Fieldwork Report for the Nucleic Acid Technology Lab

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September 4, 2008	Initial work	
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Abstract

The development of new technologies requires an understanding of the social issues technologies would confront when deployed. Such is the case of e-Science solutions like the Mini-Grid, whose future users are molecular biologists. The successful adoption of the Mini-Grid requires its design to account to the existing conditions of the molecular biologists. In this technical report we present the results of an initial fieldwork study of molecular biologists. We present their organization structure, their roles, their tools, their activities, and information management behaviors and collaboration patterns. We identified 4 roles, and a 7-step experiment structure.

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Introduction

This report presents the ethnographic work carried out from the 2nd to the 4th of September 2008 with a group of biologists at the Nucleic Acid Technology (NAT) Lab of large university, as part of the Mini-Grid project (http://www.itu.dk/research/mini-grid/pmwiki/pmwiki.php). The goal for this first fieldwork is to get acquainted with the lab. Thus, this report makes an initial descriptive analysis of the work at the lab using basic ethnographic tools like observation, note taking, interviews, and video recordings.

This report is organized as follows. First, it presents the ethnographic methods used for the fieldwork. Second, it describes the group in its organizational context and presents its members. Third, it describes the lab in terms of its physical distribution, its instruments, and the roles of biologists working in it. Finally, it presents some of the processes that take place in the lab like information management, experiments, weekly meeting, and monitoring.

Methods

As the goal of the fieldwork is to get familiar with the lab, we used only two basic ethnographic tools: observation and interviews. Two different kinds of observations took place; first we made place-based observations of the lab; later, we used event-based observation as I followed one researcher executing experiments. In these two observation our role was that of an observant participant, according to which we kept ourselves "*as unobtrusive as possible, quietly observing events from a discreet, yet strategic, position*". The observations give account of the biology researchers while working in their normal environment.

The interviews were unstructured, due to our completely lack of knowledge about the environment and the early stage of the design process; I interviewed a representative of every role, each starting with the question: What do you do? The interviews let the participants develop their own ideas, and later, the participants answered questions about the current usage of technology and mechanisms for information management.

Video recordings and pictures document the workplace, the different instruments, and the information sharing techniques. They also register our interviews and the experiment execution.

Department of Molecular Biology – Nucleic Acid Technology Lab

Our work took place at one of the research labs under a widely recognized molecular biology professor. The professor works within the Department of Molecular Biology of the said university as the head of the Nucleic Acid Function and Technology Group. The group is made of three research labs: RNA Interference Lab, Drug Delivery Lab and Nucleic Acid Technology (NAT) Lab. Our fieldwork takes place at the last one.

Moreover, access to the other 2 labs and their personnel is possible. The following diagram illustrates the composition relation of all these entities.

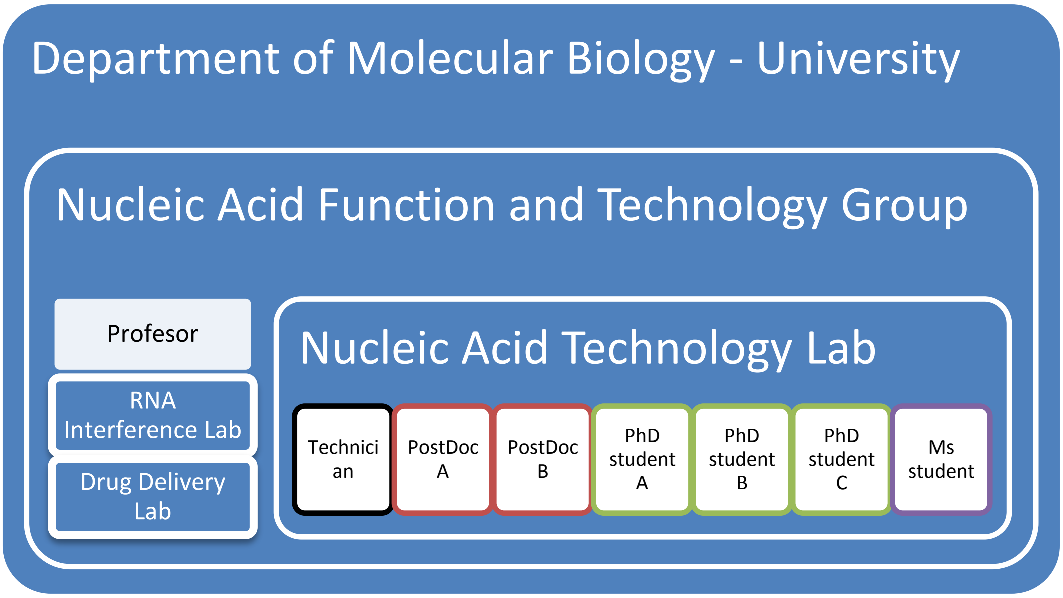


Figure 1: The lab and its context.

There does not exist a publicly available definition of what the group does, and it's mainly through its projects and publications that we can obtain an idea. However, from a brochure presenting the Nucleic Acid Function and Technology research group we can read:

> *The professor's group has developed novel types of RNA based therapeutics including in vivo stabilized siRNA with decreased off-target effects, aptamers and bifunctional RNA oligonucleotides. Using mice as model systems we can deliver siRNAs to the lung by the means of various nanocarrier designs and consequently down regulate cellular and viral genes or reach inflamed tissue as a treatment for rheumatoid arthritis. Another active area we are focusing on is the incorporation of drugs into biodegradable polymeric nanoparticles to be use in 3D scaffolds for tissue engineering. The inclusion of cell specific ligands and "biological triggers" into the nanocarrier design are used for modulation of cellular drug trafficking and in vivo delivery. We have also used SELEX to select 2'F-modified RNA aptamers that bind strongly and highly specifically to human onco-proteins with very high affinity and block processes implicated in formation of metastases.*

The following paragraph is the NAT Lab's description as taken from the lab's website:

> *A main fraction of NAT lab is concerned with DNA nanotechnology and is a part of the Centre for DNA Nanotechnology (CDNA). We work mainly with the technique of DNA origami and to develop biosensors. Another part of the lab is concerned with RNA biology where we study*

- *RNA splicing*
- *HIV RNA structure and function*
- *DNA nanotechnology*

People

The following people were lab members at the moment of this ethnographic study:

- Professor, PhD
- Technician
- PostDoc A
- PostDoc B
- PhD student A
- PhD student B
- PhD student C
- Ms student

It's important to notice that once in a while there can be other people in the lab, like visiting researchers from partner institutions or temporary users of the lab equipment.

The Lab

The Mini-Grid project aims at developing an ad-hoc local volunteer computing infrastructure that can be used by the researchers. Therefore, we seek to understand how they work, and the way it can influence their usage of the Mini-Grid. We set out to discover the lab using ethnographic methods and other tools from the social sciences. The definition that we use in this work says that an ethnographic study "is a way to develop a descriptive understanding of the human behavior". In this section we present our descriptive understanding of what the lab is.

Roles

There are several roles in the lab: the Professor, the Post-Doc researcher, the PhD researcher, and the Lab Technician (find more information on Figure 1: The lab and its context.). Master students participate sporadically, but they are not really part of the research group as their participation is limited in time and responsibilities. Our interviews helped us define each role as follows:

- The professor is the head of the group. Most of his time is spent in meetings, travelling, writing grant applications or defining new research ideas, leaving no time for any lab work. An examination of his tasks reveals that half of them are research related, whereas the others are administration related. The research tasks include the creation and start-up of research projects, the guiding of researchers in existing projects, and the reviews of intermediate results in terms of quality and impact, among others. The administrative tasks include creating the lab budget, obtaining the funding for his PhD researchers, and the establishing of cooperation programs with other institutions. To perform all these tasks he finds little support in the other members of the team, as they are focused in their research projects.

  Moreover, only half of his working time is spent at the office, leaving little time for face to face interactions with his colleagues, shifting most interactions to collaborative technologies like email, Skype and Oracle Calendar (this is not to say that his most important calendar is a paper-based yearly one that he keeps right next to his desk). Despite the lack of time, he manages to meet with his Post Docs once every second day during 10-15 minutes for consultations, supervising, and sharing ideas and results. It's not the same case for the PhD researchers with whom he is less likely to have contact with. For reviewing results the Post Docs and PhD researchers bring in a printout with a piece of raw data like a gel image, a table or just some numbers. They could also bring a couple of slides with the argument.

- The post-doc researchers presented themselves as senior PhD researchers, with more experience and independence. The Post Docs make independent decisions about, for example, what experiments to execute. Sometimes, even without informing the professor. This gives them the freedom of defining their own projects within the conceptual framework of the research group.

  Their relation with the PhD researchers is usually in terms of co-supervising a PhD's project, due to a request from the professor, an explicit interest, or because they are part of the same project. However, not all Post Docs do it. In contrast to that, the relation with the professor is best described as an assistantship, where the Post Docs report (every second day) to the professor on the progress of the work at the lab. Besides supervising and reporting to the professor, the Post Docs' job is basic research: setting up projects, defining experiments, executing them, gathering results, analyzing them, and writing up scientific articles.

- The PhD researchers: The PhD researchers usually work within a project during the whole length of their research, and they usually have a Post Doc as a co-supervisor. The PhD researchers rely on the supervisor (be it the professor or the Post Doc) to lead the project and propose the next experiments to execute. They do not usually take initiative on their own, though sometimes they can suggest activities. The rest of their work is basic research, similar to that of the Post Docs.

  There are two important resources for researchers: the laboratory book and the technicians. The researcher registers data in their laboratory books during the execution of all research activities. Finally, the researcher relies on the technician to execute the basic or ordinary experiments like "making a cloning" or "preparing some DNA".

- The technician: They have a 3 years technical education called Lab Technician. They work with the professor, the Post Docs, and PhD researchers, doing mostly lab work like running predefined experiments or other ordinary tasks (from cleaning the lab to incubating samples to buying supplies), therefore they also have a laboratory book. Their work has very-little-to-none analytical processing and they rely on the professor/researchers to create tasks for them.

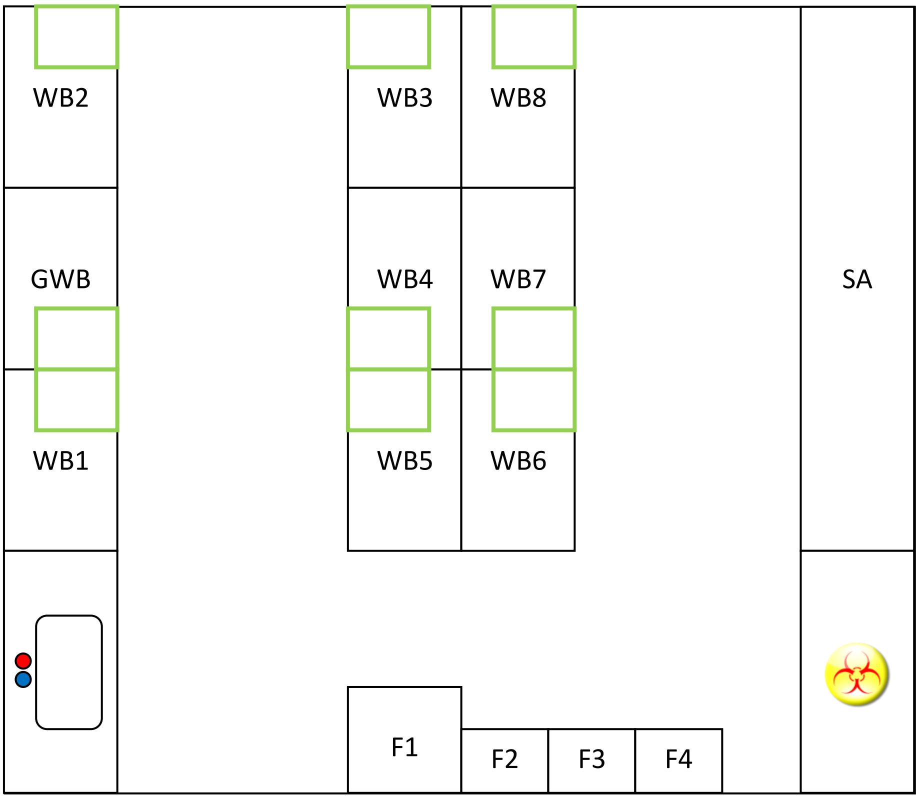
  Because their work is mainly in the laboratory, they are not required to expend long hours at a computer. Therefore, they are not given their own office space and computer; having to share one among all the technicians in the floor, use the shared one at the lab, or use the public ones available in the computers room. This is seen by the technicians as an indicator that they are not as important as the other members of the group.

However, technicians are the bridge between the things that come in and out from the lab; specifically they bring in the supplies (like tubes and tips) for executing the experiments, and order and receive enzymes and other genetic material from the suppliers. They also send samples and other genetic material to other institutions (public and private) for whatever service they provide, like chemical modifications or cloning.

Group members have specific tasks according to their role. However, each group member might have other responsibilities like maintaining up web pages, cleaning up the lab from radioactive waste, or joining collaboration projects for developing software. These responsibilities are very general and often can be performed by anyone independently of the role, project, and background.

Distribution

The laboratory is an organized place where every researcher has an assigned bench. Therefore, the number of people working at the laboratory is limited by the amount of physical space (benches) available. The following drawing shows the lab distribution:



Map of the lab

Labels to map
WBX: Work Bench X
SA: Shared Area
GWB: Guest Work Bench
FX: Freezer X

The laboratory has 9 work benches each of them assigned to a single researcher (WB1-8 + GWB). The bench identified as GWB is always available for guest researchers visiting the lab. For instance, a master student from the Chemistry Department was observed at the bench using the laboratory equipment for performing her experiments. The shared area is no one's regular working space, but a lot of equipment is located there, so many people can be sharing the space at the same time(see Figure 2: The Shared Area). In this area we find the laboratory's shared computer (not visible in the picture).

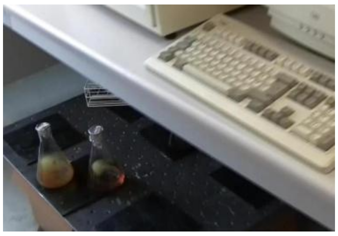
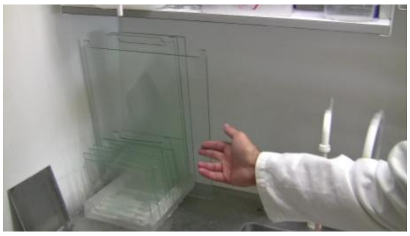
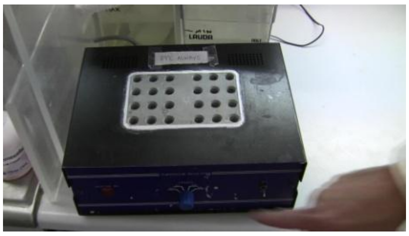
Figure 2: The Shared Area

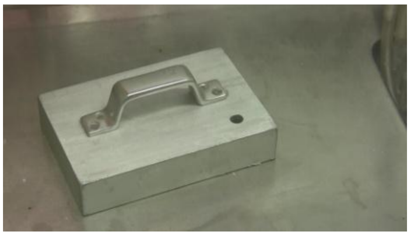
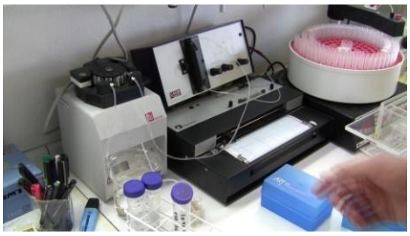
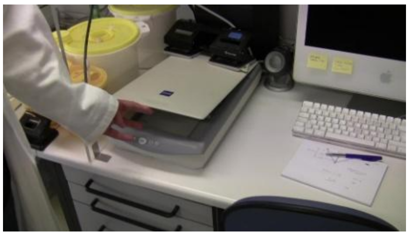
The lab has all the facilities for executing experiments: there is water, gas and air supplies, a zone for executing potentially dangerous experiments (the biohazard zone), freezers and plenty of shelves full of equipment. The shelves are hanging from the roof on top of the benches, leaving enough vertical space to have visibility to and from all the corners of the lab (see Figure 3: Visibility to Everywhere).

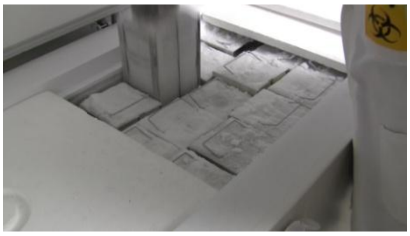
Figure 3: Visibility to Everywhere

Instruments

The following table presents pictures of some of the research instruments found at the laboratory and other locations that were identified as important by the members of the group.

 Big Shaker	 Centrifuge (Eppendorf) Tubes	 Centrifuge
 Clips	 Dangerous Chemicals	 Electronic Multi-Pipetman
 Electronic Pipetman	 Electronic Pipetman Gun	 Enzymes
 Gas-Air-Water Supplies	 Gel Imaging Apparatus	 Gel Tray
 Glass Plates	 Hand Centrifuge	 Heating Block

 Heating Metal Block	 Hot Box	 Hybridization Oven
 Lab Bench	 Lab Computer	 Manual Pipetman
 Microwave	 Nitrogen Tanks	 Power Supply – Gel Tray
 Purification Set-up	 Radioactive Freezer	 Radioactivity Geiger Counter
 Radioactivity Measuring Machine	 Vortex	 Scanner

 Shaker Heating Block	 Sink	 Stop Watch
 Storage Freezer	 Syringes	 Tubes
 Ultra Centrifuge	 UV Spectrometer	 Water Bath

Biologists Work

Biologists split their working activities between the laboratory and their offices. At the lab, they execute experiments, or interact with samples or other scientific material. At their office, they make the design of experiments, the analysis of results, Internet browsing, scientific writing, communications with the scientific community, and their personal affairs. On the other, the technicians' work is less analytical and more practical; they lack a personal office space, and have to make use of the share facilities. Therefore, they spend more of their time at the laboratory.

While in the lab, all the researchers have to use their laboratory coats and special regulations apply regarding the moving of artifacts/materials from and to the lab. They wear a radioactivity measuring device in their coats. This device contains a radioactivity absorbing plate that keeps record of how much exposition to radioactivity the wearer had. This plate is retired from the device every month and the measured data is compared against some monthly and yearly regulated tops. In case a researcher has been exposed to a higher amount of radioactivity than the established by the regulation, the institution has to treat the case according to established procedures in order to ensure the health of the researcher.

Regulations also state that everybody have to record everything they do in their laboratory book. However it's observed that only the execution of experiments is religiously recorded. Other things, like the analysis of the results or the overall development of the project, are kept in other means like Word documents or PowerPoint presentations (PostDoc A and PhD student B).

According to the professor, the culture of keeping record in the laboratory book is much more relaxed in Danish research labs than in other countries like in the USA, or even local industrial labs. He says it's difficult to assess whether it's an advantage or a disadvantage for Denmark to have such loose rules. On one hand, loose rules reduce the amount of time used filling every detail in the book, giving researchers more time for experiments and analysis. On the other side, loose rules make it harder to reuse information from the old laboratory books. According the professor it comes down to the type of person; whether they work better with a complete track of their work or they are more intuitive on what they do.

Several researchers said that this lab is very collaborative within the scientific community, interacting with other specialized labs, local and foreign. The interaction with these other labs consists mostly in sharing research results and genetic material. After the receiving part has performed the analysis of the material or performed experiments on it, the results are shared back to the provider and together there is an attempt to produce new knowledge, usually via writing a paper. Other forms of interaction are student exchanges, information gathering and sample taking (the last two especially from hospitals). All this work is mostly coordinated over email exchange.

Information Management

Most of the information used and produced at the NAT Lab has a physical manifestation: a printed table with numbers, a written number taken from a measuring device, an image print-out, etc. All of these physical information holders are brought to the physical lab book as they are taped to it, or transcribed to its pages. However, as more technology innovations reach the lab researcher, information in digital formats gains importance. An example of this migration to digital is their work with DNA sequences. These sequences are stored in large digital files, and they are the input for different software programs. Sequences are used to create other sequences, or to create visual elements like images, models, etc.

In the fieldwork we could observe examples of information in digital format and in physical format:

Digital Information	Protocols, scanned results, data repositories, sequences, primers and constructs, experiment simulation (dry cloning, theoretical cloning), images, videos, reports and scientific papers.
Physical Information	Lab book, print outs, gel images

This digital information is generally organized by project in a local computer. Some of the researchers make copies of the files and have a parallel file structure organized by date; and it's only when changes done in one side are very important that the files gets resynchronized. There is not central repository or other kind of platform for data storage and sharing, and information backup and recovery is left for each person to deal with. A typical file system for organizing digital information in a project oriented fashion will look like Figure 4: File System.

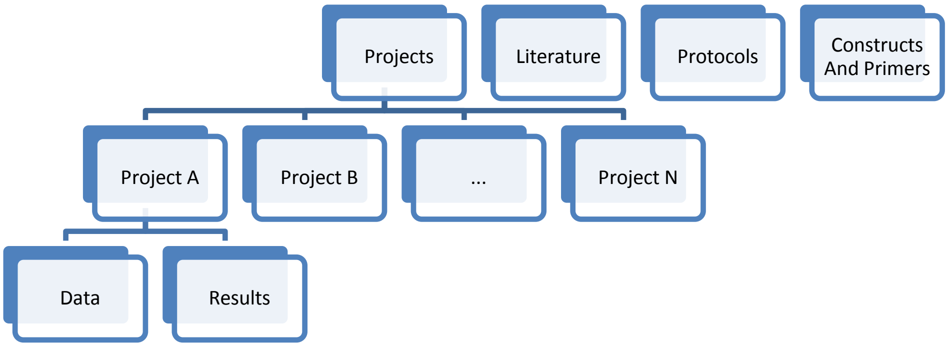


Figure 4: File System

Products

There are two different kinds of products the lab produces. The first one is scientific literature and the second one is genetic material. The scientific literature ranges from scientific papers to conference slides to educational material. The samples include enzymes, proteins, chemical substances or genetic material of many sorts like DNA, RNA, sRNA, primers, cells, etc.

There are some other intermediate products that include DNA sequences, gel images, microscope images, spectrophotometer measurements, radioactive counting, etc. All these products are important input for the analysis of results and the validation of hypotheses. They are, however, only relevant to the participants of the experiments, and they are very unlikely to be of any use to external researchers.

The Experiment

In our fieldwork we followed the execution of an experiment from end to end. We chose a regular experiment that contains the most of the steps followed for any other performed at this lab. A different experiment would contain small variations in the steps, resources and equipment utilized.

The following table presents a general experiment step by step:

Step	Description
Experiment Design	This step is usually performed in the office space of each researcher and it's mainly done by PhDs or Post Docs. Technicians seldom create experiments. The experiment design starts with the definition of a set of goals, which align with the project goals. In general, an experiment consist of a process, in input genetic material (DNA, RAN, sRNA, etc), and either an expected outcome (hypothesis) or a parameter/characteristic to be measured. In this step the researcher defines, or even designs, the input genetic material. It can be taken from previous experiments, from other researchers, or from commercial providers. Then, the researcher defines the final measurements, and optionally the expected values. Finally, the researcher defines the kind of experiment to perform, and its variations from the standard. Our observations revealed that it is optional to define the protocol. Experience researchers know certain protocols by heart, and trust their skill for performing them without a written guide. When the protocol is needed it can be created from scratch, or obtained from the literature or the Internet.

	There are many sources of information that a researcher refers to: papers, academic books, the lab book, equipment manuals, and publicly available Internet resources. All this sources are taken into account when designing the experiment. The experiments within a project are very similar and there are just little variations between each other (due to the controlled change in variables). These variations are represented in the protocols used, as changes in concentrations, temperatures, durations, etc.
Planning	The planning step takes place in the lab, and it is performed by whoever executes the experiment (this includes technicians). Here the researchers have to make sure all the required materials are available. The genetic material, enzymes and proteins have to be fetched from the storage freezers or ordered from a commercial provider. Other elements like the chemicals for the mixings are also collected from diverse places. In some cases the experiment design can vary slightly from the original, in order to make use of the elements directly available in the lab. These changes are annotated in the laboratory notebook or directly on the protocol sheet. Some of the machines are booked at this stage, like the incubators or the big centrifuges for example. All these elements and machines are specified in the protocol, in case it exists. According to the Post Doc "you have to write/modify the protocol while moving around looking for things", however sometimes "you don't really need a protocol beforehand. You can just do it by instinct as you go around finding things. Either way you should write it down for the future".
Making Samples	In this step all the input elements are mixed in the order and amounts given in the protocol.
Cooking	In this step the mix spends time in the incubator, or laying still, or at a shaker, and it's aimed to let the active components of the mix do their job; for instance to have enzymes clone DNA, or to produce encoded proteins, or to let the DNA strands fold in the designed way, etc. Not every experiment has this step.
Purification	
Measuring	The measuring step is performed in different machines and it is likely to be at different locations as well. It depends on the kind of property to be measured and it ranges from concentration, to density, to radioactive counting, to a molecular picture. Each of these measuring techniques is performed by a specialized device of which there might be only one for the whole department or even a commercial provider should be hired for the job. An example of measuring is the *Agarose Gel Electrophoresis* technique. This is one of the most common procedures in the lab and it consists in using gel and electronic voltage to separate genetic material by size. The gel and the genetic material are then irradiated with UV light and a picture is taken.
Analyze	In this step the results from the measuring step are analyzed respect to the initial expected results defined in the experiment design. Some of this data can take the form of input parameters to bioinformatics tools, generating other digital data. This analysis leads to drawing conclusions useful for the research goal, or to point

	out the need of more experiments. It's common for an experiment not to reach the initial goal, but uncover something else. In that situation the researcher decides whether to drop the new discovery, redefine the project goals towards it, or work in parallel with the initial goal.

Collaborative Work

The de-facto standard technology for every kind of communications is email. Email communication is used to request new supplies, to inquire announce experiment results, and to support project collaboration. However, the group uses other mechanisms for coordination and control like the weekly meetings.

The Weekly Meeting

Every week there is a meeting for the whole group. People from the 3 research labs gather together to exchange general information, and to participate in two presentations from members of the group. The aim of these presentations is to give an update of the progress, share the temporary results and receive feedback on the analysis or methods. Though all the members attend, what's observed is that the expositor's focus centers on the professor and the head of the lab that he/she belongs to, and it's only members from the same lab who actually take part of the discussion.

Monitoring

The work is controlled at different levels. In terms of research aim and methods it is the professor together with the researchers defining them, and having follow up meetings. However the degree of responsibility of each group member is very high, leaving little burden to the professor for following up and controlling each researcher.

The more practical monitoring concerning regulations about issues like gene modified organisms (GMO) and radioactivity are performed by a governmental agency. The agency checks the facilities in terms of radioactivity disposal, treatment and storage of the gene modified organisms, etc, according to what has been defined as good practices.

Even though the laboratory book contains data on all the experiments for later reproduction of results, claims of intellectual property and argumentation of discovery, it is ***not*** used as a mechanism to check on the work of a particular researcher.

Conclusions

This report has presented an initial ethnographic description of the NAT Lab of a large university. The originating ethnographic study included observations and interviews of the 8 members of the lab, on issues as experiment execution, information management, and collaboration. The aim of the study is not to cover any of these areas in depth, but rather, to serve as an introduction to the general structure and processes of such a lab.

We identified 4 main roles the professor, the post-doc researcher, the PhD researcher, and the technician. We further described elements of the nature of their work, their responsibilities, and their independence. We looked into the physical distribution of the lab, and found out that researchers have their own fixed benches, but also the shared area and the area for guests. We brushed some of the issues related to the regulations for working in the lab, like the fact that once objects enter the laboratory they can only leave after being sterilized, which affects the capacity of researcher to bring laptops to their benches.

We looked into different issues of biologists' work like their information management behaviors, and their final and intermediate products. We followed a researcher while executing an experiment and performed contextual inquiry on the relevant activities. Here, we identified 7 steps to the execution of experiments (experiment design, planning, making samples, cooking, purification, measuring, analysis), and found out that even though it is universally assumed that biologists always use a protocol, there are cases where they do not due to extensive experience or simplicity of the process.

Finally, we presented a few reflections on the nature of collaboration and work monitoring. Particularly, we presented the weekly meeting, and the way in which work in monitored formally and informally.