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## Collaboration versus segmentation in contemporary universities: the example of bioinformatics in Brazil

Rising Powers Research

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## Abstract

Analysts focusing on bioinformatics tend to overstate the personal and disciplinary tensions promoted by the discipline. However, the main challenge facing bioinformaticians seems to be that concerning the proper institutionalization of bioinformatics. While universities are divided into closed departments, new disciplines like bioinformatics generally benefit from an intense cross-department dialogue that is not always possible.

Institutionalization is understood, here, as a discursive process in which one justifies the relevance of one discipline in the academic domain. Three discursive tactics have been used to justify and underpin bioinformatics' institutionalization. First, the insistence on the centrality of the discipline in life sciences research. Second, the reiteration of the interdisciplinary nature of bioinformatics. Third, the absence of claims asking for the creation of bioinformatics departments.

This discursive tactics draw on the historical evolution of bioinformatics in Brazilian universities. Across the years, the discipline has mobilized many departments, which hire bioinformaticians to lecture and do research, provide bioinformatics researchers with basic background, and participate in the creation of bioinformatics post-graduate programmes.

Universities, not only in Brazil, are invited to meet a twofold challenge. They have to reinforce traditional disciplines while guaranteeing the space for the emergence of interdisciplinary fields for which cross-department work is pivotal.
Keywords: bioinformatics; Brazil; academic departments

## Thematizing bioinformatics

Are our traditional, centenarian universities still capable of assimilating emerging cutting-edge, thought-provoking knowledge fields without somehow distorting them or depriving them of their inherent cognitive dynamics? Investigating this question becomes a paramount task in our times, when universities are faced with a dilemma. On the one

hand, austerity measures, taken by national states cornered by recurring capitalist crises, have drained investments out of universities, whose departments have then been involved in a fight for funding which ends up reinforcing disciplinary divisions. On the other hand, new knowledge fields, which knock on the universities' doors to claim for institutional recognition, do not frequently fit well in old department and disciplinary segments. In this context, is it still possible to guarantee both actual scientific advancement and the preservation of universities' integrity?

To scrutinize these issues, it is worth looking at bioinformatics, a discipline of relatively recent formation and institutionalization, especially in some countries where it took longer to appear. By the way, its emergence expresses some long lasting trends within life sciences, in which boundaries have been redefined since the last decades of the twentieth century (Suárez-Díaz, 2010).

Bioinformatics can be narrowly defined as the usage of computational resources to process the vast amount of information generated by studies on molecular biology, including analyses of DNA sequences, protein structures, relations between proteins and diseases, in addition to cell modelling and construction of databases (Araújo et al., 2008; Howard, 2000; Ouzonis & Valencia, 2003). However, a broader definition, like those proposed by some authors (Chow & Fernandez, 2003; Gopalan, 2009; Suárez-Díaz, 2010) is used here. As we will be investigating the ways in which bioinformatics has been institutionalized within universities, it is important not to have too narrow a view from the outset. Thus bioinformatics is seen, here, as the usage of computational resources in order to process biological information. In this sense, every researcher recurring to computers to solve information problems and organize pieces of biological information can be considered as a bioinformatician.

Even though bioinformatics has become considerably known by researchers dedicated to life sciences, its existence is frequently obscured or even despised. Frequently, bioinformaticians are regarded as simple technicians providing a complementary, ancillary work to the "actual" scientists who take their input to carry out the main scientific work. Lewis and Bartlett (2013), as well as Baren-Nawrocka (2013), describe this situation by claiming that bioinformatics remain hidden in the "background" of science. It is as though the discussion of bioinformatics' tools and skills would be as relevant, from the "actual" scientists' viewpoint, as discussing the presence

of a microscope in a laboratory. In the words of a geneticist/bioinformatician interviewed in my fieldwork: "Bioinformatics has no end in itself. It is a group of tools that help decipher genomes and, by understanding genomes, we understand what organisms do".

In a communicative approach, such as the one I adopt, this hidden existence of bioinformatics means that the field is seldom problematized and taken as a matter worth discussing. To use Habermas' (1996, 2008) terms, bioinformatics is taken as "background knowledge". However, this type of knowledge can always be brought back into discursive arenas where its nature and components become object of scrutiny. "One can do this only by converting it from a resource into a topic of discussion, at which point – just when it is thematized – it no longer functions as a lifeworld background [...]" (Habermas, 1996, p. 22-23).

Thematization and discussion are important because, as stressed by Faulkner (2013, p. 15) in his study of the UK situation, bioinformatics ends up turning into "a functional black box" that, as a consequence, tends to be framed "in a depoliticised form". In this way, analysts and scientists tend to forget that bioinformatics, however precarious its institutionalization may be, has already political implications: state agencies have invested their decreasing funds in the field; academic positions have been created; laboratory structures have been set up; international partnerships established; international commercial flows strengthened. Thus it is crucial to reflect on such phenomena and their impacts on countries' institutional life. In other words, it is necessary to take bioinformatics from the sphere of "background knowledge" to that of "foreground knowledge". This move, along with the political and institutional reflections it entails, is the purpose of this paper.

Therefore, my goal is to understand how bioinformatics is being institutionalized within universities, focusing on the Brazilian situation. The choice of Brazil is justified by the recent emersion of this field. As we shall see, 1997 can be considered as the initial year of the field in this country where the first scientific institutions appeared in the early nineteenth century and the first university was founded in 1912. We are then dealing with a discipline that is relatively very young. Bioinformaticians, in many Brazilian universities, are still looking for the institutes and departments where they can be adequately received. Therefore, the Brazilian situation is very rich for us to observe how a new knowledge field comes to be integrated into old academic structures, causing

unexpected impacts and, at the same time, being distorted by the academic frames it tries to fit in.

In addition, the Brazilian situation is interesting because of its economic and political import. Brazil is frequently pointed to as a promising economy, due to its dynamic activities and its place within the BRICS group (Brazil, Russia, India, China and South Africa). In such a country, the creation of knowledge fields has not only academic impacts but also political and economic ones, as knowledge can sometimes be converted into applicable activities. In terms of politics, life sciences are paramount in a country like Brazil, for which the preservation of its vast biodiversity is an important challenge. It is known that bioinformatics is now essential to help defend this biodiversity (Dal Poz, 2006). Economically, bioinformatics promises to help enhance agrarian and livestock production, thus attracting the interest of private players in this country where agriculture and agribusiness continues to play a central role.

For these reasons, it is interesting to observe the institutionalization of bioinformatics in Brazilian universities. However, this study is interesting not only from this country's point of view. The Brazilian case may be reproducing or anticipating processes that might happen elsewhere in the world. As universities, regardless of their location, tend to have similar organization, they also tend to go through similar dilemmas and challenges.

This study is part of the research project called *Rising powers: state strategies of governance in global biomedical innovation,* conducted from 2012 to 2015 and coordinated by Brian Salter (King's College London) and Alex Faulkner (University of Sussex). I carried out fieldwork in Brazil from November 2014 to July 2015, which involved interviews with 18 researchers and lecturers in bioinformatics. My interviews happened in five cities: 7 were conducted in Sao Paulo (SP), 3 in Campinas (SP), 4 en Belo Horizonte (MG) and 4 in Recife (PE). These were semi-structured interviews with open questions. All interviews but one were recorded with permission from the interviewees. The research project was approved by the ethics committee of King's College London.

This paper is organized in three main parts. The first one addresses some theoretical questions about institutionalization and the nature of bioinformatics. The second part deals with the initial appearance of bioinformatics in Brazil. The third part

focuses on the current Brazilian situation while the final part brings a summary and some concluding reflections.

## 1. Institutionalization, collaboration, and segmentation

### *1.1. Institutionalization through communication*

Ideas, theories and values, "[…] have to be institutionalized in order to find not just an intellectual existence in society, but, so to speak, a material one as well" (Geertz, 1973, p. 314). In a communicative approach, institutionalization signifies the mobilization of a set of discursive resources in order to assert the relevance of certain activities. Therefore, academic researchers have to formulate a discourse about their discipline whenever they are intent on institutionalizing and claiming for academic benefits (funding, titles, prestige and so on).

Indeed, institutionalizing a new research field such as bioinformatics is important to preserve it not only theoretically but also economically.

> A bioinformatics that is not able to define and discipline itself will struggle to make the case for the allocation of research council funds, the appointment of bioinformaticians to senior positions, and the establishment of higher education programs geared to producing academics (Lewis & Bartlett, 2013, p. 247).

The considerations presented on this paper rely on two tenets. First, as I have just said, the institutional affirmation of a discipline can be interpreted as a communicative process. According to Gieryn (1983, p. 793), scientists in search of recognition build up their own ideologies, understood as "[…] incomplete and ambiguous images of science nevertheless useful for scientists' pursuit of authority and material resources".

Second, and paradoxically, the limitations of the scientific discursive power must be recognized. As insistently pointed out by Habermas (2008), statements voiced by scientists are not sufficient to construct social reality. In addition to them, there is a wide set of non-scientific statements that also count in the communicative process that is

social life. To consolidate their discipline, scientists often need to recur to this non-scientific language. This large, everyday communicative fabric of society surprisingly tends to be disregarded by a range of interpretations which, inspired by an anthropology in Latour's (2000) style, tend to look at the scientists' linguistic operations as if they could somehow summarize or represent the variety of communicative processes existing in society.

So far analysts speaking of institutionalization have depicted disciplines as desperate passengers fighting for space in a crowded train. Thus they have emphasised ideas such as "separation", "division", "tension" and, finally, to invoke a much fashionable term, "boundary". These words do reveal important things but the communicative approach proposed here also point to important and hitherto concealed phenomena. It allows us to think that disciplines can also be consolidated by the possible dialogue between them. In spite of being uncomfortably pressed one against the other, those passengers continue to journey on the same train, therefore sharing at least part of their goals.

### *1.2. Scientific "tensions" and academic structures*

Bioinformatics is frequently described as a source of tensions. Lewis and Bartlett (2013) describe the main two tensions. The first one derives from the fact that bioinformatics has been seen and used by biologists as a tool, thus acquiring a subordinate position that may frustrate, or even offend, its practitioners. Hence, the difficulty "[…] to understand the alliances and struggles between mathematicians and physicists in their interaction with life scientists, given that the main components of genomics are computer science (bioinformatics and mathematics) and molecular biology" (Suárez-Díaz, 2010, p. 73).

The second tension is already expressed by the discipline's name, which is composed by an element making reference to biological studies (bio-) and another element pointing to computational resources (-informatics). Some analysts claim that even though these two elements can be nicely conjugated orthographically, their actual combination, in the scientists' everyday practice, does not go without tensions. In Lewis

and Bartlett's (2013, p. 243) words: "The second tension is a result of the interdisciplinary origin of bioinformatics – computer science and biology are disciplines with very different cultures, values and products". In the telling expression used by Marijuán (2002), bioinformatics turns out to be the product of a "shotgun marriage" between biology and computer science.

The extent of these putative clashes can be imagined when one considers that what we now call bioinformatics has been shaped by many scientists, not only biologists and computer scientists. As explained by Bayat (2002), the field draws on contributions from disciplines as different as biology, medicine, mathematics, physics and computer science. The interests of such variegated disciplines, analysts say, cannot be easily combined.

However, as we shall see, the main difficulty faced by bioinformatics is not found in their relations with other scientists; it seems to lie, rather, in their adjustment to academic structures that tend to obstruct the establishment of such relations. Universities are generally divided into faculties, institutes and departments, such divisions following old academic traditions. In this environment, a discipline that mingles two disciplines and seeks cooperation may find it particularly difficult to deal with so many academic frontiers. In this way, bioinformatics cannot avoid being somewhat uncomfortable and at the same time disruptive.

This is why bioinformaticians frequently complain about the stringent and cumbersome divisions of universities. For example, one of my interviewees is a bioinformatician who had recently opened a bioinformatics laboratory in a biology department, an enterprise that, according to him, required a complicated bureaucratic work.

> "You certainly know that universities have been completely based on those compartments we call areas, disciplines, departments, faculties, institutes, haven't they? And to cross over those frontiers, which are barriers, this is difficult. So if you want to supervise a student who doesn't come from computing but comes from biology, and you want to supervise this student in the computing programme, you can't do it. So if you want to supervise a student coming from the computing programme within the biology programme, you can't do it…

These examples are a bit silly, because today things are no longer exactly so, but this is the idea I'd like to give you".

Another issue is that universities classify people, a task that proves tricky when researchers have had interdisciplinary careers. For example, in a Brazilian bioinformatics post-graduate program, the jury for the viva must be composed by both people based in hard science departments and people based in biological departments. At a certain occasion when a jury was being composed, one of the selected examiners would be a researcher who, in spite of having background in biology, had been conducting research in computing sciences for more than ten years. Because of his initial formation in biology, this researcher was not accepted, by the university, as somebody coming from a hard science department.

To summarize, analysts seem to be overstating the personal and disciplinary tensions entailed by bioinformatics. The basic tension, they claim, is that between biology and computing sciences, which can hardly have a harmonious coexistence, especially because biologists are used to treat computing scientists as technicians of lower scientific import. However, we shall see that the main trouble seems to be the difficult classification of bioinformatics for the sake of universities' administrative and bureaucratic demands.

Disciplinary misunderstandings have been overestimated because some analysts have dived into the conceptual labyrinth of bioinformatics, carrying out almost philosophical reflections that, albeit interesting, are seriously weakened by the absence of empirical verifications. In order to avoid the conduct of a philosophical (non-empirical) analysis, we shall focus, in the following two parts, on the example of Brazil. The purpose is to empirically verify how bioinformatics has been institutionalized in Brazilian universities, with special attention to the communicative tactics mobilized in the process.

## 2. The first affirmation of Brazilian bioinformatics

In the 1990s, in the Brazilian state of Sao Paulo, biological research was consecrated, among other things, to tackling some pressing agriculture problems. A

major challenge was to fight citrus variegated chlorosis (CVC), a disease that was infecting and killing orange trees. The disease had a special economic import for a state whose economy had in citrus production its second source of income, at a moment when Brazil was responsible for 80% of the world production of orange juice (Dal Poz, 2000). A key research hub was the city of Campinas, where studies were conducted by the University of Campinas, the Agronomical Institute of Campinas, and the Campinas unity of Embrapa, a federal company for agriculture and livestock research. In spite of all the efforts, CVC continued to infect around 30% of Sao Paulo orange crops.

Government agencies and academic researchers believed that genetic research could be mobilized as a strategic ally in that fight. In 1996, a large genetic project was conceived by Fapesp (Sao Paulo research funding agency) and Fundecitrus (a private association of orange cultivators and companies of the juice industry). Those players were very enthusiastic but at a certain moment of project design, one of the scientific advisors alerted them: for the project to be feasible, bioinformatics would be needed. The advice sounded like a truism, even though nobody knew, at that time, what bioinformatics was. Fortunately, Paulo Arruda, another advisor and lecturer at the University of Campinas (Unicamp), remembered that he knew two young Unicamp researchers who spent much of their time developing studies precisely on that quirky discipline.

These were two restless engineers who shared an interest for cutting-edge areas, in addition to sharing the first name: Joao. Both of them, Setubal and Meidainis, interrupted their work as lecturers at Unicamp to go to the United States and do the PhD. There Meidanis studied bioinformatics (or computational biology). Returning to Brazil in 1992, their collaboration was strengthened, focusing on the knowledge field they had recently unearthed. They founded the Research Group on Computational Molecular Biology at Unicamp and, in 1994, published a book called *Introduction to Computational Biology*. This was an interesting phase because, even though the discipline was already being practised at the university, it was not yet institutionalized, i.e. the research group was not fully recognized as an initiative deserving formal classes, funding, laboratory space and so on.

The simple activity of two dynamic researchers would not be sufficient to institutionalize bioinformatics. For this monumental shift to occur, it was necessary to

show that bioinformatics, instead of being an exotic scientific game, was an actual discipline with academic, social and perhaps economic value. In 1996, when Fapesp and Fundecitrus decided to attack the disease of orange crops by means of genetic studies, bioinformatics finally had its invaluable opportunity to be ushered into the realms of Brazilian science.

Meidanis and Setubal became advisors for the Fapesp project until its final version was turned into a call for proposals directed to people interested in scientific coordination, DNA sequencing, and bioinformatics. They sent the strongest, perhaps the only viable, application for the bioinformatics section of the study. In 1997, with their selection and the beginning of the study, their research group turned into the *Bioinformatics Laboratory*, nested within the Computation Institute of Unicamp. This was the first time when bioinformatics deserved full-fledged institutionalization in a Brazilian university.

Fom a communicative point of view, the Fapesp call for proposals was the first affirmation of Brazilian bioinformatics. It was the moment when the scientific community came to know that the discipline had its scientific and economic relevance. Subsequently, the statement was confirmed by the creation of the Unicamp Laboratory, which joined the Fapesp project with the major responsibility of analyzing data generated by all other participant laboratories, a task that was far from being ancillary.

However, institutionalization did provoke some institutional confusion. One researcher who joined the Unicamp Laboratory, interviewed in my fieldwork, recalled that the arrival of a laboratory deeply involved in a project of obvious biological scope caused some unease at the Computation Institute. For nobody knew if that was the right location for such a research enterprise. Meidanis and Setubal, as leaders of the Bioinformatics Laboratory, were also regarded as researchers of difficult classification, an institutional discomfort that had already emerged during their first attempts to develop bioinformatics at Unicamp. Since those first occasions, as explained by Dal Poz (2000, p. 127), "[…] those researchers' institutional position became much compromised. The option to deal with computation of biological data was a rather courageous act […]".

On the one hand, the Unicamp Laboratory was seen as a curious product because of its hybrid, interdisciplinary nature, and would not have provoked less unease had it been received by a biology department. On the other hand, however, such a hybrid work

was very much in need at that moment. The Fapesp project, as well as the Fapesp funding, was a declaration that bioinformatics, institutionally eccentric as it might seem, deserved to be considered as scientifically legitimate. At the same time, the Laboratory was important for Fapesp as well, because its presence served as a signal that the project could generate scientific advancement toward innovative and multidisciplinary efforts.

If at that moment, bioinformatics could begin its institutionalization process in such an uncertain way, it is worth asking: in the following years and decades, how could this process carry on? With the passing of the years, could the discipline find its institutional foothold? Could it build up, in different Brazilian universities, its institutional tradition, either witnessing the creation of its own departments or localizing one department to be received without provoking confusion? In order to address these questions, our analysis continues in the following part, which focuses on the current period.

## 3. Bioinformaticians' communicative tactics

Let us begin this section by directly answering the set of questions just presented above. Yes, bioinformaticians have managed to follow the path of institutionalization, even though they have relinquished a traditional institutional foothold. In order to understand this paradoxical situation, it is necessary to analyse the three main communicative tactics to which bioinformaticians have recurred: the reiteration of bioinformatics' central position in life sciences; the insistence on the discipline's interdisciplinary nature; and the absence of claims for the creation of bioinformatics academic departments.

### *3.1. The "heart" of life sciences*

The first of bioinformaticians' discursive tactics is quite obvious, consisting of reiterating the vital role played by bioinformatics in life sciences research. Over the last years, several branches of biological investigation have conducted genetic analyses in order to deepen the knowledge of their objects of study. A vast amount of data is then

generated, consequently requiring the intervention of bioinformaticians to process, analyze and store those data. Thus bioinformaticians repeatedly depict themselves as indispensable scientists. For example, one of my interviewees works in a modern and big biology laboratory that had recently been built.

> "Everybody working here generates data that go to bioinformatics. Everybody. So bioinformatics is the heart of the whole laboratory. So we have bioinformatics as the heart and, based on bioinformatics as the heart, you can do research in whichever area you chose, because, in essence, everything is the same".

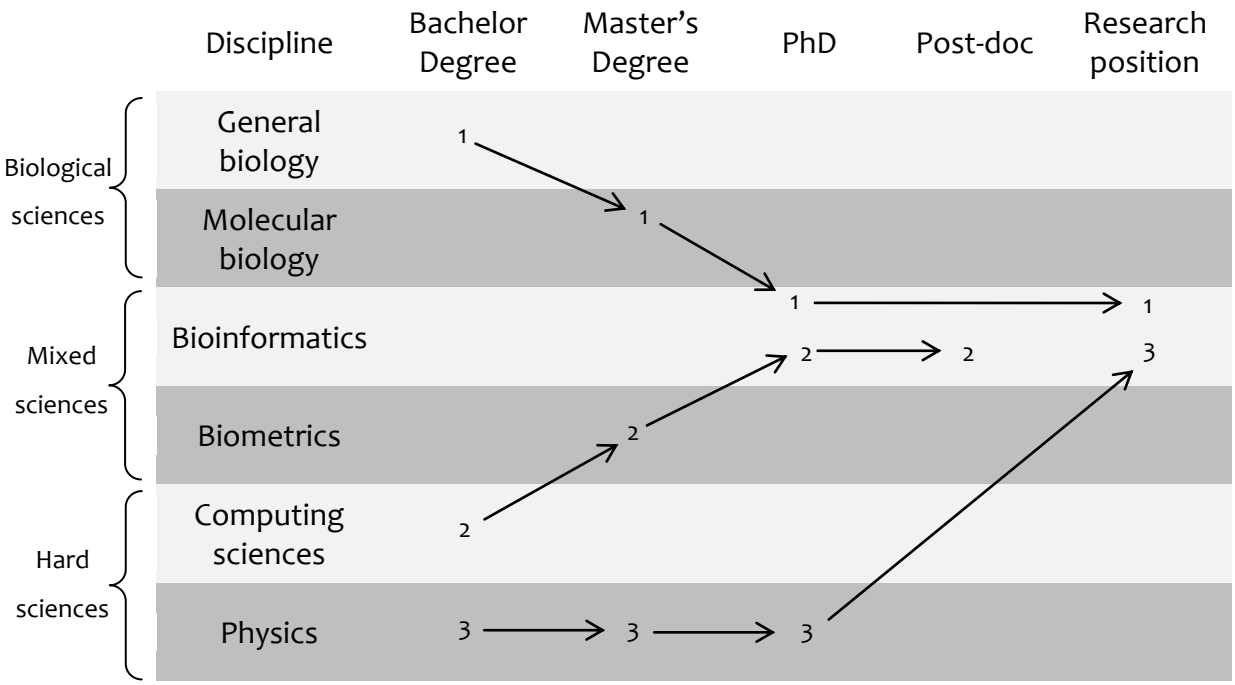
Another interviewee claimed that, nowadays, learning to use computational resources is, for biologists, as important as learning a foreign language. These communicative tactics are possible because over the last years, computational analyses are indeed turning into inescapable approaches, not only in biology.

### *3.2. The advent of an "inter-discipline"*

A second communicative tactics draws on the institutional development of bioinformatics in Brazilian universities. These latter have dealt with the discipline in so different ways that, according to Noda (Noda, 2010), different universities have their particular definition for the discipline.

Universities have hired bioinformaticians to lecture and do research in various departments. At the Federal University of Minas Gerais, for example, three bioinformaticians have been hired: two by the Department of Biochemistry and one by the Department of Computing Sciences. For students, academic trajectories have not been less diverse. The figure below represents the pathway followed by three early-career bioinformaticians I interviewed.

**Figure 1 – Academic career of three bioinformaticians interviewed in the fieldwork**




In their careers, interviewees 1 and 2 slowly approached bioinformatics. The former came from biosciences, the latter from hard sciences, and both encountered bioinformatics at PhD level. Interviewee 3 had the entire career in physics but has always had contact with bioinformaticians; after the PhD, bioinformatics has been his destination as an early-career researcher.

Figure 1 brings only a simple example of the variegated academic trajectories of bioinformaticians. Indeed, students in current bioinformatics degrees come from areas as different as computing sciences, mathematics, physics, statistics, biotechnology, biosciences and so on. It must be so, because of the lack of undergraduate degrees. In Brazil, the University of Sao Paulo is the only one offering an undergraduate bioinformatics course, created by the Department of Physics and Mathematics in association with the Department of Medicine.

In terms of post-graduate degrees, five universities have taken the discipline to high levels of institutionalization. Although in such a small number, they certainly constitute a remarkable group of prestigious institutions in Brazil and Latin America. Once again, this institutionalization has happened in various ways, as is attested by the diversity of departments involved. The following table provides us with some evidence.

**Table 1 – Current bioinformatics post-graduate programs in Brazilian universities and research institutions**

| Name of degree | Level | University | Brazilian state | Foundation of degree | Coordinating department | Departments involved |
|---|---|---|---|---|---|---|
| Bioinformatics | Master's and PhD | University of Sao Paulo | Sao Paulo | 2002 | Mathematics and Statistics | 11 |
| Bioinformatics | Master's and PhD | Federal of Minas Gerais | Minas Gerais | 2003 | Biology | 9 |
| Genetics and Molecular Biology (Focus area: bioinformatics) | Master's and PhD | University of Campinas (Unicamp) | Sao Paulo | 1999 | Genetics | 7 |
| Bioinformatics | Master's | Federal of Parana | Parana | 2009 | Biochemistry and Molecular Biology | 6 |
| Genetics and Molecular Biology (Research line: bioinformatics) | Master's and PhD | Federal of Para | Para | 2001 | DNA Polymorphism | 2 |
| Computational biology | Master's and PhD | National Laboratory for Computing Sciences | Rio de Janeiro | 2000 | Computing Sciences* | 1* |
| Computational biology and systems | Master's and PhD | Oswaldo Cruz Foundation | Rio de Janeiro | 2007 | Biomedicine* | 1* |

Universities  Research institutions

***** Research institutions are not divided into departments like universities.

Usually, some two or three departments are the most deeply involved in post-graduate programmes, one of them being selected for coordination. In Table 1, by looking at the "Coordinating departments", one sees that Brazilian bioinformatics tends to be particularly supported by biology and genomics departments. However, many other departments seem to be concerned. The "Departments involved" of Table 1 are those in which potential supervisors are based[1]. So high a number of departments

[1] Generally, those degrees involve departments such as biology, molecular biology, biosciences, chemistry, mathematics, statistics and physics.

involved is rare for post-graduate degrees, in which people search for specialization. There are eleven departments at the University of Sao Paulo and nine at the Federal University of Minas Gerais, which are by the way the two most prestigious bioinformatics degrees in Brazil[2].

Therefore, since its first institutional affirmation, in 1997, Brazilian bioinformatics has not found a specific academic niche. On the contrary, different institutions have different definitions and strategies. This circumstance, which could be interpreted as a flaw, is rather proudly pointed out by bioinformaticians. In their discourse, bioinformatics is said to be relevant exactly because it is able to engage many sectors within universities: it is called upon by different departments, which hire bioinformaticians to lecture and carry out studies; it attracts students with different background; and finally, it mobilizes different departments to underpin its post-graduate programmes.

Bioinformaticians use those circumstances to formulate their second communicative tactics whereby they insist on the interdisciplinary nature of their discipline. As pointed out by one of my interviewees, a lecturer based in the University of Campinas: "For bioinformatics, it is very difficult to have a particular goal. It is much more a collective work involving a problem of biological nature. So the tendency is amalgamation, fusion, interaction". Another interviewee, based in the University of Sao Paulo, puts it differently: "I am a product (I and everybody), we are products of a teaching system which is segmented, disciplinary and so on, aren't we? But I look at my career as a career in which I am trying to dispose of these frontiers [...]".

Exploring even more the potentialities of this discourse, scientists would abandon their specialized jargon and use a more mundane language to describe bioinformatics as a promoter of social cooperation and progress. For example, one of my interviewees declared:

> "[…] it is absolutely crucial for the technological and scientific future of Brazil to ensure investment and prioritization for this attitude towards these high-technology, quantifying biological sciences, in the sense that development… the potential that can be extracted from all these areas, for the human beings'

[2] The University of Sao Paulo constitutes a quite extreme example, because its degree involves eleven departments located in different campuses and cities.

wealth, the Earth's wealth, depends very much on whether you can look at biology with quantifying and computing eyes [...]".

In this vein, bioinformatics's relevance no longer derives from its potential to process and store data by means of sophisticated algorithms, but from its capacity to reveal the basic secrets of life. By the same token, its products are no longer restricted to a set of databases and sequences, but go as far as promoting the well-being of people and the Earth. This discursive extensions show that scientific justifications cannot be satisfactorily built up by relying, exclusively, on scientific concepts and goals.

According to Gyerin (1983, p. 782), "[...] scientists describe science for the public and its political authorities, sometimes hoping to enlarge the material and symbolic resources of scientists or to defend professional autonomy". When bioinformaticians highlight the interdisciplinary nature of their discipline, this is certainly aimed to enlarge their academic resources at a historical moment when interdisciplinarity has been praised as scientifically desirable. Furthermore, bioinformaticians frequently hide the fact that they benefit from being based in the departments they denounce as short-sighted and narrow-minded. For these departments have allowed them to access research funds and academic prestige.

This is not to say, however, that bioinformaticians are simply deceptive when then speak of interdisciplinarity. The information and data presented in this section does show that bioinformatics has fostered a considerable amount of inter-department work in Brazilian universities. In this sense, it is possible to agree with Lewis and Bartlett (2013, p. 246) when they describe bioinformatics not as a discipline but as an "inter-discipline". For it often promotes dialogue between similar (and sometimes not so similar) knowledge fields.

### *3.3. The refusal of departments*

The third communicative tactics derives from the previous one, radicalizing it. Bioinformaticians, in addition to stressing the inter-department nature of their studies,

tend to be suspicious of and contrary to the creation of bioinformatics departments. For example, a lecturer based in the Federal University of Minas Gerais argued:

> "As bioinformatics is multidisciplinary by its nature, it is perhaps interesting to have lecturers spread across different university's areas instead of creating a structure for it. Because I think this story of having departments which are locked and closed in small boxes doesn't make much sense in today's biology".

This statement echoes those of the vast majority of my interviewees. For them, the absence of specialized bioinformatics departments is not only a normal, but also desirable, fact. Nowadays, Brazilian bioinformatics has already outstanding names who would be able to launch a promising campaign for departments, but they have not done so. For example, the renowned Joao Setubal, one of the founders of the first Brazilian bioinformatics laboratory at the University of Campinas, is now based in the University of Sao Paulo. Instead of claiming for a department, he preferred to found, in 2012, a new Bioinformatics Laboratory (nicknamed Setulab) within the Department of Biochemistry.

This stance seems to be in contradiction with what sociologists of science claim to be the normal development of sciences. Lewis and Bartlett (2013), for instance, explain that when a discipline is being formed, it is frequently marked by interdisciplinarity and mixture; however, some time down the line, borderlines tend to be drawn, as scientists start fighting for funding and recognition. The history of Brazilian bioinformatics does not confirm this pattern, as its practitioners continue to lack precise frontiers and have not campaigned for them. Their communicative tactics is rather an indifference towards this lack, leaving it hidden or unproblematized.

Three phenomena can be invoked to explain such a discursive stance. First, there is the mundane fact that while devoid of specific departments, bioinformaticians are not required to conduct countless administrative and bureaucratic tasks. For the most part, Brazilian universities, and especially the oldest, biggest and most prestigious ones, have been characterized for a heavy and cumbersome bureaucratic structure. Every department is asked to conduct a series of tasks putatively aimed to harness scientific quality, publication records and financial soundness. However, the outcome has been the formation of a bureaucratic framework that suffocates many researchers' actual

scientific work. Bioinformaticians, like every other group of Brazilian scientists, are aware of the conundrum that a creation of new departments would entail. In their current situation, their administrative tasks can be reduced while shared within their host departments.

Second, as explained before, the institutionalization of bioinformatics has involved the participation of various kinds of scientists, going much beyond its basic blend (between biology and computing sciences). To a considerable extent, the evolution of this discipline (or inter-discipline) has really benefited from collaborations between people based in various departments. In this way, the creation of specialized bioinformatics departments could impair the needed collaboration and additional evolutions.

The third reason I would like to stress here can be found outside universities and has to do with recent trends in Brazilian policies and social configuration. Since the early years of the twentieth century, federal initiatives have tackled some of the country's centenary social and geographical inequalities. These efforts have enabled some initial and modest, albeit politically promising, outcomes. From 2001 to 2011, the income of the poorest people displayed a much higher growth than that of the rich (IPEA, 2012); universities have been created in the hinterlands in order to offset the academic dominance of big cities located in the coastal portion of the territory (Marques & Cepêda, 2012); from 2004 to 2013, the biggest increment in years of schooling was displayed by the poorest people (IBGE, 2014).

This social and political context favours some values such as justice, equality and partnership, which have been frequently recalled and discussed by intellectuals and journalists. The academic realization of these values is the conduct of practices such as networking, collaborating and catching up. Therefore, bioinformaticians, by withdrawing from claiming for departments, have adopted a discursive tactics that, being in tune with predominant social values, is more likely to become telling and convincing in universities and society.

As an outcome, Brazilian bioinformatics' institutionalization has been a successful process, although different from that of traditional disciplines. Rather than drawing borderlines and tying to secure too big privileges, bioinformaticians have indeed tried to cross over academic boundaries and launch collective projects, including the design of

studies, the formation of degrees and the application for funding. Paradoxically, though, they have undertaken these complex tasks while based in traditional departments with their administrative frontiers and bureaucratic limits.

## Last words

Generally, analysts focusing on bioinformatics tend to be quite anxious, apparently supposing that the wayward formation of the discipline would somehow constitute a scientific threat. In countries like Brazil, where institutional uncertainty can be extended in time due to economic and technological national limitations, the sound formation of bioinformatics would then be particularly jeopardized. However, Bohr (1996) teaches us that knowledge fields, in their evolution, pass from chaos to order, and the middle stage is precisely the one in which imagination is taken to the highest levels. In fact, in its rather slow evolution, Brazilian bioinformatics seems to be in this middle stage where chaos only begins to be removed and, as a consequence, much scientific and institutional imagination has to be put in place. Thus a rather beneficial imaginative work has been conducted not only by bioinformaticians themselves but also by their academic collaborators, university administrators and public officials dealing with science.

In a sense, this work requires a great deal of courage in order to consolidate bioinformatics in universities without consenting to the academic expectation that at the end of the day, the discipline will be tamed and inserted into its scientific compartment. For, as the traditional thought goes, how could a discipline become an actual discipline without its own departments, institutes, chairs and people to occupy such positions? Furthermore, how could a discipline exist without overtly participating in the academic competition for funding instead of joining such competition while hidden in some dark coins of departments?

It was this type of thought that Joao Meidanis and Joao Setubal had to face when they founded the first Brazilian bioinformatics laboratory at the University of Campinas in 1997. From that time up to our time, the institutional position of bioinformaticians

continues to be imprecise within Brazilian universities, a circumstance that demands much discursive effort to be justified.

Justifications are required not only from bionformaticians. Human activities, especially those of recent emergence, need to be explained and justified so that social actors come to recognize their meaning and importance. This is a basic condition in societies whose members suppose each other to be rational actors. "This supposition states that a subject who is acting intentionally is capable, in the right circumstances, of providing a more or less plausible reason for why she did or did not behave or express herself this way rather than some other way" (Habermas, 2008, p. 36).

The amount of justification expected from bioinformaticians has been particularly big both because of the relatively recent constitution of their field in Brazil and because of the particular ways found to realize its institutionalization. Three have been the discursive tactics used by its practitioners to justify their practices. First, they have stressed that bioinformatics has become the core of life sciences research. Second, they have pointed out that the discipline is interdisciplinary by nature and, therefore, helps establishing bondages between knowledge fields that would otherwise conduct research in isolation. Third, they have eschewed the creation of specialized bioinformatics departments.

This last stance may be regarded as irrational or naïve because, one might think, bioinformaticians would have faced less institutional woes had they created their departments. However, three factors must be taken into account. First, considering the heavy bureaucracy of Brazilian universities, researchers have more time to do actual research if they share administrative tasks with other researchers at the departments in which they are based. Second, in its evolution, bioinformatics has benefited from cross-department dialogues and collaborations, which is more likely to happen in the current situation than if specialized bioinformatics departments were created. Finally, Brazilian federal policies have strived to tackle social and geographical inequalities, creating an ideological context in which social actors sound more telling whenever they speak of cooperation instead of claiming for divisions.

With these discursive tactics, bioinformaticians have managed to push forward with their discipline's institutionalization. This is not to say, however, that they have been the only players responsible for this process. On the one hand, they have special

expertise that enriches the academic life in the departments where they have been received. Their arrival represents an enlargement of possibilities, enabling the conduct of analyses (such as genetic analyses) that will generate large amounts of data to be processed with bioinformatics tools. On the other hand, however, bioinformaticians, as outsiders who find their heaven in other scientists' departments, must adjust to the scientific and institutional dynamics of their hosting departments. Eventually, nobody (neither bioiformaticians nor the scientists who receive them in their departments) can be said to be fully steering the institutionalization of bioinformatics. The process carries on under the aegis of multiple factors and with collaboration from various actors.

What bioinformaticians can do is identify opportunities, accept some conditions, impose others, and formulate their discursive tactics to describe all this complex process. In this way, their statements cannot be framed as the whole truth but as interpretations of ongoing institutional and scientific events. And interpretations, as Geertz (1973, p. 15) teaches us, amount to fictions, "[...] in the sense that they are 'something made,' 'something fashioned' [...] not that they are false, unfactual, or merely 'as if' thought experiments".

In the formulation of this discourse, bioinformaticians cannot use only their own, bioinformatics language. In order to be convincing, they have to be as comprehensive as possible, using the language of other disciplines (especially those which are spoken in their hosting departments) but also the everyday language of society. That is why my interviewees, when presented with the opportunity, do not hesitate to claim that their work can eventually help to bring beneficial products, therapies or knowledge to the Brazilian society. In spite of their specialized knowledge and expertise, scientists never cease to be engaged in everyday communicative processes and, in this way, have no privileged right to build up social reality with their discourses.

The situation of bioinformatics, as it was analyzed in this paper, can help understand the nature and position of some other disciplines that have appeared over the last years. At least in the domain of life sciences, the formation of "inter-disciplines" seems to be a trend. Let us only consider the emergence of knowledge fields such as computational neuroscience, neurogenetics, nanopharmacology and so on. Increasingly, old orthographic and disciplinary frontiers seem to be challenged by those new scientific investigations. Here, I am speaking of not only the old multidisciplinarity whereby

different disciplines where put together to discuss and find common points. Now, we are dealing with disciplines that carry in themselves a fusion between two or more knowledge fields. Nanopharmacology is not simply what derives from the dialogue between nanoscientists and pharmacologists: it is rather the discipline practised by those who possess at least a reasonable knowledge of, at the same time, nanoscience and pharmacology. In those conditions, the set of questions asked is particular, as particular are the approaches adopted to answer those questions, and the kinds of answers provided. For this kind of professional (or inter-professional), actual inter-department dialogue can only be inspiring and beneficial.

Therefore, universities are certainly invited to rethink their structures. The old scheme, with researchers separated in departments, seems to become a less and less viable solution. Although the existence of traditional disciplines and their value should not be negated, it is important to find new administrative and disciplinary solutions to fulfil a twofold task. First, traditional disciplines should be reinforced and revalorized. Second, new disciplines, which tend to emerge as inter-disciplines, should find an adequate environment so as to flourish and promote the dialogues they are destined to engage in.

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