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How to Follow Bruno Latour through a Russian or US Biological Lab

Abstract: This article presents the preliminary results of a comparative study of US and Russian laboratories, part of research towards a doctoral dissertation in sociology.
Keywords: STS, sociology of science, laboratory study, Russian scientific crisis

Introduction: When Scientists Try to Overcome a Scientific Crisis on Their Own

On the fine autumn day of September 9, 2009, something unexpected happened. A letter was sent to the president and the prime minister of the Russian Federation by e-mail and published in national newspapers (Open Letter from Academics to the President, 2009). Almost no one expected, of course, that the letter's authors would receive a direct reply. Russian citizens sometimes write letters to the president and prime minister and usually get a polite response from their subordinates along the lines of "Thank you! We will consider your case further," but sometimes they can wait forever for an answer. But this letter was unusual in that about 140 Russian-born scientists, now the chairs of prestigious departments in Britain, the US, France, and Germany, had signed the letter, entitled "Fundamental Science and the Future of Russia." These distinguished scientists – we might call them spokespeople for the Russian expatriate scientific community – not only drew the government's attention to the troubles plaguing Russian science (the high rate of intellectual emigration, obsolescence of equipment, low levels of scientific productivity and professional prestige), but also offered their help in reforming science policy. As the letter's authors stated, former Russian scientists might even be able to return to Russia to build major new laboratories or take charge of existing ones.

This appeal by the Russian expatriate scientific community did receive an answer, as it seems now. In the annual Presidential Address to the Federal Assembly and in several special statutes, the government declared a new policy agenda: a turn towards modernization of the Russian science and technology sector, expansion of the knowledge economy, and educational reforms. In fact, a policy of economic modernization had been discussed earlier in the decade and the government had made many promises, but an immediate change in science policy did not seem to be the principal point of the agenda then. No one could have anticipated that the people who had initiated the open letter and gathered over a hundred signatures from their colleagues would be invited by the government to act as the main experts for the new reforms. It was a huge victory for the Russian scientific community and its expatriate spokespeople. If the situation had been stagnant for twenty years, why did the 2009 letter make such an impact?

The scientific system in the Soviet Union consisted of three large segments: the Russian Academy of Sciences (RAS), with its dozen regional branches, focused on basic or fundamental research; the design and engineering bureaus, which belonged to state enterprises and ministries, were engaged in research and development; while the universities, the third segment, performed basic educational functions. We can hardly assess now how efficient this system was, because it was mostly closed to the international scientific community.[1] Nevertheless, the system worked well enough to provide for the country's domestic needs. After the Soviet regime collapsed, this three-tiered system fell into ruin. First, for lack of resources, the greater number of existing R&D and ministerial design and engineering bureaus was dismantled; second, financing for the RAS was substantially cut. Consequently, most of the functional connections between fundamental science and industry were also severed. Some experts estimate that during the first ten years after the collapse of the Soviet Union approximately two thirds of the Russian academic community left the country (Carnegie Center Materials, 1999). Thus, in the 1990s, US companies invited entire graduating classes from Russian university biology, chemistry and physics departments to emigrate and work for them.

The problems facing the post-Soviet scientific world had been discussed over the past two decades, of course. Science observers and science journalists collected and published ominous statistics, but not much changed as a result. Each subsequent Russian government found it easy to quietly ignore the country's internal troubles, but when suddenly the international community was presented with a dismal picture of contemporary Russian science, it was embarrassing to the authorities. So the letter of 140 academics to the president has proven to be more visible and thus more effective than the dozens of complaints voiced by Russian scientists earlier.

The Failure of the Great Experiment and Laboratory Studies in Russia

What followed was a recent attempt to recruit world-class scientists to reform scientific policy, which has started with an announcement by Valdimir Putin in December 2009 that Russia would invest $1bln each year into science and education in 2010-2012. As a sub-project within this ambitious spending program the Ministry of Education and Science included a competition for 40-80 huge grants (approximately $5mln each) to attract international scholars with proven scientific achievement to lead the reconstructed or reborn labs in Russia; people from Russian scientific

1 Over the past two decades, a huge transformation in the self-evaluation of Russian scientists has occurred. According to surveys, even in the 1990s, Soviet science was characterized by informants as "mighty," but scientists are now more critical in their assessments. This turn can be explained as a result of the opening of borders and expanded opportunities to compare different scientific systems (Kuznetsova, 2008).

diaspora seemed to be particularly welcome. The competition for $5mln grants was announced in June 2010, its results have been published recently. This has been a genuinely interesting experiment.

It has demonstrated two facts, however. First, the special grant programs, created by the government, are not really adapted to the needs of Russian expatriate scientists. For example, the proposal that "advanced projects" should be created using existing Russian labs as bases presupposed that western "stars" would sponsor these scientific organizations. Second, expatriate scientists who took charge of such labs would have to spend at least four months of every year in Russia while their projects were in progress.

This restrictive requirement has discouraged a great number of scientists from participating in the programs. Scientists have been unable to leave their home institutions for long periods, especially when the Russian government has been unable to offer them salaries comparable to what they make in the US and Europe. Occasionally, other barriers to participation have emerged. Russian universities have been unable to provide the full infrastructure for advanced research, and expatriate scientists have had to purchase all necessary equipment and materials in their adopted countries and ship it to Russia, with all the customs hassles this has entailed, or to buy all these things in Russia for a higher price and wait for delivery, as other Russian labs typically do. Another problem has been the lack of convertibility between Russian and US/European funding: expatriates have not been able to spend "western money" in Russia (to cover gaps in financing) and, vice versa, they have not been able to use their Russian grants abroad.

The compact between the government and the scientists, which was not strong to begin with, has begun to collapse. These are some characteristic lines from the interviews, describing previous attempts to bring the expatriate scientists back:

Interview 3

Informant: Have your heard this joke about the children of [Russian State Duma] deputies? No? After the program of seven-month collaborations was launched, everyone was joking that the program was created for the sons of deputies. All their children really do live in America or, at very least, in Germany. [The joke went that] they created this program not to save Russian science, but so they could invite their children to Russia and not pay for the tickets.

Interview 15

Interviewer: How do Russian labs profit by participating in the program?

Informant: Money. It's one way to attract financing. Only money.

Interviewer: But the idea of the program is to support training in innovative approaches, no?

Informant: Yes, but I got involved for the sake of T., my very old friend from my university days. And it is hard to be there [in Russia] for such a long time. But there are ten people in the lab, and he needs to feed them. He needs this money.

At the same time, Russian academics have come out against the new reforms, arguing that they would create a huge divide between two types of scientific collectives – potentially well-paid, technically advanced, western star-oriented galaxies and typical Russian organizations. This has marked the beginning of a major war. Expatriate spokespeople have begun preparing a project to reduce the entire RAS system (that is, that part of it that has survived from Soviet times). The issues of "efficiency" and scientific productivity have been the central categories of the controversy. But such monitoring systems as statistics or interviews have not helped resolve the controversy – the same data on financing levels and publication activity has been used by both sides. For example, the expatriates have argued that the high level of coauthored research in Russia indicates the lack of opportunities for independent research, while their opponents have assumed that this is a sign that Russian scientists collaborate in many international research projects (Guriev and Livanov, 2009). In another instance, when the state reported that it would increase financial support for the scientific projects fund, some witnesses commented that all the money would be shared by a few institutions (Dezhina, 2007). In reality, the controversy has uncovered deeper problems: the three actors in the reforms process do not have a shared "ideal pattern" and a common aim. The government wants to save face with the international community and save money at the same time (because it sees the RAS as a "black hole" in the national budget). Russian scientists who have never left Russia want to avoid competing with successful expatriate colleagues by retaining the advantages of the former (Soviet) system while also increasing funding levels. (In other words, this is another game: people who do not have access to state resources want to remove the old "elite," but they have no plans to destroy the system.) The goals of the expatriates have seemed more altruistic: they are prepared to make an attempt to reform and restore Russian science. At the same time, however, the expatriates have not been prepared to give up their home labs, good incomes, and, more important, their tenured positions and foreign passports. So, for these people, Russian science policy reform has been viewed as an "Operation Barbarossa": they want a quick victory so that they can return home before the long winter sets in.

I should add that the expatriate scientific community is not integrated and well organized. The academics represent the different scientific cultures of their adopted countries and so they do not have a single plan. By default, the US system has been chosen as the ideal. But how can the Skolkovo research park be turned into a copy of Silicon Valley? Why do Russian scientists call

Skolkovo a prison or compare it to the *sharashka* phenomenon?[2] Why do existing faculties not appreciate the idea of creating new university research centers that are industry oriented?

Through this controversy it has emerged that such tried-and-true sociological tools as questionnaires, statistics, and interviews have been able to point to the problems but not how to solve them. Indeed, they have not explained how Russian scientists and sociologists of science should begin to look for new evaluative methods (Grishina, 2009). What does "normal science" mean? How does a successful research team work? These methods have not been able to explain the principles of scientific organization and show the differences between different scientific systems. In this way, the ground for laboratory studies in Russia has been prepared (twenty years after the field was founded).

Bruno Latour's actor-network theory was chosen as a methodological basis for this research project. During the first part of the project, we attempted to adopt this methodology to the Russian context. We have discovered that here in Russia we cannot apply "controversy research" without alterations (Artyushina, 2010):

- First, Russian scientific labs do not feel that they are in competition with one another. They do not generate scientific controversies because they do not have the standard equipment required for this.
- Russian scientific labs do not participate in international "academic sports." They avoid competitive fields.
- Russian scientific labs do research for the domestic scientific market, but they do not produce large numbers of publications and are thus "invisible" to the international scientific community.

Some of the indicators that help the sociologist examine controversy thus do not exist in contemporary Russian scientific laboratory activity: results – facts/devices; competitive labs – labs and anti-labs; significant citation levels; scientific debates and public discussions.

Nevertheless, nine months of research have shown that the basic laboratory studies methodology works in the Russian field as well.

The case-study method proposed by Latour views scientific work as a strategy for bringing hypotheses/projects to the level of recognized scientific facts that functions like a black box (alternately, this can be a device that functions like a black box) (Latour, 1987: 21). In the process of creating products, scientists compose a network – they find and associate available resources

2 In the Soviet Union, *sharaska* was a term for special closed laboratories, usually hidden in northern and eastern Russia, where scientists worked on secret weapons. Scientists were separated from their families and could not leave the sites without permission.

(Latour, 2005: 4). The constellation of heterogeneous resources and their connections influence the eventual credibility of scientific results.

The hypothesis of our research was that the Russian biological laboratory network is maintained by collaborative practices. The laboratory network is constantly insufficient, so we supposed that to fill the holes in this network and reinforce weak ties, scientists consume more resources (human and material) than one particular lab can offer.

Our Ph.D. research includes an examination of two cases – a microbiology lab in Russia and its counterpart in the US.

In both cases, the laboratory workers are Russian scientists. The Petersburg laboratory is a subsystem of the RAS. The US laboratory is a unique organization: scientists who had been working in the RAS system (Moscow) now work in the same field at Rutgers University. Consequently, both collectives have assimilated the practices of the Russian scientific community, but they work in different organizational environments. In this way, we can compare how Russian scientists build networks in Russia and in America, and what elements are obligatory for efficient scientific work.

In this paper, we present some data from the first case study – a microbiology laboratory in Saint Petersburg. The second case – the US biological laboratory – is a work in progress. Nevertheless, in the last part of the article we will present some preliminary data comparing the two cases.

Case 1. Exploring a Russian Biological Laboratory: The External Network

> Interviewer: And what if a rank-and-file researcher writes a grant application?
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> Informant: Well, anyone can write an application (*laughs*). Our system is such that… how should I put? Grants are given to people who are already acknowledged in the scientific community. And this is how it should be! This is how the community organizes itself. If a scientist is visible in the community, if he has a good reputation, he receives grants. But who knows young scientists?
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> Interviewer: Okay, it's understandable with young scientists. But by "good reputation" do you mean the quantity and quality of publications? Or something else? Why, for example, is it so complicated for a scientist who has worked in the west for a long time to get a grant, even when the results of his work are fine?
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> Informant: The key phrase here is a "reputation earned in the west." Here no one knows him. Any organization is staffed by human beings – the members of [a grant] commission cannot know everyone.
>
> Interviewer: That is, it turns out that grants are awarded to [particular] names, not projects?
>
> Informant: No, no one is going to give money to complete malarkey. Look at the RFFR[3] web site: very worthy

3 The RBRF (РФФИ) or Russian Basic Research Fund is the major governmental foundation supporting basic research projects.

projects are subsidized. It's just that the [Russian scientific] community is very small: everyone knows everyone else, everyone knows the quality of everyone else's work. But if someone appears out of the blue... Well, it's just somehow [not done].

From the ANT methodology we accept the concept of the obligatory passage point and the notion that a network has two parts (Law, 1992). Very often, a network has two pieces – external and internal subnets. An obligatory passage point usually connects the two subnets: without this element a network will decompose.

As you can see in Diagrams 1 and 2 (Appendix), the central element and obligatory passage point between the two subnets is a human being – the laboratory director. But a Russian lab network includes three subnets – two, vertical, and one, horizontal. Two subnets can be generally considered external, and the third, internal. We will use the external/internal designation as a research tool, but the network boundary issue will be discussed further.

The first (external) subnet (Diagram 2, top) can be called the "broker network." It connects the director, grant-making organizations, and "brokers" – "informal" elements that mediate between funds and certain applicants. The main resources circulating in this network are money and symbolic goods. Money is constantly being exchanged for administrative and political support, for prestige and status.

Only the director has access to his "own" brokers (a broker is usually someone who works in a fund; sometimes he is a member of a commission; sometimes he is a relative/friend/lover of higher- or lower-ranking officers in the fund), so all the financial flows pass through him. Only the director chooses a project; only he secures the purchase of chemicals and all other equipment. In addition, only the director can get a grant for paying bonuses to laboratory researchers. Such additional payments are essential in Russian labs. The regular institute salary for the average Ph.D. researcher is about ten to fifteen thousand rubles a month (330–500 USD), so receiving additional grant payments is one of the basic ways for lab workers to survive.

Interviewer: As I understand, the laboratory director works in the field of X.[4] And what about controlling practices? How does he influence employees to work on one problem and reject others? And does it happen that someone doesn't like a topic? Does it happen?

Informant: It happens. How does he control us? It's very simple. The simplest way to control somebody is money. Namely, he [the head of the lab] has the basic budget; he has all the money in his hands, all the big grants. If you are in these projects, you get money; if not, you are sidelined. So if you have your own grants, it's up to you: [you can choose] any topic you like. But you will have a very small income. So it is the most effective

4 The name of the particular field has been disguised because the field is narrow and some of our informants know each other.

way to make somebody work. To do what you like is hardly possible. There have been some conflicts over such matters. Yes, it's an interesting subject, but the lab doesn't have money to work on it: that was the director's position. If you find money to support this research – good luck. Otherwise, the director will find a topic for you.

The second subnet of the lab is the internal or "local" network (Diagram 2, center). This network includes the head of the lab (as in the first subnet), the administration of the institute, and the laboratory scientists. As with the "broker network," this subnet is hierarchical. The head of the laboratory assigns research topics to the employees, and he accepts or does not accept people into the Ph.D. program. Just as the lab director has absolute power over his scientists, the institute director has unlimited power over the laboratories. In this situation, the head of the lab is a mediator between lab workers and institute management. A lab whose chair enjoys good relations with an institute's administration receives more financial support than others. Alternately, when a lab director is in conflict with the institute administration, layoffs in laboratory staff are intensified.

Interviewer: What do you mean by a "dead lab"?

Informant 1: For example, the NN lab. Really old people work there. They are so scared... Well, they are afraid that their own students will replace them. They don't accept students. That is, formally they have graduate students because they have to have them, but either they have no interest at all in seeing them defend their dissertations or, as soon as the kids defend their dissertations, they are immediately sent to another lab. They are so scared.

Informant 2: Ludmila [the head of the lab] is in conflict with Mikhail [the head of the institute]. They don't have long to go.

Interviewer: Why? Will the lab be closed?

Informant 2: Because Mikhail is not interested in such labs. They are dead weight for the institute. With him, everything is strict: how many articles you've written in a year, how many grants you've received. If you haven't written them and haven't reported on grants received, that's it. He can fire you just like that.

Informant 1: Mikhail is not a real scientist. He is a manager. And well, he will never fire Zhenya. And you yourself know whom else. And you know, if he treats [all the] laboratories in this way, he'll have to disband the whole institute. Most of our labs write articles hoping that no one will ever read them. Dead labs… Actually it's harder to find laboratories that are alive. Look at the institute's web site, for example: how many labs have their own pages? That's indicative.

Interviewer: And what about these "dead laboratories"? They weren't always dead, were they?

Informant 2: Certainly not. Sergei, Elena, and Dmitry were leading scientists back in the day. It's just that new methods and new technologies have emerged now, and science itself has changed a lot. Even the methods used in the 1990s are now considered obsolete. Of course, it's hard for people to adapt.

Informant 1: Yes, it's much easier to not accept graduate students, to sit and wait for a death. The main thing is not to lose your job.

The process of evaluation is constantly under way at the institute. The administration evaluates their employees, and the scientists evaluate each other. The problem is that Russian labs can hardly be evaluated because they do not have standard equipment (Artyushina, 2010). The most successful labs are those that have purchased equipment that is at least approximately comparable to that in western labs and whose workers are capable of assimilating new methods. Also, the laboratories that publish large numbers of articles can be absolutely invisible to the international scientific community because the articles are written in Russian and published in in-house journals.

How does peer review work within the institute? The external broker network enables the lab to be evaluated as successful. The lab director, included in this network, is a stable recipient of network benefits (grants and symbolical support), and so his colleagues consider him a successful scientist and manager. In addition, he can use the broker network as a resource in his conflicts within the institute. So to be considered a successful scientist and preserve his laboratory, the lab director needs to be visible – that is, *visible for his brokers.*

For the same reason, the director is the center of this network. Even if someone from the lab has their own connections with the institute's administration, they cannot act independently or be in conflict with the director. Research depends on the resources distributed in the broker network, and so no one can avoid this network hierarchy.

The resources circulating in the second network – the "local" one – include the theoretical and methodological knowledge that the lab director transmits to his students, as well as the basic recourses provided by the institute (land, buildings, Internet, chemicals, materials, books).

The third subnet is the "collaborative" one. It is internal and external at the same time. But in contrast to the other two parts of the network, this subnet is horizontal rather than hierarchical.

The function of this network is to fill the gaps in the other two networks. As you can see from Diagram 2 (the collaborative network is at the bottom, but actually it encompasses the second, local subnet), the basic elements of this network are medical firms, universities, scientists at other labs, and western labs. The recourses circulating in this network are primarily scientific and technological resources – chemicals that are hard to find in Russia in a timely fashion and for a good price; equipment that scientists do not have in their own labs; and other materials. It is precisely via this network that scientists learn research methods:

Interviewer: How long does methodological training usually take?

Informant: It's a very individual thing. It depends on the person, on his trainability and willingness to learn.

Interviewer: How was it in your case?

Informant: I have never had trouble with [molecular biology]. I always had problems with morphology. For

> example, when I was studying at university, I usually got C's in all the morphological, descriptive subjects – that is, the subjects where you don't need to think analytically and logically, but simply have to memorize large volumes of information. But in all the molecular subjects [I got] A's. That's a big difference. In this case, Vitya [or Victor, the informant's lab colleague] transmitted his own experience to me. And A.S. [a scientist at another biology institute] helped me a lot. She taught me a lot of things, certain subtleties, things that come from personal experience. But she is not from our lab. A.S. probably had the biggest influence on me. And then Vitya.
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> Interviewer: Why have you singled out A.S.? You don't work with her, do you?
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> Informant: Simply because A.S. knows more than other people, and knows how to do more things.
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> Interviewer: Did you turn to her yourself?
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> Informant: Yes. We have communicated since the time I when I was still doing my bachelor's [practical internship] and worked at the NN institute. She was working at R's lab on the next floor up. And I hope she works there now.
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> Interviewer: Did she train you after your internship as well?
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> Informant: Yes, even now, when questions arise that I really don't understand, I call her on the phone and consult with her, ask her what she thinks about it.

The personal resources of scientists are usually dispersed. They study methods in a friend's lab, borrow a nanometer in another lab, use the material of a third lab, and verify the results of their research on a sequence owned by a medical firm. This subnet is horizontal, but even here the lab director has a number of resources, for he can provide his scientists with access to other labs.

This data suggests that the laboratory director is the central element in the network. He controls all three subnets and the self-reproduction of the lab.

Knowledge Transfer and Self-Reproduction in a Russian Bio Lab

In Diagram 3, we can see the reproduction schema of the Saint Petersburg laboratory. The first generation of scientists is at the top of the diagram: they are the founders of the lab. The younger scientists call them "true" biologists. The second generation includes the students of the lab director and his friend and confidante Alexander. The third generation is the most numerous and consists of Ph.D. students and undergraduates. Another part of the diagram is the technogram (on the edge of the diagram): the ellipses denote methods used by the scientists, and the squares, the devices they use.

The first thing that the schema shows is that the first generation of scientists has no influence on their juniors. The second generation, represented by Elena, Elizaveta, and Victor, does not have strong connections with the laboratory's founders. Svetlana, who is a member of the first generation, is an exception to this rule. Svetlana practices a very complicated method in cytology – FISH (fluorescent in situ hybridization). For this work she needs optical and fluorescent microscopes, and special detection systems (these devices exist in only two Petersburg labs, but not in her lab); she also uses a great deal of material, as well as a thermostat and a freezer set to minus 70 degrees Centigrade (to obtain a permanent specimen). The method itself is likewise quite labor intensive: for example, Elena (the second-generation scientist), who has collaborated with Svetlana, analyzed in a published article a probe numbered 105 (the previous probes had failed). Svetlana has influenced Elena and Elizaveta, who have done several research projects using this method, but both scientists later worked in "western" labs.[5] In German and French labs, Svetlana's pupils learned more advanced molecular phylogeny methods. So the knowledge transferred by Elena and Elizaveta to the next (third) generation was not Svetlana's methods, but new ones.

Elena and Victor (second generation) are the students of Nikolai (lab director) and his confidante Alexander. As lab director and academic advisor, Nikolai trained his students in theory and the basic methodology of scientific research, helped them to select reading material, and gave them emotional support.

The role of Alexander (first generation) in the process of knowledge transfer and the lab's self-reproduction process is very ambiguous. Alexander has a specialist's degree, so formally he is not allowed to teach Ph.D. students. Nevertheless, he was one of the co-founders of the lab. In the 1990s, he was the first to learn new molecular biology methods[6] and began to teach them to students. Also, it was thanks to his managerial skills that the lab acquired new devices such as an amplifier, thermostats, and electrophoresis cameras. Alexander taught Elena and Victor the then-new methods for manipulating genetic material manipulation of PCR (polymerase chain reaction) and electrophoresis. In the lab, the PCR method is used to reveal general DNA sequences in plants.

In this way, second-generation members Elena, Elizaveta, and Victor were taught to work in the field of molecular phylogeny, and they earned their Ph.D.'s. Elena learned sequence analysis methodology (dideoxy sequencing) in France. Elizaveta (Svetlana's second-generation student) learned the same methods in Germany. Victor was taught by them.

Sequence analysis is a methodology for examining DNA and RNA where scientists transcribe the atomic structure as a nucleic and amino acid sequence. Before 2009, there was no sequencer in the lab. For that reason, research material was given to a medical firm for analysis.

The third generation of scientists – the current Ph.D. students – have been taught by Elena and Victor. The young scientists call themselves "bio-engineers" because they are interested in gene manipulation. In this way, the third generation distinguishes itself from the first generation (whom they call "real biologists") and even from the second generation. In their view, the first lab

5 "Western lab" is a marker that scientists use for all laboratories abroad, whatever their location.
6 It is important to remember that molecular biology and genetics were forbidden disciplines in the Soviet Union.

generation was interested in these methods as a tool for examining plants (they were also interested in classical biological issues such as evolution), but the current Ph.D. students are more interested in genetic characteristics themselves. (Why does protein react in such a way in vitro?)

Sometimes, knowledge transfer works backwards. For example, Vladimir (first generation) was taught new methods by Victor (second generation). Now Vladimir is interested in plant evolution but uses advanced methods and works as a co-author with Victor.

Why has the generational connection been broken? Why is that connections between the first and third generations are nonexistent, and the connections between the second and third generations are so weak? The second generation has been united by new material objects – amplifiers, thermostats, shakers, electrophoresis cameras, PCR machines. These devices came to be the center of the work process; these technologies gave the lab new opportunities for getting grants. It was precisely these *res communis* – devices and the methods connected with them – that inscribed Vladimir (a first-generation scientist) into the work of the second generation, but cut off the rest of the first generation from their own students. It was those who were able to learn new methods (rather than those who had status or previous scientific records) who became the leaders and teachers at the lab.

As Diagram 3 shows, Elena (a member of the hard-working third generation) instructed Mikhail, Veronica, and Evgeny (third-generation Ph.D. students) in the new methods before immigrating to France. Victor, who did not emigrate, continued the education of these students. The third generation has been united around a new device – a sequencer (which was purchased with a special government grant in 2009). Now all the new students are taught by Mikhail (third generation). Another common characteristic of this generation is that they are not only united around advanced technologies, but they depend on them more than their predecessors and realize clearly that the Russian laboratory network is insufficient. They are preparing to emigrate.

The Construction of Time in the Laboratory Network

"I'm going to leave Russia. Why? Well, because I have already lost four years here. Do you know what one can do THERE[7] in four years?"

"I would like to go to Sweden, like Dimka. I even had a contract – in the sense that I was recommended for the job – but English was a requirement. That's when I understood that I needed to learn the language."

"Veronica? Her goal is to leave for France and join Elena. Everybody knows that."

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7 This accented "there" is used by Russian scientists to denote all laboratories abroad.

“They probably told you that I’m looking for a postdoc position now.”

“The director will never put his money on him because he’s planning to get out of here.”

“For several years running, we have no incoming students. There are no new students! Because everyone realizes that to secure a place for yourself THERE, you need to leave right after the bachelor’s. The earlier you leave, the better your chances of securing a place for yourself.”

Why is the level of intellectual emigration so high? In the case of our laboratory, the process began with the first collaboration with a German laboratory. One of the scientists went there for a four-month period and did work that would have taken a year to complete in Russia. Lab workers thus understood that anyone who goes “THERE” obtains a huge advantage in his or her research.

It is primarily the lab network – the totality of its resources – that constructs the scientist’s sense of time. The individual scientist’s sense of time, the rhythm of his life, is constructed around research cycles.

For example, one of the third-generation scientists carried out a research project in the lab that took five years. His time management was influenced by waiting for the purchase of a thermostat (more than six month) and preparation of a permanent specimen. Then he had to search for additional material, after which he went through a period of waiting to get access to other laboratory equipment (a mercury vapor microscope and special photographic equipment).

The Russian grant financing system establishes the special rhythm of laboratory work. Scientists have to create a purchase plan for buying all chemicals and equipment a year beforehand (usually they get grants for a year or two after the application process finishes). That is why scientists usually try to buy everything for future use. If something (chemicals, usually) runs out in the middle of the year, scientists cannot buy it because they do not have access to grant money or because this item was not included in the budget. It is also difficult to obtain funds in the first two months of the year. There is a rule that all money must be spent before mid-December (the next grant is often received in April), and that is why scientists spend all funds immediately. It is hard to pay additional salaries from the grant money because this would raise the level of taxes paid.

As a result of such obstacles – the inaccessibility of grant money, running out of necessary chemicals, and lack of equipment – the scientist in question had to delay his research project several times. At the same time, he had to solve his own financial woes, so like many of his colleagues he began to work as a part-time technical translator. In the lab, additional part-time jobs are considered a necessary evil. Biological research is organized in such a way that the scientist is dependent on the speed with which chemical reactions unfold, the unpredictable characteristics of the objects under investigation, and the well-coordinated work of the devices. But the incomplete network of the Russian lab makes this situation even harder: scientists depend not only on the devices and technology that are major network elements, but also on other – missing – resources.

The informants who work both in Russia and abroad (in other words, they circulate between Russia and the west) have an absolutely different time management system:

> Informant: I would sit in the lab [in Germany] twenty-four hours a day, seven days a week, and I couldn't tear myself away from it. First, because it was interesting, fascinating… And, second, you can't step away [for a second] – everything is working, in full swing, everything is turning out… It was so stunning! I got a result from three probes. It was unbelievably simple. Here you waste so much material, but there… I was certain it wouldn't work.
>
> Interviewer: Do you go there [Germany] constantly to do research?
>
> Informant: Yes, I gather material [in Russia] and I go… It's so convenient. There, everything is at your fingertips, as it were. You get results after a half-year's work that would probably take you three years here.

For the scientist who works in Europe or the US, time is focused on the technologies used, on knowledge; it is centered on the "production" of knowledge. Scientists must compete to stay ahead of their colleagues. As in contemporary sports, victory is a matter of a few seconds' advantage, of using more advanced "doping" technology. In the competition between bio labs, the time advantage is crucial. One group will win if it gets access to the new chemicals or devices and obtains results earlier. These results are converted into citation indexes, and these indexes, into new grants:

> Informant: Well, I think it came from the... It's such an American type [of scientific research], when you need to publish a lot of articles to be the first, to have the highest citation index. That is, if, say, someone has two ideas, then he's ready to divide them and quickly write two articles instead of one because he needs more articles. Your grants depend on this; your rating depends on this. There is no time to think.

As is well known, the article is the basic resource in scientific competition. Because the publication process requires a large amount of time, scientists use different opportunities to present their work earlier than colleagues:

> Informant: The archive is very representative in this sense. There is this database that is called just that – the arXiv [http://arXiv.org/]. It first appeared in Los Alamos. Practically speaking, it's a preprint library. Someone who has a written a new article usually posts it there now. The article still belongs to him as it were, but it becomes accessible to everyone, before peer review, before publication in a journal. Time has shown that it's a very convenient way to get ideas quickly to readers.

We can thus see how time is constructed differently in Russian and European/US labs. Research projects carried out in Russian biology labs can drag on for four to six years. Scientists leave for other labs, then return; they try to make careers in business or industry; some try to combine both jobs. Articles are published when scientists feel they are ready. No one competes with anyone else. Scientists are always waiting for something – for a grant, chemicals, equipment, etc. Just like Soviet science, Russian science lives in isolation from the global scientific community and experiences its time as an eternity: “We will we take as much time as we need.” The overall time for research is limited by the researcher’s desire and his own lifetime. The reason for this is that the laboratory network is always incomplete. Scientists are forced to spend their own time dealing with domestic, financial, and technical difficulties. Nearly each step of the research is problematic, and not much time remains for scientific work.

Bruno Latour has suggested that the laboratory is always the anti-laboratory (Latour, 1987). But Russian biological scientists are generally not included in global “scientific sports,” and they see no antagonists in their own country. They keep track of innovations in their field, but the most common strategy is to avoid competition:

> Interviewer: Have you been in a situation when you’re doing [some kind of research] and suddenly find out that the same thing is being done, say, in the US or another country?
> Informant: That happens to a lot of people. But you have to think through your work so that the emphasis is on other aspects. Say, they’re emphasizing this one thing, but you emphasize something else so as not to duplicate them. You search for an aspect that hasn’t been investigated. Such situations occur, of course.

Construction of Network Space

Thus, the Russian biology laboratory network is incomplete. We can single out the following indicators of systemic failure:

1. The absence of a stable, transparent system for project financing.

The only source of financing for laboratory projects is the laboratory director, who has access to the broker network. The director receives grants for the entire laboratory, and there is no way to go around him to get money, because grants are usually given not “for something,” but “to someone.” Even when the director has special access to grants, money is paid out with huge delays and irregularly. But when research involves “moody” biological material, this system is absolutely inefficient.

2. The absence of standardized and well-equipped laboratories; overall problems with providing laboratories with resources (devices, chemicals, and other materials).

3. The absence of competition between laboratories.

According to historians and sociologists of science, competition is the main driving force for a productive science (Latour, 1987; Knorr, 1980). Russian labs are not in competition with each other and exist in isolation from the global scientific community. Only labs whose directors are included in the broker network have the opportunity to work at levels approximately comparable to those of European and US labs.

4. The absence of science-oriented industry.

On the one hand, there is no market for laboratory equipment production. On the other, there are no private companies that finance and purchase the products of science.

5. The absence of "corporate" science.

6. The inability of scientists to find full employment in labs.

The low level of salaries and stipends forces scientists to seek additional income, and this prevents them from being completely engaged in their research. Scientific work occupies a secondary place vis-à-vis the principal source of income.

7. Intellectual emigration and the knowledge transfer lag.

The high level of intellectual emigration eliminates middle-aged professionals from the laboratory networks. As is shown in Diagram 3, the connection between generations is quite weak.

The first generation cannot teach the third generation because they are unfamiliar with the new methods. But if we look at the second generation, we find that two of the three specialists have emigrated or have dual citizenship (Elena and Elizaveta). The third (Victor) works in the lab, but only few days a week because he has several part-time jobs. He is not involved in educating new students, and we should add that he pursues his own projects in a Spanish lab. Most of the Ph.D. students are searching for postdoc positions abroad.

Thus we can propose the following model for Russian knowledge transfer.

The most talented Russian scientists look for opportunities to collaborate with European and US laboratories. After their first postdoc positions end, they return to the Russian lab and train colleagues in the use of new methods. They also usually bring back large amounts of chemicals and devices (because all these things are more expensive in Russia). After a few postdoc positions, they usually find a permanent position and stay abroad.

Students and colleagues who have been taught by these emigrating scientists retain and transmit "residual knowledge" to the next generation – that is, those bits of knowledge that they were able to receive during the limited periods between the postdocs of their "advanced" colleagues. But even when a scientist has been trained in a good laboratory in Europe or the US, it does not mean that he will transfer this knowledge. First, it is very difficult to adapt new methods in technically under-equipped Russian labs. Second, scientists in the RAS system do not receive extra pay for teaching students, so they consider such training a waste of time. The only way for a young scientist to learn scientific methods is to work with a more experienced colleague and learn "by doing." But because middle-aged scientists (who have not emigrated) do most of their experimental work abroad, even this form of education is hampered. The importance of “tacit knowledge” in scientific work is well known (see, for example, Knorr, 1980; Goodwin, 1997; Owen-Smith, 2001). But it is precisely at this point that the network reveals its greatest deficiency.

Scientists attempt to overcome the “holes” in the network in various ways. The main tool for fixing problems in the network is the horizontal network (which we have called the “collaborative network”). It is much easier for scientists to solve technical problems than problems having to do with the transmission and reproduction of scientific knowledge. For example, when they needed a fluorescent microscope, the scientists at the lab turned to the Scientific Research Center of the Botanical Institute in Saint Petersburg; sequence analysis was done at a medical research center where friends of the director work; to get additional chemicals, they applied to German and Swedish bio-molecular labs, the Cancer Research Center of the CNRS in France, the soil research department at Saint Petersburg State University, and so on. Material and technical resources circulate throughout the collaborative network. For this reason, as we have pointed out (Artyushina, 2010), Russian scientific laboratories have diffuse boundaries: the stated boundaries of institutes do not reflect the actual boundaries of scientific collectives. Laboratories exchange material and technical staff, work collectively on projects, receive people from different institutes and train them. But this type of collaboration is peculiar.

Because of the knowledge lag, scientists are not full experts in their own fields: they require help. That is why all the projects carried out inside the lab are done collectively. One of the scientists is good at sequence analysis; another knows morphology fairly well; a third is good at performing electrophoresis, etc. In this way, scientists attempt to assemble decomposed network resources. Each research project thus generates a new constellation of scientists doing different parts of the research, a new constellation of devices and links between human and non-human. The lab collective in fact has no specialization and no boundaries.

Preliminary Thoughts on a Comparative Study of Russian and US Biological Laboratories

We will present some theses from our comparative study at the conference. Now we will only outline a few topics.

On the basis of nine months of research at a Russian biological laboratory, we can suggest some points around which to compare the two cases.

The most substantial attributes of the Russian biological laboratory network are technological insufficiency, the knowledge lag, and the absence of specialization.

- The time of the Russian bio lab network is eternity. Scientists are not involved in the competition of international research. At the same time, they are always in pursuit of "western science."

- Network space has no boundaries. Because of "technological holes" and the absence of knowledge transfer, the collaborative network is the only means to carry out projects.
- Russian science is invisible to the global community. Within the country, there are no scientific controversies because labs do not have standard equipment.
- The only one way to get a grant is through the director's broker network.

In the current phase of our research, we are investigating a US biological laboratory. There are several points that distinguish the two scientific systems:

- The first point is laboratory boundaries. The US laboratory consists of several research groups and independent researchers. Each one is a fully competent specialist in a deep area of study and the corresponding methods. The idea of collaboration is based on this type of specialization: complicated questions cannot be solved in one disciplinary field. New knowledge is generated through the combination of disciplines. Collaboration does not revoke institutional and laboratory boundaries; on the contrary, it reinforces these distinctions.
- Lab scientists usually have their own project grants (in addition to the large grants for the entire laboratory).
- Lab scientists are updated on innovations in their field and try to work in competitive areas.
- Lab scientists try to publish their work as soon as possible.
- When a lab scientist achieves great success, he can get his own laboratory, and this is a very common goal.
- Lab scientists have no difficulties in purchasing chemicals and equipment.

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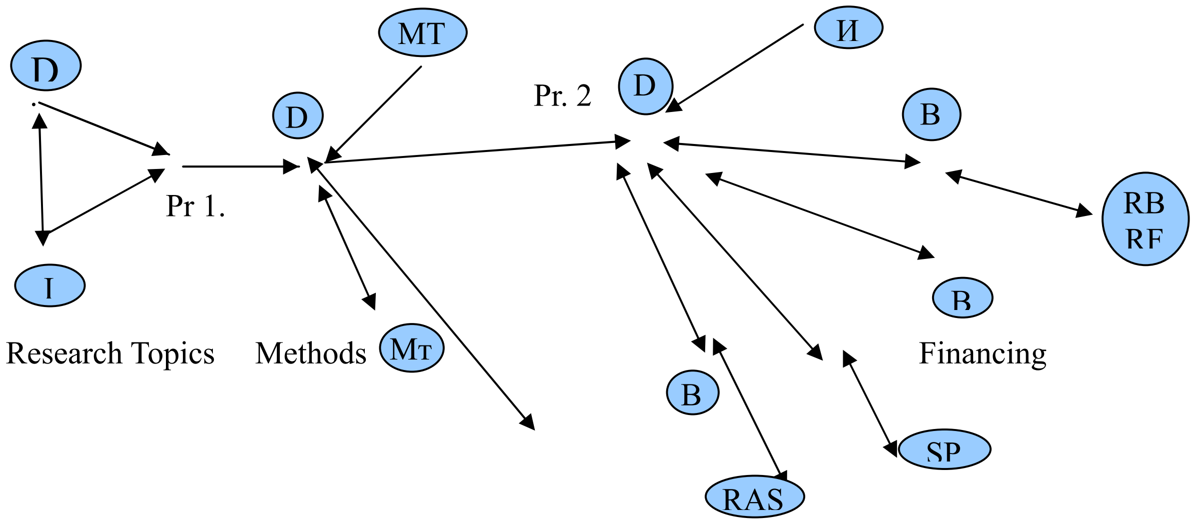
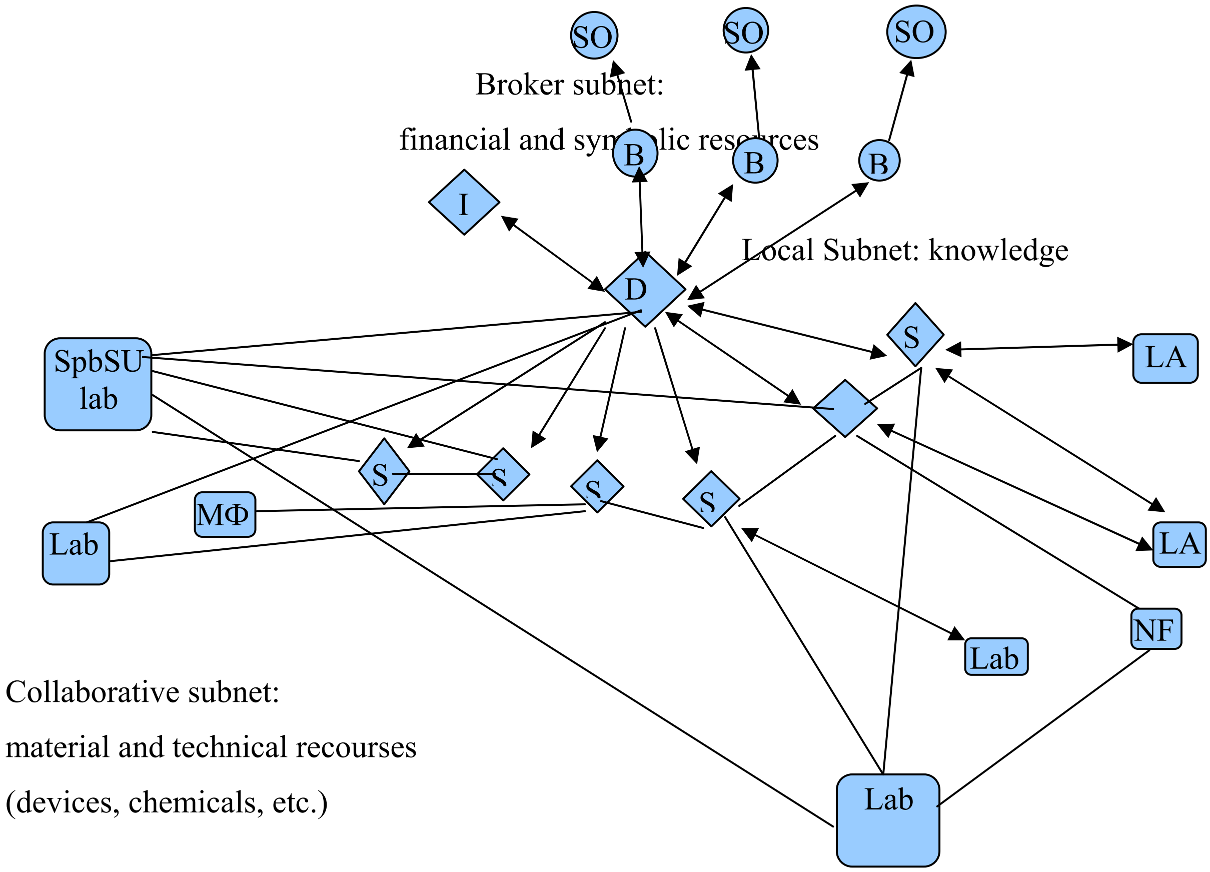
Appendix

Diagram 1. Scientific Research Stages in a Russian Biological Laboratory



З — director
I — institute
MT — material and technical base (devices, chemicals, etc.)
Mт — methods
Alab — laboratory abroad
Б — broker
RAS — Russian Academy of Science
MN — Ministry of Science
RBRF — Russian Basic Research Foundation
SP — special state programs
Pr. 1 — the first version of a project presented by a scientist and/or research group
Pr. 2 — the second version of a project, created after the involvement of all external actors

Diagram 2. Russian Biological Laboratory Network (includes three subnets)



D (obligatory passage point) — laboratory director

SO — state organization financing scientific projects

B — brokers

I — institute administration

S — laboratory scientists

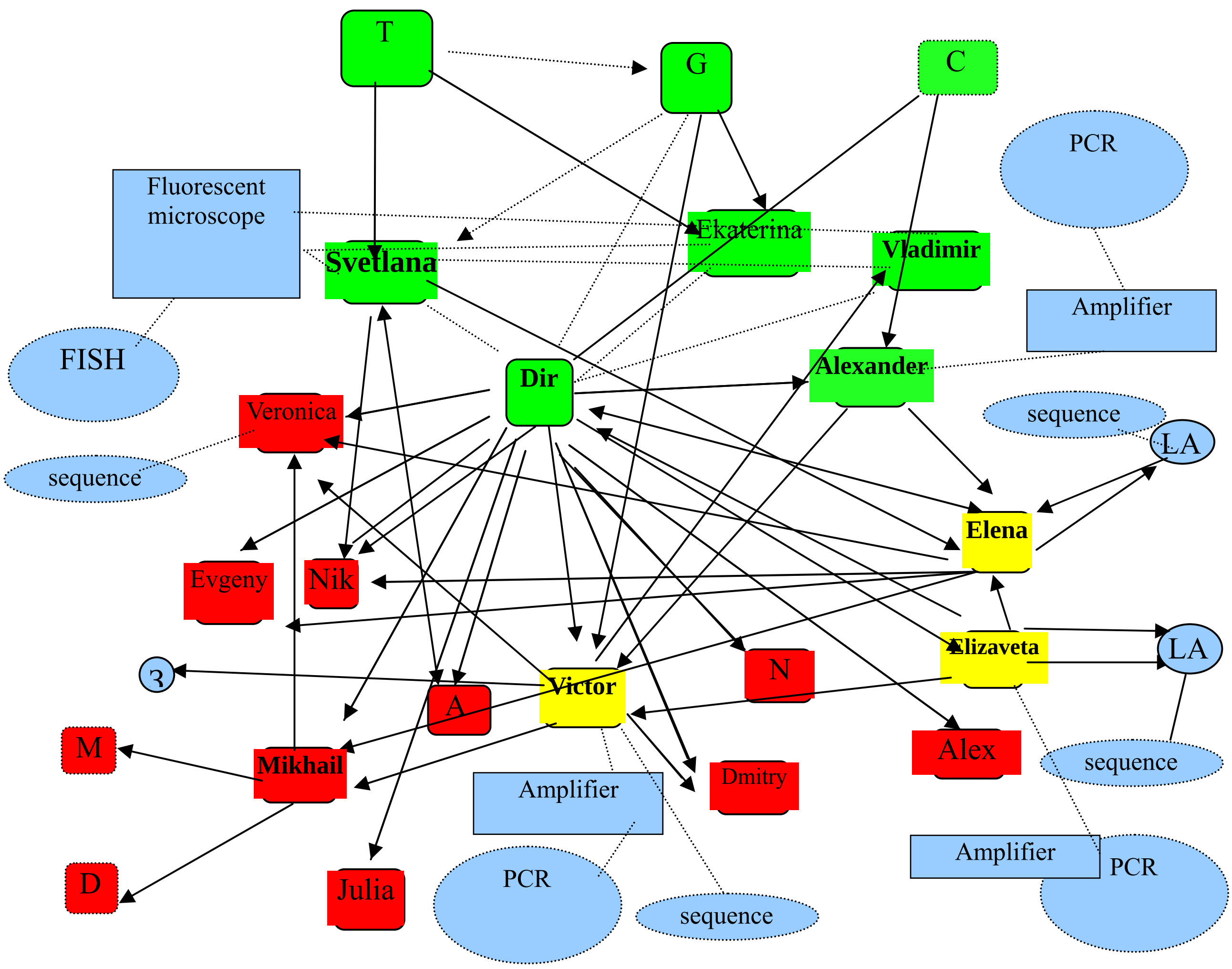
MF — medical firms (device purchase and sequence analysis)

Lab — other labs

SpbSU lab — Saint Petersburg State University labs

LA — laboratories abroad

Diagram 3. Laboratory Self-Reproduction and Knowledge Transfer



From top to bottom:

1. First generation of scientists (green). T, G, and C, well-known biologists, are the laboratory's founders. Key persons in the first generation include Dir (the director); Alexander (who taught second-generation scientists); and Vladimir, a first-generation scientist who was taught new methods.

2. Second generation of scientists (yellow). Key persons are Elena, Elizaveta, and Victor. The arrows pointing to ellipses marked "LA" indicate that they are working in laboratories abroad. They have taught new methods their colleagues.

3. Third generation of scientists (red). Post-graduates and students. Key person is Mikhail.

LA — laboratory abroad

Squares (blue) — devices. Each generation is centered around several devices.

Ellipses — methods.