocapital, The Constitution of Postgenomic Life, Rajan wonders about the nature and value of the goods of genomics, about what companies and researchers are motivated by. The goods of genomics are informational. They rely on treatment and handling of biological materials in order to create information from it. Rajan then proposes a decomposition of that informational product, the genome. That decomposition will make it possible for us to consider how the ethical stakes have to be regarded.

Rajan's decomposition :

Genomic information = Genetic Materials + Genotype Information + Medical Information

Then, without taking anymore from Sunder Rajan’s works, we have to consider that ethical questions about biosecurity have to be seen through two angles about the nature of the goods of synthetic biology : biological material and genomic information. The informational nature of goods coexisting with collaborative platforms in order to support “free” exchange of these goods within the community (as the (BioBricks) foundation) are considered risky in biosecurity concerns. By allowing anybody access to information increases the potential risks of voluntary misuse.

If we focus on public reception of biosecurity concerns, we can find some markers of the social construction of fear. In that perspective, the declaration of Roger Brent, Director of the Molecular Science Institute of Berkeley that 100 000 people are able to create anthrax is mentioned by observers and the media as the thing we have to be scared of. The very high figure, the potentiality of that risk regarding these “capacities” held by so many people and the object of this fear “anthrax”, referring to the post 09/11 alerts are very persuasive elements in order to create fear. Vivagora refers also to an initiative from the The National Science Advisory Board for Biosecurity (NSABB) about surveillance of genetic resources linked to pathogenic agents. Discourses about terrorist threats are built through these markers and effectively shift ethical concerns, but have to alarm us about what kind of social control devices are indirectly promoted here. Anti terrorism laws and devices (mainly the Patriot Act) seem necessary to life sciences in order to match with ethical concerns. Political implications, consequences and matters which underly the debates are needed to be considered seriously.

2. What Kind of answer to biosecurity concerns?

Vivagora claim an integration of the principle of precaution in social and institutional devices about biosecurity. “In a report published in 2007 by Michèle Garfinkel from the J. Craig Venter Institute are presented rules of good practices, urgent procedures, enlargement of biosecurity committees, based on the extension of biosecurity frameworks already developed for recombinant DNA(Garfinkel 2007). We can find the proposal of Raymond A. Zilinskas and Jonathan B. Tucker, bio terrorism specialists, to take into account the principle of precaution. “It could be necessary to banish the use of every artificial micro organisms until the solid evaluation of risks” estimate both author of the article The Promise and Perils of Synthetic Biology.”(Tucker and Zilinskas)

The main issue of that proposal, through their institutional forms, is to call for control of the states seen as the one that can legislate about these concerns. Church's paper also goesin that direction, proposing the creation of agencies, procedures and international agreement about biosecurity issues. Thus, the Garfinkel report "suggest that the American Congress legislate in order to force every synthetic genomes manufacturers to check the absence of pathogenic sequences in ordered DNAs. "Such regulation need to be international to be efficient" emphasizing them"

Auto regulation?

Industrial labs are not forgotten in this debate, as Vivagora shows.

"On its own site, the Industrial Association of Synthetic Biology (IASB) has presented its regulation strains through an editorial of Nature of September the 25th...Thus, and in a voluntarist way, the American Gene Foundries Blue Heron Biotechnology don't honour the dangerous orders when the screening software detects sequences from agent classified as "bioterrorist". No more than one third of companies practices that vigilance today."

Thus, that "good will" is claimed, forecasting different kinds of positioning and strategies from these labs. As Sunder Rajan reminds us, bioethicists are now mostly coming from biotech and genomic companies. In his analysis of the biotech company Repository X (Rep X), bioethics is now included in the business models of such companies :

"So clearly, bioethics is a key area in which Rep X takes an interest, which is not unusual for a biotech company these days. Indeed, Rep X has its own in-house bioethicist, a bioethicist being an emergent form of expert mediator in the ethical debates that surround new biotechnologies. In fact, the CEO of Rep X says of hiring bioethicists : "I'm surprised more companies don't do it. It doesn't cost us anything, and in the end it may save us [money, time or reputation]. I mean, the whole idea of it is so reasonable. We've always said that if we're going on the front page of the New York Time we'd better make sure get it right". In other worlds, bioethics is an integral component of Rep X business model."[5]

This preventive aspect is about to put them strategically in a debate which is about to take more and more weight in the next year, even faster if something like Church's proposals are carried out. That way, they could get the part of bioethics experts in the new born agencies or biosecurity organisations. This taking into account of ethical and biosecurity matters can also be seen through a political, economic and strategic positioning, for example, supporting risk precaution about biosecurity more than biosafety.

Biosecurity concerns impose on actors to privilege "political" solutions in addition to "biological" solutions about security. Thus, the world that appears under our eyes has two components, embodying both naturality and artificiality : the living and the political. We can reiterate here that the life' that is at the heart of our reflexion is a synthetic life, and so, the question of its naturality will be much more complex. The natural element to which we refer here is the thing on which anguish and risks are built on. It is the last natural part resting after handling and lab manipulations : the risk of modification of the organism through its evolution. Thus, even in the case of a synthetic organism, it is its membership to something like a dynamic of the living, connecting it to naturality, which is the focus of the ethical

[5] Biocapital, The Constitution of Postgenomic Life p 62

discourse. In other world, even if there is very little that is natural in a synthetic organism, that naturality will be the purpose of the ethical discourse. Life is so understood through concepts as “out of control”, “irregular” and “unpredictable”, leading us to risks and necessitating regulations. That regulation process will be lead by an other kind of artificial organism, created by man : the State. Artificiality of the State, already theorized by Thomas Hobbes (Hobbes 1960) , now take on the meaning of that regulatory body. Our way to deal with risks, unpredictability and uncontrollability caused by naturality make us entrench ourselves to the State, understood as a complex, artificial, reliable and predictable body. I admit that argument can be seen as quite exaggerated but it is a way to put into light how, sometimes, we are tempted to refer, to protect ourselves through simple diagrams. Here, we entrench ourselves in the protective arms of States, agencies, procedures and protocols, not only because of rational explanations, but also because they indirectly refer to something very artificial, constructed, by man, for man, and, through Hobbes' eyes, in order to find the security we hadn't in nature.

Different from the “winner” bacteria of biosafety concerns, people with malicious intentions are qualified with a different lexicon, lying in law-and-order discourse, formulated through the intervention of the States, agencies or necessary suspicion of labs. The unpredictability of the living, with a meliorative lexicon, is compensated by a pejorative discourse about mankind through figures of the failing scientist or the malicious terrorist.

3. Conclusion : the Steve Kurtz's case

To conclude this part, I wanted to enlarge the debate, to complexify it with the help of an example, the concrete case of the artist Steve Kurtz. The Kurtz case allows us to illustrate a large scale of stakes in life science practices nowadays. Among that stakes we could find intellectual property matters, containment, bioterrorism, DIY practices, exchange between the scientific and uninitiated communities or repression.

Steve Kurtz is professor at Art at SUNY Buffalo and is founder of the activist and artistic association Critical Art Ensemble (CEA). In 2004, the artist worked on the GenTerra project, an ironic look at GMOs, GenTerra is about producing organisms “that help solve ecological or social problems”[6] and on the Marching Plague project, mocking “the notion that biological terror presents any serious practical threat, arguing instead that extravagant spending of tax dollars to defend against bioterror is no more than a means of "maximizing profit and consolidating power through the matrix of biocatastrophe."[7]. To carry out these projects, Kurtz kept at his home strains of Escherichia coli, Bacillius subtilis and Serratia, considered as inoffensive and daily handled in academic laboratories. After the heart attack and the death of his wife, Hope Kurtz, Steve called 911. Finding his “home made laboratory”, the police, present for Kurtz's wife’s death called the FBI and the Joint Terrorist Task Force who arrested the artist and opened an investigation about bioterrorism. Art works by Steve Kurtz often relyon biological material and already had been presented in art galleries and museums. One week after the arrest, the New York State commissioner of public health confirmed the inoffensive nature of the biological agent in Kurtz's house. After the failure of that bioterrorism accusation, the US Department of Justice charged Steve Kurtz and Dr. Ferrel

[6] http://www.medienkunstnetz.de/works/genterra/
[7] http://www.counterpunch.org/cox07132006.html

from Pittsburgh University of mail and wire fraud. That investigation of mail, and listening of internet and telephone communications by police forces were permitted thanks to the US Patriot Act. Even if the name of the charges seemed less serious than bioterrorism, mail and wire frauds could lead both men to 20 years in jail. Dr. Ferrel is accused of illegal use of the Material Transfer Agreement (MTA) between Pittsburgh University and the American Type Culture Collection (ATCC) to get the $256 strain of bacterias sent to Steve Kurtz. Indeed, academic laboratories get biological material from companies like ATCC through such agreements. The MTA specifies that it is forbidden to sell, share, post, or reproduce the material. Such specifications are not very respected in the academic and scientific field. Kurtz and Ferrel are accused of a rupture of contract, but neither institution (Pittsburgh University and ATTC) lodged a complaint about it. The Kurtz case is the first time that the US Department of Justice went so far in such a case. In its Criminal Resource Handbook, the Department asserts that such interventions are justified only in the case of prominent risks for the public and not for little cases. Mail and wire frauds are used in order to transform a civil offense in a federal pursuit. In June of 2008, Steve Kurtz won the case and was allowed to take his home made material lab back, after the failure of the FBI investigation.

That case is so dense that we will only mentioned the more interesting elements of analysis here, the main issue I want to point out is the blurring brought by the reality. We cross all the ethical issues, biosecurity and biosafety concerns by manipulating concepts, stakes and precautions without taking into account the complexity of the reality of human relationship, forms of exchange, discourses, etc. I think the Steve Kurtz case has to remind us that boundaries between scientific and uninitiated fields, interests and motivations, identities have to be considered as complex and moving. In that perspective, we can focus on how human networks expressed themselves with more fluidity than every procedure previously described. As mentioned, human connections, confidence or even friendship between people blur the picture we've tried to draw of the academic world. In fact, human connection and motivation are complex and unpredictable too and even if the MTA existed between Pittsburgh University and ATTC, it doesn't prevent Kerrel from giving bacteria to Kurtz, because of friendship or any other motivations. We also have to notice that the gap between academics and uninitiated persons seems blurred too, numerous kind of links and connections exist between all the social actors, leading to numerous kind of material and informational exchanges or practices.

I wanted to use this biosecurity case to show how it is possible and rich to use ethical approaches to learn about how people are related in science, now understood as a complex social world. That complexity, now visible and in a feedback loop, has to be taken into account in our ethical process, notably about certain proposals that now can appear to us oversmoothed regarding social reality of how synthetic biology, and life science in general can be actually practiced.

II. Naturality and Artificiality.

Most of the texts we have been through point to synthetic biology's modification of nature as an ethical matter. Two concepts, naturality and artificiality,are presented as raising an ethical tension. We will, in this section, try to get at why such tension should be analyzed by ethics, what problems both concepts bring and what kind of issues are proposed.
In a first look, we can legitimately wonder about the "problem" : what is the point about naturality and artificiality? Indeed, as we already said, our ethical approach asserts a connection with reality, with human actions, with pragmatism. In that perspective, aren't we wasting our energy wondering about a conceptual tension? In other word, we will try to find out why naturality and artificiality are in a certain way, an ethical stake.

The issue through which we will enter that points is : do we have to consider naturality and artificiality as real entities, as the things that science is about? That question will permit us to know if we have to include these entities in our ethical reflexion with practical ambitions.

Our first work has to be in defining terms. I'm about to skip this step, and I'd rather not include it in our reflexion, relying on the intuition of the reader that maybeis precisely the point here. If we admit, from now, rigid definitions of naturality and artificiality, we won't be able to perceive the dynamics of the changes that these terms are about to be under.
Dealing with these topics, we also have to face the risk of being too philosophical, understood as more concerned with theoretical structure than pragmatic perspective. The paper Newtons of the leaves of grass, by Joachim Boldt and Olivier Müller is a good example. Because of their wondering about ruptures and continuities from synthetic biology with other biological sciences, they are lee to the question : how can we evaluate the change, the hybridation of the organism? How are continued changes able to make an entity becoming an other? The question about the nature of change in synthetic biology is, in my opinion, more about philosophical concerns than ethical, and, with all our respect about that approach, I've decided not to treat it.
But, as we already mentioned through Evelyn Fox Keller's writings, scientific work is not only about material production, neither epistemological. It is also a discursive one. Thus, revising, defining, re-defining, reconfiguring words and, through them, worlds is one of the processes of science. Let's face, trying to be unbiased, unprejudiced, on what nature and device could mean, and try to understant what kind of stakes they are culturally crystallizing to people's eyes (both scientists and non-scientists) to contain or express ethical stakes.

A. From "what" do we have to protect nature?

Most of questions raised by literature about these topics seem already applicable to other contemporary life sciences practices. Thus, when La Note de Veille Stratégique (Suet 2009) wonders about whether "synthesis of the whole or a part of a living organism is ethically acceptable?", can wonder if that question wasn't already needed in the field of molecular biology or about GMOs. The new waves of questions about naturalness raises as a new stake when we will have to face an entirely synthetic organism as promised by Craig Venter.

We will have the occasion to notice that new accusations and charges are expressed against synthetic biology, through new formulations, claiming the “defense of nature” against manipulations by biologists.

B. Performing Lexicon : The playing God issue?

How are these criticisms formulated? What kind of arguments is called up in order to critic manipulation of nature?
We will refer to some different kinds of sources and lectures we have encountered during this ethical reflexion. Most of the threat expressed against nature are formulated through two ways, hardly differentiable, fighting against both scientists and scientific productions of the field. Thus, the first are accused of “playing god” by creating the second, feared and treated as monsters. It is that traditional fear of the Demiurge and the Golem, which are reconfigured in a techno-scientific cultural approach.

We have to remember that threats and warnings are mostly coming from uninitiated areas and we can find their expression on blogs or comments from popular science papers about the stakes of synthetic biology. Non-scientists’ fears, as already mentioned, don't have to be rejected at the first look but have to be consider precisely as social markers and discuss in order to support our democratic perspective. We will rely on the report of Andrew Balm and Paul Martin from the Institute for Science and Society from the University of Nottingham (CRI). That report relies on another, from the European Union, the New and Emerging Science and Technology program (NEST) written in 2005. The experts (bioethicists and synthetic biologists) recommend and encourage researchers to establish a definition of what life is, in order to rely on it and to show a certain obsolete feature of the threat. As we see it, the main part of the question will be about definitions, but, not only.

What are the formulations of the different fears? Balmer and Martin quoted some :

On the moral front, Mooney [of the ETC Group] says of Venter: "God has competition."[8] To argue that the making of life should remain the province of a divine creator is no argument at all.

Scientists are a step closer to creating artificial life after transforming one type of bacteria into another. … But the announcement has also triggered unease, with some critics warning that the scientists were 'playing god'[9].

Fears have been raised about the dangers of tinkering with life and releasing malignant bugs. "We don't yet know what are the social, ethical and even bioweapons implications of this research," said Hope Shand of the ETC technology pressure group. The most ominous note was struck by a scientist at MIT: "The genetic code is 3.6 billion years old. It's time for a rewrite."[10]

[8] Anjana Ahuja, ‘Life is Just a Bowl of Petri’ The Times July 2nd 2007
[9] Reporter, ‘Scientists ‘Closer to Creating Artificial Life’’ Daily Mail June 29th 2007
[10] Feature, ‘The Scientist Who Wants to put a Microbe in Your Tank’ Sunday Times July 1st 2007

That list has to be taken into account in order to know if fear about synthetic biology is taking more and more importance for uninitiated people.

In a quite different perspective, we can wonder : “how do we qualify a new organism?” Do we have to distinguish that organism from all “natural living organism”? Thus, Balmer and Martin show us how that organism is qualified by different institutions or personality of synthetic biology.

« Venter’s team calls these minimal genome microorganisms, synthetic biologists more broadly may refer to them as chassis, those in the UK synthetic chemistry field have named them chells »

That different process of discursive marking of synthetic organism will take a part in the debate. Depending on the way we will name it, we will perceive it as organism (conceptually attached to the “living”) or as chassis (referring so to the lexicon of construction, material support) : two ways, two possibilities of perception are offered to us. In the case of using the word “microorganism”, we will include it in the whole group of the living, make it understandable through the evolutionary process or through its autonomy. In the case of the chassis, we will perceive it as something which will help us to build an application, answering to our utilitarian needs.

However, the initial question about naturality and artificiality is still not solved. That point is about to show how the question of qualification is redirected when the debate is happening in scientific or uninitiated field even if the object, the “minimal genome”, doesn't change. When the signified is not the point (which is the point of the biosafety and biosecurity questions), the question of the signifier rises.

C. A false question? ...

The question of concepts of life and nature, the question of the signifier is gradually criticized in Balmer and Martin's report, progressively viewed as a “false question”.

Referring to the work of the philosopher Edward Machery from Pittsburgh University, the authors put into light both the difficulty and, above all, the uselessness of a definition of life. Thus, trying to define life and explain its complexity had face many failures : “This (…) is no surprise and is consistent with a whole programme of “life definitionism” that fails to confine its object”. That point is supported by a quote from a 2007 editorial of Nature showing both the tension and failure expressed by the naturality / artificiality concerns : “Many a technology has at some time or another been deemed an affront to God, but perhaps none invites the accusation as directly as synthetic biology (…) It would be a service to more than synthetic biology if we might now be permitted to dismiss the idea that life is a precise scientific concept ”.
Otherwise, authors enlighten the idea that, if we decide to keep that ambition of definition, it has to be interdisciplinary. It leads to other problems, not for scientists but for the observers, ethicists or critics : if definition of life is that complex, unstable and ambiguous, why do we refer to its alteration, manipulation, or its creation, with immoral characteristics?

D. … An ironical answer

Although the idea of the “false question” is proposed, the report relates the answers that were proposed by it. Through these answers, we can find the proposal from the NSF funded synthetic biology Engineering Research Centre, the SynBERC's “Human Practices” project, lead by Paul Rabinow from University of California, Berkeley and Ken Oye from MIT, the PACE consortium and the CHELL Program.

First of all, we have to notice that the first question of naturality and artificiality were gradually turned into another : we are not talking anymore about the ethical statute of nature and devices but about what kind of qualification we can put on the productions of synthetic biology.

With the aim to put qualifying “living” or “unliving” to that “emergent scientific objects”, the CHELL Program proposed something interesting. Researchers from the CHELL Program proposed an altered version of the Turing Test in order to question that statute.

Alan Turing is the inventor of the first artificial intelligent system. In Computing machinery and intelligence published in 1950, Turing wondered about the same kind of question about machines : “could a machine think?”. The obsolete nature of the question will be enlightened by the pragmatical approach of the engineer in his way to answer it. The test is to establish to what point a machine can pass itself off as a human, in the scope of a discussion with a human. The success of the test is, then, the success for the machine to get the discursive appearance of a human being, succeeding in misleading the human. If I use the word “obsolete” to tell about the question, it is because of the kind of process Turing proposed. Indeed, the realistic imitation of the computer, relying on human failures and mistakes does not answer “directly” to the initial question, or let's say rather, it twists its signification and presuppositions : “could a machine think?” is now become “can we consider a machine as a thinking being”. In other words, the human failure in the qualification process means the success of the machine, now becoming a thinking being.

Picking up that pragmatical model of proof, researchers from the CHELL proposed :

« Their version of life is one that requires individual self-replication, self sustaining systems, and a mechanism that allows for spatio-temporally resolved organisation of information within these systems, though they themselves find this somewhat restrictive [Crowin et. al. 2006]. The equivalent of the Turing test would be one in which the chell was able to interact with natural cells in an appropriate manner so as to be unrecognisable from those same cells. They foresee an ever increasing level of complexity in both their understanding of the cell in its natural environment and their capacity to imitate those processes such that the test for life becomes ever more stringent. »

With the “replication” of the Turing test, the false question from the start is now appearing to our eyes. Indeed, the human process of qualification seems now very related to a certain unreliable perception. Turing's pragmatical approach is, that way, also answering to another question, which is upstream. How can we certify of the “thinking characteristic” of any other thing : machine, human, etc. We have built some cognitive process of recognition of what a “thinking being” is, and, through it, “being able to discuss”. In that perspective, the test is just saying that conditions through which we use to consider something as a thinking being can be

fulfilled by a machine. Accepting that, we clearly crossed a huge step : we are forced now to admit that, if a computer can have a discussion with a human such as the human considers that the computer is actually a thinking being (a person), the computer is now a thinking being. In other words, being a thinking being is nothing else but being regarded as thinking.
That replication is not without putting some new stakes on the table : as Turing enlightened the obsolete form of the question "could a machine think", the question "is a synthetic organism alive?" is transformed into "is a synthetic organism able to be regarded as alive?".
To me, this replication ironically answers the question of the distinction of a living and unliving world, putting into light the subjectivity of qualification. In other words, the validation of our definition of the living doesn't seem able to be satisfied by "unsatisfying" answers such as the Turing test. An other formulation of the logic of the test can be found in the text What is it to be a bat? from Thomas Nagel (Nagel 1974) . In that text, we explore the cognitive conditions of the limit of the qualification process.
The authors remind us of Marchery's arguments about the lake of solidity of a biological concept of life. The uncertainty of the concept shows that the quest of definition can only comfort fears about boundaries between the living and the artificial, that quest being necessarily unsatisfied.
It is with the same problem, now regarded as insolvent, that we finish that brief analysis. That dissatisfaction shows, to me, that the question of naturality and artificiality is also obsolete in the way we figure it. The biological test of Turing is ironical in that way and so distinguishes itself from the lexicon and the justification process of the other actors of the debate. The "playing God issue", the will of "saving nature from life science" has to face that pragmatical arguments and seems now reduced to an obsolete criticism.

In our pragmatical ethical approach, we now have to wonder if "real questions" can be asked of synthetic biology about the stake of naturality and artificiality. Our own qualification of real and false questions are needed to be criticized, it is not about reliance of fears and tears expressed within, it is a way for us to distinguish the "resolvability" of these questions. The way we've crossed from now was about wondering on "protecting the living from synthetic biology practices". We tried to show how, without any stable and reliant definition of the life in question, the feedback on the initial concern will be to transform it to a insolvent question.

E. What "real question"? : Practices and alienability of the living.

We can find two set of "solvable" questions which could answer to the reliance of the ethical perspective we are trying to get. These questions will lead us, at first, to the field of practices in synthetic biology. Then, we will wonder about the status of the living, not about its "essence", but as a "social object" : an object of exchange.

The work of Vivagora enlighten the question of practices. If there is an operative question about naturality and artificiality, practice could be an indicator of it and we can follow our survey by wondering if and how scientific practices are affected by that dualism.

The question of naturality and artificiality makes sense in the challenge of interdisciplinarity the field of synthetic biology implies. Thus, if we leave the literal analysis to wonder about the practices hidden by the term “natural” and “artificial”, we will find a set of stakes, maybe more disciplinarian than ethical. That new entry on practices will also take us to a different goal : we won't notice the trying to oppose naturality and artificiality (by trying to get to the tension between these terms), but, on the contrary, to make them coexist, reconcile, and so, to give up that tension.

As Vivagora show it, the question of the natural and artificial could be reached by the hard attempt of an “engineering will”, used to work with controllable devices and the living, which is aleatory and unpredictable. Without succeeding in defining either concept, we will try to attribute some “quality” to artificiality and naturality. Those qualities are called up to progress in our inquiry, we are neither trying to “fix” what could be natural and artificial, nor to juxtapose it rigorously to the scientific practices we will describe.

We are less wondering about the artificial organism than about practices which, trying to create it, are taking a part in the question of this type. We have to evaluate the canons, the models of engineering : what is an engineer looking for? By roughly relating them, we will discover that they are clashing with some quality we can attribute to the living. Through these canons of the engineering method, we will find the formulation of technical needs, the abstraction of a process in order to replicate it easily, the homogenization and constitution of norms and standards of production and uses of the technology. That brief list, non exhaustive, of the objectives of the engineer's practical and methodological needs seems at work in synthetic biology. These aims are then transformed into ambitions, challenges when they try to apply themselves to the living world. Indeed, after even a rapid talk with laboratory operators, we can realize that the success or failure of a manipulation is quite unpredictable. Even deeper, it will be difficult to figure the nature of it : is it a human error? a failure or the occurrence of a “unhappy hazard” in a manipulation? That point underlines the importance of the steady tracking of the lab notebook. But, even the lab notebook only permits a retroactive reading of the experience and does not permit any prediction. Probable fallibility human handling, the variability of local manipulations (which are often hardly reproducible from one laboratory to another) or the “aleatory” characteristic of the development of the organism or colony in the manipulation process make the engineer's ambition very hard to succeed.

Thus, we have to call up artificiality and naturality, relating each of it to practices, in order to wonder about the making of the aims of the biological applications of engineering. Artificiality, devices will, in that perspective, understood through its controllable characteristic, able to be submitted to the abstract process of the engineer, when the living escape to that logic.

Of course, the fact that calibration, homogenization and grading of the living are now totally improved in the field of agronomic engineering can make us suppose that this challenge could overcome. But, taking into account the genomic scale and the bacterial level of challenge, technical, practical and methodological stakes are numerous.

Beside the question of practices we can find another element which leads us to the question of naturality and artificiality. That reflexion will take us along to our final part, by wondering about models of exchanges in synthetic biology.

The question of exchange will indirectly question the “nature” (or at least, qualify it) of the exchanged good and, that way, could be a good way to clear up the debate.

That question, already opened through debates regarding GMOs is now reconfigured in synthetic biology about animate beings. Intuitively, forms of property that we are used to about animate living are about individuals or groups of individuals. For example, we are

proprietary of our dog, or of a herd, etc. That form of property is material and could be compared to land ownership.
At the contrary, the living are seen as “nobody's property”, good of their own (even if we can possess them), or, thinking about species, something close to a patrimony, and in every case, deeply inalienable. The question of alienability of the patrimony brings them close that particular good as national territories (In France, the inalienability of the national territory was in question during the religious war).
That *patrimonial* status of the living is also what seems to support environmental discourses to defend it. We do not defend in the same way an item of property as we defend a species about to become extinct. In the first case, we are defending something because it is our good, in the second case, we defend it because a moral value makes that extinction unacceptable to our eyes.
Environmental ethics enlightens us with the concept of “intrinsic value” of the living, as distinguished from what could be an “instrumental value”. That distinction permits us to consider nature not only as a resource, or a means, but also as a end. That way, we have to respect the Kantian maxim, already enlarged. Kant, in the *Foundations of the Metaphysics of Morals* argues fact that every good action has not only a means, but also an end(Kant and Gregor 1996). With the concept of intrinsic value, environmental ethics permits us to apply that maxim to the living, and assure its inalienability. Nature is an end in itself.
But, what about species built by synthetic biology? The science could, by new production and forms of exchange, call into question that inalienability of the living. The case of Venter's patent is an example of the perspective of a living-good, from its abstract conception, even before its material realization. The *form* of property applied here is not a material ownership anymore, like the farmer and his or her herd. Because of the invention, the design, it is an intellectual property. Intellectual property, applied to the living-good, upsets totally two sets of elements: our representation of the living and the form of our exchange. Living will be, from that point, able to be qualified as both natural and artificial. It won't be necessarily “given” but could also be constructed, designed. In that second case, it is so attached to intellectual property and will be submit to the forms of exchange of the intellectual goods. But, as we will see later, it will also permit to critics to use the arguments of the opensource and free software movements.
If we add, to that two upsetting point, the trends of costs and the industrialization of the material and intellectual production of the artificial living, we are risking to assimilate synthetic species to exchangeable goods and commercial products.
Thus, what kind of property, non already explored, could be reach by these mechanisms? Does every constructed thing have to be understood as product? Don't you think that something like a *species* has to be defended from that merchandizing by our ethical approach.
Can't we do as environmental ethicist with can, enlarging the people and things concerned by the “means and end” kantian maxim or by the intrinsic value?
Most of that stakes will be retaken in our next analyze about opensource but we have to wonder with caution that question of *alienability* and the *patrimonial* status of the living. We will see that opensource models will permit us to see how the living, now both natural and artificial, could be understood both as “nobody's property” and as a “common good”.

F. Conclusion

To conclude this reflexion about naturality and artificiality, I want to focus on something quite different. I wanted to reverse our perspective and make an “open” conclusion by

rejecting the question “from what and who do we have to protect 'nature'?” in order to reach “from what and who is ‘nature’ protecting us?”. My aim, inherited from the social studies of science and also from gender and cultural studies, will be to put into their light how political and cultural stakes are involved in the construction of a discourse about nature. The stake of naturality will be now considered through that conceptual tradition : the living is natural.
Social parts of scientists regarded as pure decipherers of nature, reaching objectivity and formulating the universal truths they discover is at the heart of the criticism and the deconstruction of science studies. Thus, theoreticians showed the influences of political, cultural and social contexts in the production of scientific facts, practices, discourses and results. The analysis of scientific controversies was regarded by science studies as a better way to enlighten that process of construction. Many analysts showed how scientific research and debates weren’t about discoveries of a natural phenomenon, now visible to the scientist but to a construction of it. The scientist who was the “winner” of the controversy was the one whose story was written and maintained for a long time as History of science. By constructing nature (with the help of facts and results), in a dynamical process, he also constructs new active social critters that reconfigure what is true and false, the objective and subjective, the learned and the ignorant. A very good example of that construction can be found in The Leviathan and the Air Pump of Steven Shapin and Simon Schaffer (Hobbes 1960). They show how Boyle, winner of the controversy against Hobbes, had built modern criterions of scientificity. The controversy was about establishing, as Boyle defended it, through the air pump, the “nature” of air and the “proof” of the existence of vacuum. Through the model of the air pump, the laboratory became the space of the science, the instrumental experimentation became the scientific method. In the same move, the “pure” literary form and the modesty of scientific witnesses of the experiment (as the insurance of objective certification) had deeply figured the form of modern science. Thus, beside the concept of nature, there are hidden stakes we cannot intuitively imagine. By winning the controversy, Boyle imposed new conceptions of truth, of proof, of scientific literature, of scientist as a “social group”, of objectivity and subjectivity, of gender (as show by Donna Haraway in (Haraway 1997)). Scientificity and truth are now separated from opinion.

Bruno Latour will call “grand partage” (“big division”) that aim of distinction of entities that compose our world. The “modern challenge” was to oppose opinion from truth, nature from technology, human from un-human, inhumanity of science from humanity of society, scholar from politic... Is our concept of naturality and artificiality not included in that grand partage?

Deeply more political, the theoretical approach of Donna Haraway is to denounce the domination process (both material and ideal) which was constructed in the same dynamic as naturality. The process of essentialization are in the collimator of the philosopher : essentialization of the differences between genders, races, species. Building differences, said “natural”, between these entities show a set of stakes we have to keep in mind in our aim of a fair and responsible knowledge, reached in our ethical reflexion. Through Haraway's works, which I cannot summarize entirely here because of their complexity and importance, we have to consider sciences, in particular life sciences, as deeply political. By ruling about forms of the living, biologist can rule about what is, and so, about “norms of being”. The political characteristic of the scientific discourse has to be related to a standpoint epistemology. Every knowledge is situated : in time, space, culture, history, vocabulary. Words are said by a particular mouth. We have to wonder politically about our own discourses and try to perform that deconstruction of essentialization. These points will have consequences on our subject, through the contradiction Haraway showed in the process of distinction between natural and artificial. Deconstruction is now claiming the hybrid form of entities which surround us. Everything is both “natural” and “artificial”. Natural because it takes a part in our reality and artificial because it is constructed. Nature and device, pure and impure, truth and false, and so many other dichotomies through which we look at the world are now deeply upset.The concept of *nature* is hiding these mechanisms of construction and of domination. It blurs them to invisibility. Something “natural” is something you can't control but also something you can't fight. Deconstruction and effort of deconstruction must be daily practices for us.

III.Practices

The approach developed in this work aims to point out the stakes and challenges that animate the field of synthetic biology.
As observers, we also have challenges and responsibilities. We will now use this third part to face questions about governance of the discipline, challenging our ethical reflexion with a realistic perspective. Thus, a topography of actors and decision making processes will enlighten us about what is “possible”, “thinkable” in order to fulfill what is ethically necessary. We also use this part to put a last look on fundamental concepts about the new perceptions brought by the discipline and by the actors, in order to get at how these topics will affect our societies.

Briefly and schematically, we can have a look on our previous reflexions and observe that we had to consider two sets of stakes and challenges to impose into the consideration of the actors of the field.
That stakes are *technical* and *social*. As I try to figure out in my methodology and criticism, *technical* and *social* questions have to be regarded together, because of their common dynamics and co-construction processes. For example, how to distinguish the “Synthia” project from the Venter Institute, the bacteria which is not yet *materially designed* but already patented, from the question of the artificial life and the theme of intellectual property?
Social and technical stakes are also commonly involved in the necessity to define who is going to have decision making power in the field. What position will be obtained for the one who succeeds in the decision on standards? What dynamic permitted Venter and his Institute to be a major actor in the field of synthetic biology if it isn't by his participation in the race of the Human Genome Project? Both elements have to be regarded together, as in biosecurity and biosafety concerns and proposals : technical, legal, institutional, etc.
However, asking “who decides?” is nonsense if we do not, in the same way, talk about the people and practices concerned and involved in the decision and its consequences : practitioners, students, patients, States, populations, etc. We hope to make something like topography of these actors.

Synthetic biology, facing these debates, both feared and loved, questioned by others field of science, non scientists, institutions, politicians, NGOs, is kind of “forced” to rule, decide and pick its practices, actors, norms, regulations. That “need” of form seems to indicate the relative youth of the field. These decisions, not yet taken, these rules not yet settled, still permit the existence of numerous divergent and conflicting initiatives. That plurality won't disappear with new regulations, but, markers of differentiations will be built and sides will have to be chosen. That youth is also visible through the nature of the stakes formulated: contemporary figures of risks, opensource's questions, DIY experimentation, etc. We will try to put into light how that youth can modify the potential development of the regulation of the field.

A. What form for what life science?

One of the most fundamental stakes about governance will be about standards. Constitution of standard is both technical and strategical for actors, by the essential part standards could play in the constitution of a community and its habits, process in production. Thus, the movement to determine norms of production will determine uses, actors who will organized themselves through it, tools (lets think about BioBrick™) and the form of the following standards (which will be build regarding the previous). Decisions about standards are strategic : the one who will succeed in imposing the norms will be a fundamental actor of the science production.

1. Why standards?

The initiative of a *standardized* biology can be read in numerous perspectives, answering to experimental, practical and theoretical needs of biology. Standardization, through it "rational" part and simple decomposition, proposes a new way to wonder about the complexity of life. Drew Endy considers that it offers a "direct and compelling method for testing our current understanding of natural biological systems". That new theoretical approach, that pragmatical perspective in order to answer unsolved questions has too its practical and experimental counterpart : knowing how a biological system is functioning implies being able to control it.
We are now getting to the *canons* of production of engineering, now biological, mentioned in our previous reflexions. As Ben Howel shows it (Auyoung), standardization in history of technique is mostly about two stakes. Referring at Michael Kershaw's work in "The international electrical units: a failure of standardization?" *Studies in History and Philosophy of Science* 38 (2007): 108-131) : Standards had "to support the work of scientists taking precision measurements" as well as "commercial measurement systems". Howel also reveals that the aim of standardization was about resolving security problems : the technical norm permits assurance of the well functioning of the systems which rely on it, permitting its evaluation. The place of techno scientific standards does not need to be proved anymore in the technology that surrounds us, but Howel notices that standardization process wasn't present in the field of genetic engineering. That way, synthetic biology is disconnected from its *disciplinary parents* and developed its own engineering approaches through abstraction and calibration.

2. Popularization of standard as a strategical stake :

Howel offers us a luminous comparison to explain the popularization process of standards in synthetic biology. Howel compares it to the establishment of the big technical standards decided in the 19th century (as railroad, electrical measurement, etc). Technical norms, in the 19th century in a climax of industrialization process, were decided in large international meetings, congresses of norms' constitutions. Thus, delegations of engineers were meeting in order to establish norms. That centralization of decision making is totally unversed in popularization of standards in synthetic biology.
The initiative from MIT, Harvard and University of California of San Francisco's researchers, through constitution of the BioBricks Foundation is a vary different system for standardization. The BioBricks Foundation provides the material and management support of the Registry of Standard Biological Parts (a collaborative registry initiated and managed by MIT, making publicly and freely available access to DNA sequences and characteristics of BioBrick™). A BioBrick™ is a « is a standard for interchangeable parts, developed with a view to building biological systems in living cells ». The standardization process is in the restriction enzymes used : the only accepted enzymes are EcoRI, XbaI, SpeI, and PstI. The collaborative form we are about to point out is not present in the choice of these norms, these enzymes have been chosen by the Tom Knight and other laboratories are using different enzymes.. The local and university initiative of the conception of the standard BioBrick™

show that the strategy of development and establishment of BioBrick™ as norms is not a centralized strategy, embodied in international organizations and decided in large meetings of engineers. US researchers have developed a strategy of *aleatory proliferation* by the use of BioBrick™ and, in that aim, had to make choices with social consequences. Thus, the Registry is based on the model of opensource template, deeply collaborative, it relies on the principle “get some, give some”. Everyone can get, everyone can give and, most of all, the database is enriched by users. We don’t have to forget that this “get some, give some” is only an academic privilege, if we remember the Steve Kurtz case, the safety issues are often used to prohibit access to non scientists. This collaborative and participative model refers to development models of free and opensource software. Indeed, the main characteristic of information is that it is a “uncompetitive good” : consumption is not making the good disappear or lose its value but, on the contrary, the more the good is consumed, the more value it gets. This model is essential in free software development, contribution of users often permitting to keep the software free and increasing the possibilities of amelioration.
The BioBrick™/Registry initiative relies on the largest use to make its standard established. In order to fulfill this goal, IGEM is a strategic operation. In 2009, 110 teams and about 1200 participants are involved in the competition and are constrained, by the rule of the competition, to respect the BioBrick™ norms : encouraged to use existing BioBrick™, committed to use the four enzymes of restriction to build systems with it and encourage to make most of it available on the Registry. By the management of an event, a “science concourse for undergraduates students”, MIT and the BioBricks™ Foundation are able to influence practices of young and motivated students from universities all around the world.
I didn't had the occasion to search in-depth other initiatives of standardization, but, they are totally conceivable. The internationalization of the norm does not rly on centralization. We can say that the development of the 19th century technical standards was at the image of the mode of government and exchange of the time, relying on centralization, bureaucracy, top-down decision and industrial capitalism. Differently, biological standards relied on liberal dynamics : free competition, local, intellectual and academic initiatives, referring to economy of knowledge, and relying on canons of liberalism. This possibility of free divergence, opening to debate, to compeition, but also to a culture of open science : concourse of young student and opensource models to support the establishment of norms.

As already mentioned about standardization, the missing of any center of decision permits divergent and competing initiatives. The “scientific public” can make its choice and “may the best win”. The pragmatic marker and the liberal culture is particularly visible. As in the opensource communities, the idea that the community is best able to choose the good standard seems to be working. The work of Janet Hope is mostly focused on promoting opensource business models applied to biotechnologies, relying on all kinds of strategies and innovative models permitted by opensource. Thus, thinking of the Richard Stallman slogan, the main idea is close to "free software is a matter of liberty, not price”. To understand the concept, you should think of 'free' as in 'free speech', not as in 'free beer'. The opensource models are not anymore opposed to a merchandise logic.

B. Self or Exploded governance?

Relationship with market has also to be through the positioning of actors, in particular regarding "out of science" matters, such as social and ethical implications.

From that perspective and in a ethical and activist approach, the ETC group, a non-profit civil organization of expertise on « the socioeconomic and ecological issues surrounding new technologies that could have an impact on the world's poorest and most vulnerable » criticises the Report on Synthetic Biology Governance from the J. Craig Venter Institute and Alfred P. Sloan Foundation in their report Syns of Omission. (Garfinkel 2007). The ETC group authors critique the pseudo impartiality of the report's proposal of regulation, wrongfully presented as a "project to examine the societal implications of synthetic genomics ».
The main critic of ETC group is the self governing both proposed and performed by the researchers. And, by reminding us that the Alfred P Sloan Foundation is financing this report with around half a million dollars, the ETC group brings out the partial orientation of conclusion. The Foundation of A P Sloan, former boss of General Motors, is working on science and technology topic, but is mainly focused on terrorism concerns. The ETC group points out that the bioterrorism risk is over accentuated, and that scientific errors are minimized. The report is denounced by Jom Thomas from ETC group as a "partial consideration of governance by a partisan group of authors".
Legitimacy of discourses, through the question of internal or external critic is making the question of governance more and more complex. How should we consider civil society in a decision making process about such a technical subject? If trust in scientists about such important concerns is not possible, what other subjects should be governed by the whole society? What about other fields which are equally important? Is a real consensus with so many actors thinkable? Aren't we about to put our trust in the best speaker? Won't it be, in the end, a scientist? Even deeper, how should we consider the border between the internal and external standpoint? Aren't we always on both sides?

We have already mentioned non-scientist participation in these decision making processes, in a macroscopic way and we put it as a principle. The ETC group enlighten how private interests can build up biosafety and biosecurity concerns have already been raised. However, two additional social stakes mentioned by the ETC group are:
Economics : synthetic biology is a capital-intensive technology likely to have massive downstream impacts on marginalized peoples if it is adopted and promoted. Impacts will come first in agriculture and health but then in geo-engineering climate change. Synthetic microbes programmed to make industrial substances could potentially de-stabilize South economies and employment.

Control : like biotech, companies are already patenting critical synthetic biology technologies and processes. Although some in the synthetic biology community may be advocating for opensource biology, others such as Craig Venter have a long biopiracy record of profiting from human and non-human gene sequences. Because the science can be privatized and monopolized it becomes more attractive to companies seeking profit rather than addressing social needs.

The ETC group obviously defends the idea of a *public concerned science*, promoting external and exogenous control, regulation-building processes and decision making. That point is once again revealed in the *Open Letter from Social Movements and other Civil Society Organizations to the Synthetic Biology 2.0 Conference* (ETC 2006). The initiative of the *Synthetic Biology 2.0 Conference* in May 2006, was to mix up scientists from the field in order to write a « "voluntary" code to prevent biosecurity risks ». The conference is criticized by ETC group and many other organizations (such as scientists, engineers, environmentalists, farmers, social justice advocates, trade unionists and biowarfare experts) because of the internal control promoted by the “voluntary” perspective and is compare to the Asilomar Conference of 1975.
Asilomar was conference about the ethics of emerging genetic engineering proposed by Paul Berg in 1975. Paul Berg was then about to insert a gene from the SV40 virus in *Escherichia coli* and decided to stop his research because of human health considerations. He decided to invite other scientists to a debate the ethical stakes of transgenese and to build up a moratorium. That initiative was only about scientists, no consensus was found for the moratorium and the conference was only able to propose some precautions, mainly focused on human health. Most of the criticism against the Asilomar 1975 Conference was about the scientists' lack of ecological and socio-economic concerns (regarding agriculture, patenting of genes and organisms, etc).
The critic from the ETC Group and the organizations of the civil society authors of the *Open Letter* is coming with a set of proposal in order to build a new governance of synthetic biology. In their view, the main problems and proposals are :

Society - especially social movements and marginalized peoples - must be fully engaged in designing and directing societal dialogue on every aspect of synthetic biology research and products. Because of the extraordinary power and scope of synthetic biology technologies, this discussion must take place globally, nationally and locally
Scientific self-governance doesn't work and is anti-democratic. It is not for scientists to have the determinant voice in regulating their research or their products
The development of synthetic biology technologies must be evaluated for their broader socio-economic, cultural, health and environmental implications not simply for their misuse in the hands of 'evildoers.'

We can end that reflexion about society and synthetic biology with something pointed by Kaushik Sunder Rajan in *Biocapital* (Rajan 2006). He analyzes how genomic companies are building ethical discourses, mostly focused on biosecurity concerns, as in the *Report on Synthetic Biology Governance.* Rajan shows, by quoting them, that ethical discourses pronounced by genomic companies seek legitimacy in slogans such as « saving life », « genomics for life », etc. Thus, companies are not only defending ethical statements and values in order to prove that they are responsible, they gradually become themselves “ethical entities”. The biosecurity problem allows discourses to be constructed about the “bad” and “malicious” , as opposed to them, the ethical company. To understand this, we refer to Michel Foucault’s concepts of “biopolitic” and “biopower” to consider how *life* can be used as a means to exert power and how power is now expressed on individual and collective life. In that light, bioterrorists use biological material to affect your life whereas genomic companies are at the service of your life, by defending and ameliorating it with individual biomedical consulting and by writing ethical reports. *Life* and its possible improvement through biotechnologies is now a fundamental concept in the constitution of a political and economical scene with huge stakes. The scale of genomic is now so precise that we are not talking anymore about *life* as an abstraction, a pure concept. Through genomic information, we are now talking about *your individual life*, as *your life* can be reached by bioterrorism, *your life* can be saved by genomic biomedical companies. Individualization is now biological through our genomic information. Our bodies, our health are now included in the individualism paradigm of our western societies, added to the political and economical individualism we are already used to.

C. Forms of critics

That brief presentation and reflexion about civil society proposal has to be deepened.
Indeed, the tone of such critics, although still legitimate to me, presents a quite simple image of what we call the "synthetic biologist". Who is that scientist? Is every biologist like Craig Venter? Of course, the ETC Group is not so simplistic, some scientists are even very activist in such pro democratic science movements, but, I think we can use this conclusion to show how the youth of the discipline, already *conceptually* mentioned, is embodied in practices and scientists, and how because of new methods and ways, science is actually performed differently than what the Craig Venter Institute is promoting. The youth of the field offers the opportunity for actors to try out new ways to build knowledge, manipulation, place of science, criticism, etc.

It is above all a way to check out what kind of internal critics are made. That critics are both obvious, claimed as *different practices* by groups such as Do It Yourself movements, than something more softly performed in everyday science making process.

DIY practices are, to me, highly critical. By leaving academic laboratories, by building (both conceptually and materially) new kinds of experimental places, new tools, new ways of communication between scientists and open to non scientists participation, DIYists are clearly performing something new, which gives other aim to the science process. From a narrow perspective, science could be regarded, amongst other characteristic, as a way to build knowledge, technique and technology. DIYists consider science as a *social activity* thus changing radically the standpoint we can have on it. That way, science is regarded as something in which you can find *personal achievement*, in contrast to the more traditional perspective where the scientist is erased in the process of knowledge construction. Science as an activity, as a hobby, as a way to find fulfillment, changes, as a logical consequence, who will be involved and concerned by such practices.
The logic is quite simple: when science is about creating knowledge, not for yourself as a person (in a learning process) but in order to contribute to the whole system of knowledge, your aims, concerns and perspectives will be different. Of course with social studies of science, we already noticed that human and social factors are involved in the scientific process. There is nothing such as a pure scientific mind. But, the discourses about "why do we make science?" are mostly lead by such participation to a whole system of knowledge. That way, the traditional scientist's aim is to contribute to a big ensemble, transcending their own work, their own person, even their own discipline. However, if we look at science as an activity, you can answer the question with something like : "making science to have fun" or "to build knowledge from scratch, in a garage or a kitchen". That way, non scientists can be welcomed by DIY communities, and such aims can be imagined as something to be shared by

everyone. That *openness* to non scientists, now called "amateurs" (motivated but uninitiated people) allow us, in my opinion, to link DIY perspectives with critical discourses, such as that from ETC Group. Regarding decision making, local practices, and the aims of science, DIY is obviously open to the democratic perspective defended by ETC Group. More deeply, some of their concerns are claimed by DIYists as aims. In that way, the DIYbio.org website[11] presented themselves as "an organization dedicated to making biology an accessible pursuit for citizen scientists, amateur biologists, and DIY biological engineers who value openness and safety. This will require mechanisms for amateurs to increase their knowledge and skills, access to a community of experts, the development of a code of ethics, responsible oversight, and leadership on issues that are unique to doing biology outside of traditional professional settings".

As such, biology is then *conceived* and *made* as a set of social practices, open to both scientist and non scientist in order to answer to very different goals than traditional science: for example scientific skills, ethical reflexion, and new ways to cooperate are now integrated with the actual science goals.

This description doesn't have to lead us to consider that there are two worlds in synthetic biology, something like "Venter Institute versus DIY practices". The portrait of the field of synthetic biology is much more complex : big companies, little start -ups, universities, institutional or associative organizations, movements, groups like DIYbio, etc. Everyone is pursuing both different and similar goals and a lot of ideas, discourses, practices and people are circulating in all spheres. We can view the IGEM competition as one such place (along with so many others) where people and practices from these different worlds can meet. The huge advantage of such an event is that it allows us to observe something like a *cross section*, or an *extract, of the whole picture* permitting us to get stakes and debates clearer.

D. To finish with... A case study

But, events like IGEM are not only offering us a certain visibility, they are creating something and something more than the individual student projects.

As we mentioned with respect to opensource strategies in standardization, the IGEM competition is stimulating new practices, new "science *spacetime*", for students : choosing their own subject, building their own team, dedicating their holidays to that program. In a certain way, IGEM is promoting something close to DIY practices : science is not only about courses and classes, it also seen as an innovative project, even if everything is done in a rush and hardly finished. The imperative use of the public wiki makes the competition very unusual and indirectly announces an open approach to science making. Summer and temporary labs aren't thought to be close to the world. Sharing, meeting, looking at other projects is encouraged. Some elements are new for students, such as the use of BioBrick™. In the same way, the "get some, give some" principle has to be integrated as a new way of making science, and, in addition to the standard using habits, free exchange between scientists is performed.

But this portrait has also to reflect the conflicts, so normal in projects of this kind. As an example, let's consider the attempt of participation of a DIY team in the IGEM 09 competition. On February 2009 DIYbio Groups had initiated the idea of a DIYIGEM team[12]

[11] http://diybio.org/

[12] http://diybio.org/2009/02/09/diyigem/

with a “home made project” and started to think about what they can propose, regarding their material conditions of work. Regarding posts written on DIYbio googlegroups, website and blogs, on April 10, the initiative was rejected by the IGEM's direction. Mackenzie Cowell from DIYbio, former student and researcher at the MIT and instructor for IGEM, related the official reasons for rejection in one of his post, quoted from Randy Rettberg, IGEM Director :

1. “IGEM depends on the academic institution of each team to provide a safety framework for that team. Because there is no formal safety framework or guidelines or precedent for amateur teams working outside of traditional labs, IGEM is afraid of the potential safety liability and doesn’t want amateur teams to participate until there is some kind of framework (2010!).
2. Most of IGEM’s funding comes from grants to support undergraduate education. A host of amateurs who are not undergraduates would be supported by grants for undergraduate education, which could be a situation the grantors wouldn’t like. Randy didn’t want to take that risk.”

We can see that concern over biosafety is called up by the IGEM Direction to reject the DIYIGEM proposal. The second point is a very different argument, putting into light how both youth and academic composition of teams are important to grantors.

Two important things follow the rejection: how the DIY community proposes to take strategic advantage of it and how IGEM 09 Competition answers.

If we keep going on the post, Mackenzie Cowell is proposing different things to react to the rejection. At first, the rejection seems to lead DIYists to challenge safety concerns for two reasons. At the same time, in order to endure in the field and to be well considered by society, these safety norms will have to be established. And once these norms are established, it will be a way for *garage practices* to be known and recognized as serious and responsible, rather than being seen as a security risk. Then, the post proposes a very local strategy to create something about its rejection: Mackenzie Cowell proposes to make a “DIYbio symposium at the same time and place as iGEM” and follows, “it would be very valuable to bring as much of the community together as possible to meet and discuss these issues and to present a collective snapshot of their work and projects to the world. There would be cross-pollination with many of the iGEM participants, and lastly, I’d like to use the symposium as a deadline by which some group or groups of people could formally present thoughts and work on our safety strategy to the community and to the rest of the world.”

As in traditional activism, the DIY movement knows that an innovative and quick reaction, even about a “bad news” can get round the problem and turn it to their own benefit.

The MIT reacteded, presumably to the pressure of DIY groups, by a surprising but small initiative. The IGEM 09 Competition will be the first to propose an “Open Division”.

On the IGEM 09 official wiki, you can find:

“For iGEM 2009 we will are opening up an experimental track for individuals or small teams that are interested in participating in iGEM in a limited capacity. These non-competition teams will have a chance to present a flash 5-minute presentation and present a poster at an exposition section of the iGEM 2009 Jamboree on October 30 - November 2, 2009. Non-competition teams will not be eligible for the standard prizes from the iGEM judging committee but might be eligible for a single award specific to non-competition teams."[13]

That way, MIT and the IGEM Direction are able to keep an image of openness to the participants, to DIY groups (which are mostly composed of very qualified biological engineers) and to grantors. Without making eligibility for global prizes and requiring teams to be "affiliated with a university or educational institution", "have at least one faculty instructor" and reserving the right to give DNA on a case by case basis, MIT seems *protected* from "home made" projects.

[13] http://2009.igem.org/Open_division

Conclusion – Last words

I want to end by raising some questions regarding all we have been through, to suggest what can be understand about what is happening in that emerging field, and to make a recommendation.

First, regarding the third part of our analysis, we can see an explosion of actors, something like a scientific chess board, where companies, states, civil society movements and observers, students, DIY movements are all vying to be involved in the governance of the field, and both to answer regulation necessities and to fulfill that aim, they are proposing different ethical *inventories* and *perspectives*.

This hybrid world of synthetic biology says something about the state of an emerging field in science, and how the scientific field is now -- as it always been -- clearly linked, mixed up with, and related to *economic*, *social*, *political* and *cultural* stakes.

Given the hybridity of actors and multiplicity of stakes, synthetic biology is like a *festival*, were the ethical needs can be related to the appreciation of the "public". This public is at the same time concerned citizens, patients, media, readers, etc. As in a *festival*, the cartography we elaborated in the third part can lead us to consider something like an *In / Out* separation in the field. In the "In program" we would find scientist, companies, states and international institutions, universities. In the "Out program", civil society and DIY movements, activist like Steve Kurtz, etc.

But some elements like decision making processes, visibility or legitimacy to the public don't match up with that In / Out interpretation. Sides and borders are not so rigid. Cases like the DIYIGEM initiative prove that things can be reorganized and redesigned under unforeseen events and we cannot predict who will finally take advantage of the situation. Largely, in the governance question and through scientific, technological and leadership issues, it is also very difficult to predict how and who is about to be the main deciding actor of the field.

Let's keep in mind that safety concerns, as proved by the DIYIGEM rejection, will surely smooth out this hybridity, and make an *On / Off* separation more established.

What kind of statement can we draw from that? I think it could be interesting to question it ethically, in the scope of the youth generation meeting of IGEM 09. We can wonder about what kind of consequences this portrayal will create for future biological engineers. Taking over Merton's expression (Merton 1942) : In what *scientific ethos* is this generation about to work?

Are there *universal norms* that can now be shared by all the synthetic biology community? Can the values of communlalism, universalism, disinterestedness, originality and skepticism be shared both by biotechnological companies' scientists and by a DIY engineer?

I personally think that polyphony, explained in our introduction, is creating something like norms and duties. They now look more like a *toolbox* in order to build an ethical position, rather than *scientific community norms base* as described by Merton in 1942.

Beside an *ethical toolbox* which permits both scientist and non scientist to position themselves in all the debates we have been through, something like a *critical individualism* seems to be operating in the actors' mind. The idea of a *critical individualism* is that we no longer have the necessity to submit or adapt ourselves to the ethical and moral criteria of a whole community; differences and divergences are accepted and regarded as a possibility of new and innovative ideas. Beside that kind of freedom in positioning, which comes from liberal western culture which promotes the individual as the decider, criticism still matter and organized. Thus, the scientist can join with very different perspectives, as the Craig Venter Institute or the DIYbio local group of his city.

This *critical individualism* seems to be the *new scientific ethos* in synthetic biology.

To summarize our work, we can remember that the two first parts about the ethical stakes lead us to the governance question. In order to face it pragmatically, we tried to describe the interests and interactions of the different actors of the field. We always try, in this work, to answer two imperatives : observing and questioning what can be a morally and politically good practices in synthetic biology. This statement leads us not to limit ourselves to the risks but to face more global ethical needs such as socioeconomic problems.

We have to know how to take advantage of the emerging characteristic of the field as a freedom to challenge :

- In a daily and local effort : A reflexivity in a ethical reflexion on practices, discourses and social interactions. Elements that are building...
- … Disciplinary and larger problematic : A responsible position regarding what *scientific paradigm*, through concepts, perceptions and values, is coming with this field, still under construction but soon established.

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Appendices : Reports of the collective discussion in the team : Real time ethical reflexion

This reports can be find on the Paris Team wiki of the IGEM 09 Competition[18]

Our process

As others iGEM 09 teams, we plan to join the « message in a bubble » project with an ethical reflexion about it in particular and synthetic biology in general.
An anthropological study of the Paris team is running in parallel with the iGEM 09 competition, we decide to join this move to that ethical reflexion, and it lead us to perform it in a special way. We've decided to have an everyday thematic one hour talk about ethic and social practices in science and biology. We decided to make that talks observable for everyone, even if something more constructed will be, at least, produce. You'll find on this wiki page the talk reports, with questions asked to the team and the main argument of the discussions. It should also be considered among an exercise and a report of experimental and anthropological thought. This should be regarded as an ethical and anthropological « lab book », as an everyday, real time look on the reflexion of the Paris' team about that kind of questions.

Enjoy our daily mileage in ethic, sociology, life science and synthetic biology !

Introduction

1. Why an ethical endeavor in science, life science and specifically synthetic biology? *(08/18)*

The main aim of this first discussion was to introduce ethical questions in science from a broad point of view. We started with the following question: «Which conditions are we willing to accept in order to acquire a new knowledge? ». In other words - and in a "what acceptable means to our end" process - which one of these two fundamental posture do we consider prominent : our quest of knowledge, or the possible consequences of that knowledge - by his existence itself or in its applications?

We wondered about the tension between the obvious necessity of an ethical endeavor in science and the inherent slowing down it imposes on the research and innovation processes. That led us to discuss the principle of precaution, starting with the fact that it seems impossible to get the effect of a certain discovery without actually experimenting it. In this light, the precautionary principle appears as a limitation to the process of research - and even worst, something that may incite ourselves to inaction. All these questions and arguments were illustrated with concrete examples : treatment of nuclear waste, stem cells cases in France and in the US, psychology experiment with animals in the 50's and 60's...

Then, we thought about who have to take the ultimate decisions in science with respect to ethical issues. The position of the Paris' iGEM team was quite homogeneous : scientists must take decisions, because the ones who hold knowledge must be responsible for it. Such a

[18] http://2009.igem.org/Team:Paris/Ethics_ethicallabbook#top

regulatory role would be played by a scientific council - or anything which represent the scientific community. One of us evoked a more social and democratic approach : if every citizen is concerned by scientific productions, then everyone has to decide. Nevertheless, everybody admitted that nowadays it turns out that the legislators are those that finally take the decisions, even though they are not necessarily fully aware of what they do.

At the end of this first discussion, some proposal and analysis were expressed : Knowledge is amoral while the ethical problems relies on applications. what about a *"note for good use"* written by scientists?

As a brief conclusion, we can notice that - from the first question to the final point - all ethical questions, analysis and recommendations are specifically expressed by the team from a scientific standpoint. The main issue here deals with the will to gather knowledge and questions how acceptable fulfilling this will is. Such ideas would be very different between different communities. The ethical questions, deeply pragmatic, are included and performed in that *"how to"* concern, which then framed and stated as a *"how to get and manage both knowledge and its application"*.

2. Definition of Synthetic Biology by the team *(08/19)*

The challenge of this discussion was to confront the personal opinions of team individuals so as to come up with a collective definition of synthetic biology.

I submit that exercise to the team because the main concept underlying this new disciplinary approach of biology is defined in a variety of different way in the literature. The engineering method and the design of standardized parts generally stand as the main principles to build a definition of synthetic biology. Some authors contrast the bottom up and top down methods to manipulate life, others gets to *design* to characterize synthetic biology (as opposed to *description* or *understanding* that characterize "natural biology"). *Utility*, *artificiality*, *function*, *component*, *living* devices and systems, *assembling* and *disassembling* are the key concepts, methods and materials that are used by scientists, sociologists and others to construct their own definitions.

We round the table to estimate the degree of diversity of definition within the Paris 2009 team. The main idea was that of *"providing new functions to existing organisms"* and it was mostly expressed in the framework of utility. In their own words all was about "creating", "re-creating", "engineering", "using", "knowing and being able to divide" the *living*. Nevrtheless, the diversity of viewpoints apparent in the literature was also expressed by the team: Charlotte mentioned the process of "controlled evolution" (to give an organism some characteristics it wouldn't develop "naturally" through artificial selection). Guillaume, Vicard, Pierre and Christophe were concerned about the kind of new and defined function we can get from an organism - specifically about what degree of complexity could reasonably be attainable. Romain proposed a quite different approach by putting knowledge at the heart of synthetic biology. In this view, knowing every functions precisely and being able to divide and manipulating them comes as a prove of our understanding of biological processes.

We identified that the "evolutionary approach" mentioned above locates synthetic biology within a larger paradigm of life science. However, it reverse the usual trend by putting biological practices and goals as a new cause of change, a new way - a rational one - for the organism to gets new characteristic. Similarly to the agronomic perspective, the evolution of organisms in synthetic biology is now managed, decided and operated by human - and not only by the organisms' own contingent needs. Then, we discussed the perspective of “making an organism that do something we decide”. At least, we discuss about an inventory of biological knowledge is performed across molecular biology methods.This last perspective seems to be close to the “re-writing” process, seen as a performance of our knowledge and technologies about life science.

After covering our own definitions, I proposed various definitions that one can find in the literature in order to discuss them.

Artificiality

The idea of synthetic biology as building “artificial life” is quite rejected by the team - or at least temperate. Members of the team reject the idea that, in the lab work, researchers could be in a "state of mind as to create artificial life”. They didn't recognize themselves in that “Frankenstein"'s attitude. The fact that life sciences - and particularly agronomy - is about creating something unnatural is globally admitted, and cannot be considered as a peculiarity of synthetic biology.

Utility and implementation in natural systems

In the team's (collective) mind, the difference between “natural” and “synthetic” biology is caught between “understanding life” and “using this understanding to manipulate life”.

Bio engineering : relations and differences with traditional engineering

That point led to the question : *Are we able to put life into engineering process?* This process is seen as both a question and a goal. The aim of engineering is to get to simplicity to make things works together and to be able to build faster, concepts that are embodied in the “specification process”. The basic concern of engineers is to get their designs to work. From this theoretical standpoint, traditional and bio-engineering are easily comparable. However, things are quite different in reality, and traditional engineering may rather be viewed an analogy or a metaphor which is hardly achievable for synthetic biology. The specification process is a fancy for biology, biological parts are not bolt or screw, and will never be. That is, all theoretical and material systems that frame a bolt (well controlled specs, independence with respect to other components) might be beyond reach for biological systems. The “bolt paradigm” is not working here. Why? Traditional engineering works by planning a whole system, you hardly can be surprised by the results because one controls everything in the specifications. This contrasts with synthetic biology, wherein the limits of understanding are often crossed, leading to surprising, unpredictable and uncontrollable behavior. Pierre proposed the idea of retro-engineering as more adapted to the biological endeavor thus far : researchers deconstruct living entities to small, understandable pieces and question it. Synthetic biology would then re-build entities with minor variations owing to that newly acquired knowledge. The main point common to both synthetic biology and retro-engineering is the way to question the object : how do it work? How could it work better? The main difference - and it's a big one - is the fact that living things are historical entities. They can be compared to a mechanism, but in reality it is an irrational mess evolved as it could to cope with changing needs. In this way, a living entity can be compared to a computer program patched for millions of year instead of completely re-forge its architecture.

This discussion was about defining synthetic biology. Usually, this kind of exercise relies on identifying links and differences between objects that are regarded as close from each other, in order to highlight their own particularities. This way, we tried to "locate" synthetic biology in a larger disciplinary field, to qualify it and to draw a system of reference. I noticed the diversity and heterogeneity of the references we discuss, which - from my point of view - underlies the interest of that discipline. Indeed, we went through various methods (bottom up/top down, design/understanding), concepts (utility, artificiality), goals (creating, re-creating, re-writing, standardizing) and paradigms (evolution, engineering). This large "landscape" shows the complexity and the stake of the exercise. To define oneself seems always both difficult and necessary. Referring to Evelyn Fox Keller's works, synthetic biology is trying to define itself and the outcome will be, as always, decisive for the development of the discipline.

Practices

1. DIY in synthetic biology (*08/21*)

What about DIY in synthetic biology?

We started the debate by watching the diybio video headlined "DIYbio in 4 minutes", a presentation by Andy Mac Cowell, an active diyist from the DIY bio Boston group.
The DIYbio Community - Presented at Ignite Boston 5 (2009) from mac cowell on Vimeo.
First, I have to make a notification about this post. That talk leads us to something a bit discussed, like a controversy. My own opinion about DIY and amateurs in science is not the point here, even if my graduated work is mostly about that question. Here, I just try to transcribe what I presume understandable in the team's position. I don't share the team's mind but that is not the point.

I wanted to know more about the reception of DIY practices in biology for the team because of several question. The iGEM concourse seems to be a way to experiment, to test some new way to make science : young students spend their summer time on a own-build project, the teams are undergraduated, the project are often innovative or stimulant. The DIY in biology claim that kind of alternative way to make science as one of their goals. So, for the team, regarding the iGEM science making experimentation, what about a daily experimentation? We also can notice that, even if they aren't totally "admit" in the iGEM competition (named "non-competition teams"), DIYist and amateurs have a place in the 2009 event to compete for their own "non-competition price"[19]. The iGEM projects are often planned, design or wanted as "fun", "sexy" or innovative. What about "having fun" by "making science"? That point take us to a more global question about research, work and producing scientific knowledge : Do every scientific work has to be a strain? Is effort and hardness necessarily close to scientific production? Can't we imagine having fun in the lab? Do that "sexy" projects are serious? Can biology be a hobby? The DIY practices in synthetic biology take us to two more points : amateurs in science and link with the innovations in informatics and web 2.0. DIYbio wants to make amateurs more involved in biology, proving that DIY is the better way for them to learn, and that they can bring some new and innovative knowledge for biologist they work with : a cooperation, everyone take from the other, a "get some, give some" movement (I borrow that maxim to the Registry of Standard Biological Parts). The "get some, give some" is questioned by some student of the team as a new way to create elitist community of

[19] http://2009.igem.org/Experimental_track

users and that communalism is not so obvious nowadays. The link with the Internet world is claimed by DIYbio in a pragmatical perspective. Cooperation, barcamps[20], “having fun projects” is also presented as the way innovations are made in the Internet. So, why not in biology?

Everyone in the team agrees to reject it, to me, more as a matter of principle which is expressed, embodied in concrete cases. In other words, it lays the question of the system of practices in science as a question of epistemology, practical paradigms and the way scientist perceive and have accepted the architecture of their own work. The principle expressed by the team is that “science is serious, science is not about having fun”. The team's global reject could be reduced to two element, about science's principle and its effect on practice : science is not about “having fun” but about knowledge (as a moral precept of science) and that the researcher's work will be strain, because biology is not a hobby (about the scientist work).

How that principle is defended by the team? What are the embodiment of that position? In which theoretical and practical examples?

Informatics.
What about taking in other “knowledge production sphere” their methods of creativity and innovation? For the team, what happened in informatics can't be traced in life science. The idealization of the geek mythical character (young, learning on his own in his room, quite critical and/or asocial) is quite operative here. That kind of character, making that things possible in informatics, can be find in informatics, not in biology.

IGEM : a certain DIY way to learn?
Christophe, who is from an traditional engineer school, admits that the way he “reach” biology through iGEM was quite DIY and on his own. He has to learn it by himself and, above all, for his own interest and needs : nobody asked him to do that. The idea of build your project, build your knowledge seems quite operating in iGEM competition. That idea leaded him to think that amateurs in science could be a good way to make people wonder about new stuff, and hope, in this direction, that “something happens”.

The idea of material constraint : what the lab permit to scientist, what the garage forbid?
The question of the cost of the failure is one of the main point expressed here : coding is free, of course it takes time but it is not like wet materials. Failure has not the same cost in both disciplines, so you don't take the same risk by doing it with amateurs and/or in a garage. Guillaume expressed the fact that a lot of what make synthetic biology interesting is in the lab. That thing can't be bring at home, for both cost of the outfit and the danger of handling.

“I don't laugh by doing a PCR”
Among that talk, the most representative sentence I've heard was something close to “I don't laugh by doing a PCR”. Is Molecular biology not fun because of the scale? Because of the special practices implied by that scale? The idea that “molecular biology is not fun” reconfigures the question : if you are not looking for fun or cooperation, you are looking for efficiency, results. That way, the failure finds other signification, the way to get that knowledge and results is not self-sufficient, results and knowledge are wanted. That idea was

[20] http://en.wikipedia.org/wiki/BarCamp

also symbolized in the critics against the MIT 2006 iGEM's project (which was about making bacterias smell banana or wintergreen), saying that the general process was impressive, but the “have fun” point was bad : why didn't they choose to make about it a project more useful?

What kind of misuse?
When we evoke the question of misuse, the main problem pointed by the team wasn't that “bioterrorism fear” but the risk that some innovation permits by life science today could be used by everyone for bad reason. That way, bioterrorism is not dreaded, but “own and home made paternity test”. That point lead us to that particular place life science technology are about nowadays : new form of knowledge take us to new form of control. When that technologies are in everybody's hands, that control can be too.

The Steve Kurtz's case : a way to reconsider DIY politically.
During the debate, I refer to the Steve Kurtz case : Steve Kurtz is an American professor and artist of the Critical Art Ensemble, was arrested in 2004 under the patriot act law, because of his possession of biological materials in his own house, preparing an art exhibition[21]. It was, for our talk, a way to wonder about the political element of that kind of DIY practices. Someone in the team reconsider it in that new light of political resistance, thing went more “useful”. DIY is good to protest, not to make science.

To conclude, that talk wasn't about doing crazy stuff in your garage, but about science : aim, methods, places, creativity, professional and amateurs roles in that process. That kind of uncompromising way to perceive alternative practices in their field is obviously about that, because of acceptation of it in other discipline (informatics) or for other goals (protest).

About ethics in our project

That talk was pretty important. We really had to make that ethical reflexions more “practical”, appreciating that questions in our own practices, our own habits, our own project. Different stakes were discuss during that talk, making it seems a bit messy, I'll try here to arrange it to make that stakes more obvious, I hope nobody in the team will mind about that kind of “over conceptualization” I'm about to do. We started that talk with a method I propose, a before/during/after evaluation of our own way to estimate the ethical parts of our project. What do we had in mind when we had to choose our project? What happened when we choose to work on vesicles? What happened then when the lab's manipulations started? What will happen after? What are we responsible for (in both senses) : by asking us questions at the time and by producing something in that iGEM's conditions? All that questions, put into that light, were quite delicate to handle... My own reading of that certain “caution” is that there is both factor of closeness and factor of distance from the ethical question at work in the team's mind. We try to enlighten that point at the end of that post.

***"Before"* : the ethical implication of the choice of a fundamental research project**

The unrealistic perspective :

The choice of that “unrealistic” term has not to be read as a pejorative word. Unrealisticness is about “not wondering about a certain application”, but about something more global, that long

[21] http://www.caedefensefund.org/

distance communication system between bacterias. Unrealisticness is about "not decreeing now about reality". Before choosing the *message in a bubble* project, during the brainstorming period, we wonder about a lot of different project which could be more "ethically fitted", in particular when we were talking about biomedical projects.

It lead us to a question : is there some "favorable ground" for ethical reflexion? Why it seems so hard for us to "find" ethical questions to ask to our project? Why closeness to mankind seems to make ethical reflexions possible and relevant? To me, the way bioethics was culturally and historically built was to answer to pragmatical needs. After World War II, then with the "authority crisis of the 60's/70's", the person, the individual, is put in the heart of ethical reflexion : giving him rights, conscious, "free and well-informed consent", etc. That process, mainly lead by Americans thinkers in that pragmatical perspective, put the individual, the single, the man, at the crossing of all concerns. The issue was, at that time, about claiming that science and knowledge, even if necessary and "good", couldn't be allowed to forget mankind in their process. What about ethical reflexion when there is so few man? So few reality? The way that point was express by the team was by certifying that our project was about fundamental research, and we don't believe in the application nowadays. The application is so, the moment, the instant when mankind is coming into the science process, when it is not anymore "science for science" as a "is this project possible?", when you have to answer to other imperatives, and among it, ethical imperatives. That "science for science" period is close to a world of concept, of will, of future, of performances of knowledge and practices. Then, it is the crossing between two set of question : from "is this possible?" to "is this good?".

Conceptualization of our project : "create a language".

Our project is about communication between bacterias with OMVs, about building a framework which can be easily expanded to a lot of different inputs and outputs. As express by Christophe during the talk, we are not creating a practical tool, we are at the anterior and more meta level, trying to create and to control that communication system. Bacterias are thought through the metaphor of the transistor. That perspective, already defined as more "fundamental" than "applicative", is also a new way to enlighten what can be a engineered approach of biotechnology : looking for a "ground work", a "base" in the perspective to be used for some very different applications.

About the analogy with a communication system : is it ethically problematical?

I was personally wondering about that analogy with communication and computing. Is this a problem? Do we have to consider it ethically? Do "life" has to be treated as "mankind"? What kind of changes are we performing? Referring to the analytic philosophy of John Austin and it rewriting by the gender studies (Austin 1975), reflexions about performativity[22] and speech act[23] could help us to ask a new question to our project : Does performativity has to be include in ethical reflexions? I think I was the one finding that question relevant, but I allow myself to tell a few words on it. Performativity and speech act are very useful tools to resolve the problem of that "fundamental" versus "applicative" perspectives. By saying that words are

[22] http://en.wikipedia.org/wiki/Performativity
[23] http://en.wikipedia.org/wiki/Speech_act

actually "doing thing", the theoretical and practical perspectives are now joined in "real world". By creating an analogy between communication, computing and life sciences, we are actually performing something, creating a new regard on bacterias, from now on tool to communicate. I really think that kind of performativity is really one of the most interesting point for social science studies and epistemology to look at synthetic biology. To the question which underlies that reflexion : "is that performativity ethically acceptable?" the team seems quite unanimous even if quite intuitive : sense and signification about what is "life" is always moving, by the research dynamics and discoveries in life science, it is not a problem, it is actually what "science is".

"During" : **A certain deviation about practices in science**

By asking the "during the project" question, we were in a kind of deadlock. Nobody seemed to be "affected" by ethical questions during the project. Mankind is far away from our lab. So, we went to a more general question about the lab practices : "what can you accept?", "what is your limit?".

Lab : Accepting degrees in the manipulation in the team, the notion of scale.

We went round the table to know what was that limits, and what was the ethical stake of manipulating bacterias. It was pretty funny to ask the question of "animal rights" by the means of bacterias. The analogy with mankind was again the point. Everyone was referring to a limit that cannot be exceeded by similarity with mankind definition : to be a mammal, to have a nerve system, to have a brain. Soufiane bring a good point to the debate, by saying that one of the explanation of the fact that nobody really cares about what could happen to bacterias was that animals, mouses, even insect was a "unity". We are in the scale's question : bacterias are regarded in colony, they're never perceived as a unity. Remembering what we already told about the birth of bioethics, we also can bring to our reflexion the fact that the question of individuality and its respect is one of the way to threat ethical question. When you face something which look more like a drop than a "being", it is quite hard to consider it as something able to "afford" ethical perspective.

Modeling : "It's only a curve"

After asking that "lab" ethical question, we had to consider the second part of the project process : model-building. Can we ask ethical question to modeling? Does abstraction could be responsible for something? Of course, yes. Intuitively, if you are building a model to "killing a large group of people", the ethical problems will appear very quickly. If we have in mind the work of Hannah Arendt about authority and bureaucracy (Arendt 1992), picking up the idea that procedures, protocols and organizational structures to manage activity can be a part of a certain disengagement of the actor's responsibility in the process. Let's consider that problem in our project : do abstraction can turn us away from ethical topics? Modeling in our project relates to mainly two phenomena: the emission of vesicles and the reception of the signal. Modeling has, among other thing, like purpose to think and perform the increase the virulence of the bacterium. That work is mainly focus on implemented mathematics, the product of that work is expressed in formulas, equations and frames of references. Is this a depreciation in the perception of the phenomenon by the means of these mathematical "detours"? Up to what point, the mathematical expression moves away the students from the ethical issues related to their models? Christophe expressed these detours: “it's only a curve”. Thus, we can issue the fact that a specific vigilence has to be built looking at the stakes of modeling. The abstraction of the mathematical tools is likely to involve a depreciation of the ethical issues of the phenomenon, the models expressing “only curves”. We could refer to the linguistic theory to make that point clearer, by the distinction between signifier (the mean, the mathematical expression of a physical phenomenon) and signified (the physical phenomenon itself). The signifier, even complex one, should not make us loose sight of the fact meant. This phenomenon must be examined in all its reality, in order to not neglect the ethical problems it could pose.

Ethical stakes of IGEM process in Paris

Samuel putted forward the remark of the access to biological knowledge and to the laboratory during the summer, by the IGEM team. Indeed, we have to consider modes of pedagogy and biological accesses to the material which are possible within the IGEM participation. You can join the team of Paris by answering to a call for participation of the Center for Research and Interdisciplinarity (CRI) and after the selection of the students. An evaluation of the motivations is made but, encouraging the autonomy of the team, pedagogical principles deserve to be questioned in that “responsibility approach”. Indeed, and without criticizing fundamentally the aspects of this autonomy of students, we can point the following problems : which visibility, which control can we have on the learning and the techniques transmitted to the students? How can we be insured about their good practices during the preparation of the contest and after this one? Without any obsessional theory on the possible obscure motivations of a student, the question of the respect of the standards of containment and safety, protocols, etc is also posed in these terms. During the summer, the Parisian laboratory is in free access to the team. Knowledge, techniques and potentially risky practices of handling are taught to students. Confidence and will of transmission of the learning are motivations that I obviously won't called in question here, but we must, in order to get to these ethical “situated” and reflexive reflections, consider questions which arise in our ethical perspective. Is this autonomy ethically problematical? How liberal principles of education can be assessed? In other worlds, how to deal autonomy as an educative principles and responsibility as an ethical one? Are that principles contradictory? The Center for Research and Interdisciplinarity was founded in 2005 inside the Medicine University of Paris Descartes and define itself as a convivial place at the crossroad between Life Sciences and exact, natural, cognitive and social sciences. New way of teaching and learning are daily practices at the CRI, for graduate students, Phd and researchers. The originality of that collaborative, non hierarchical interactions between students and teachers can be find in the autonomy of the student (they collectively choose the content of the classes) but also in the main research's themes and perspectives, by the Interdisciplinary Approaches to Life Sciences master program and the European Interdisciplinary "Frontiers in Life Sciences” PhD program. The CRI has also educative projects to promote science to children or to high school students from disadvantaged environment.

That alternative educative principles are performed in the IGEM competition too, going on pretty well with the IGEM' spirit. We spend our summer working on the “message in a bubble” project, on our own in the CRI's premises, without any “teacher” or “chief” except with the help of Guillaume, educator for the laboratory part of the project and the global management of Ariel and Samuel. We had to work on our own, to manage meeting, schedules, defining our own rules and work's organization. Autonomy is a real experience, quite risky sometimes, but very attractive and exciting and permitting student to perform they own way to practice science. That autonomy, confidence to student and educative principles performed at the CRI during the IGEM competition could scare people. How the CRI's leaders manage the safety and security issues of the competition? We can refer to an other educative principle to explain it : the transfer of responsibility. That transfer is not like a contract or a pact, but like a process. Teachers and researchers did not pick up any safety/security manager or special leader of the team to deal with that question. In all the brainstorming phase, by their presence, their advices, their own practices, they progressively lead us to consider that questions, as we were now in their part. We came to responsibility “softly” and “naturally”, without pressure from the researchers, but as playing that researcher part. The IGEM competition is, in the CRI, the occasion of a correlation between a system of confidence, teaching principles encouraging the autonomy and the creativity of the team and a certain “taking risk” regarding the access of student to “risky knowledge and materials”. Autonomy and the confidence granted to the team also relate to the respect of the safety regulations and the “good” use of the received learning on this occasion.

A regard on the team difficulties to consider ethical questions

Regarding a certain difficulty for the team to take in hand that ethical question, I try to understand what factors could explain that difficulty. Let's consider both factors of distance and proximity with ethical problems, creating that tension.

Factors of distance : scale and time

Scale :

As we already notice, the particularity of bacterias as object of knowledge can be divided in two “set of questions” referring to two standpoints. Who is the subject of the ethical question : bacterias or man? If we focus on bacterias, as it already has been told, it is so far from mankind that the usual ethical questions are hardly raised and the answer seemed quite obvious to the team, that “bacterias can't be hurt, bacterias can't suffer from our handling”. We had to go through general questions about animals in laboratories to get to that conclusion. If we focus on man, the fact that our bacterias are non pathogenic makes thing quite different regarding risks. Even if unintentional mutation could happen, the risk is not daily dreaded as if we had to use pathogenic bacterias. Ethical problems seem, in both case, a quite far away from us.

Time :

A second factor of distance is the question of “runs” of time, creating a certain tension for an ethical reflexion. There is two different runs of time in the team's mind : the “long run” of the project stakes and the “short run” of the IGEM project. As already told, the main ethical problems are thought through hypothetical applications. The idea that the project could be use for “bad” applications is faced seriously by the team. But, it is approached as an abstraction, a so distant future. Charlotte even tell us that she didn't believe still being alive when that kind of project could find a serious application. Risks linked to industrialization processes or to safety issues when mutated bacterias are set into people's environment, are handled like SF-problems, even if they already exist here and now in “potentiality”. Student are living in an other temporality : the temporality of the IGEM concourse. From June to November, we had to build a team, pick a project, read papers to choose our way to implement that project, realize it, etc. All that specification needed for the IGEM concourse take a part in the fact that it seems difficult to care about what could possibly happen in 200 years, because of that radical focus on what could happen tomorrow, in that “IGEM project temporality”. Stress, short time project, deadlines, are factors of distance with ethical problems.

Factor of proximity : synthetic biology and IGEM spirit

In spite of that factors of distance, we can find some items which explain why the ethical questions are nevertheless relevant. That items are mainly linked to the development of synthetic biology as discipline. The democratization of the scientific stakes, the place increasingly important of a citizen debate about biotechnologies (let's think about GMO, stem cell, nanotechnologies...), or the profane visibility on debates of experts with internet, explain, among other things, why the formation of a new scientific discipline occurs with, at the same time, at its sides, the questions of its regulations. The ethical questions, strategic, or related to the forms of its governorship are questioned.

The increasingly large importance of the social stakes related to the technoscience today has as a consequence the fact that the question of ethics does not appear anymore as a solution “after blows” to face a failing responsibility but as a preliminary and necessary frame. The question of the responsibility, of the morals and social values which are performed in the scientific practices of the new discipline takes form at the same time, but in tension, with the very first development of the discipline in question.