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Brazilian biotechnological research, especially regarding bioprospecting and genomic programs, are presently celebrated as a sure source of revenue for the country. The reasons are two-fold: on the one hand, the world's greatest biodiversity is located in Brazilian territory; on the other hand, Brazil has biotechnological capability, a surplus of trained researchers and leads the field of tropical agricultural technology.

Biotechnology is one of the new generic technologies underlying global industrial growth (Van Wijk, Cohen and Komen, 1993). In the present context of international trade and biodiversity negotiations, Brazil is inevitably in the spotlight. To take advantage of this condition, however, the country faces the challenge of overcoming historical problems: Brazil has an immature industrial innovation system and traditionally neglects Intellectual Property regulation. Most of the country's research is concentrated in Public Research Institutions (PRI), especially in universities. To top it all, Brazilian institutions have not developed either the institutional support or the expertise for Technology Transfer from PRI's to industry. Economic losses with bio-piracy and the challenges of opening biodiversity resource exploration to foreign initiatives are immediate concerns. There is great controversy around bio-prospecting agreements with multi-national corporations, legal issues involving monopoly of natural resource exploration and interpretations of macro-agro-ecological zoning results. Intellectual Property and Technology Transfer are matters of urgent action in research institutions and the government. These and other

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facts suggest a new relationship between biological research and innovation in Brazil. It also exposes conflicts of interest that characterize the challenges of development and of participating in a globalized economy (Siebeck 1990).

In this paper, we introduce the research program on *Intellectual Property Rights, Technological Transfer and Biological Research in Brazil* presently carried out at the Núcleo de Pesquisas sobre Ensino Superior at the University of São Paulo, under the auspices of FAPESP (the Research Support Foundation of the State of São Paulo). We outline: 1. the historical roots of Brazil's present shortcomings concerning biotechnological innovation, 2. The basic requirements for biotechnological innovation; 3. Our understanding of the gaps in the Brazilian system; 4. Our research lines.

1. The historical roots

Yes: no doubt Brazil has historical shortcomings concerning industrial innovation, domestic research and knowledge transfer from PRI to industry. This brief outline of such origins must serve, however, to move ahead of "comprehending" reality. It must help to design programs to overcome difficulties.

The task of analyzing and interpreting the origins of Brazilian innovative immaturity has been brilliantly accomplished in previous studies. Schwartzman, for example, has described the chronic difficulties met by the Brazilian S&T system in achieving a relevant role in society (Schwartzman 1991, 1995). One reason for this is that short-sighted elites never permitted successful research activities to continue beyond immediate needs (Schwartzman 1991, Coutinho 1999, Coutinho & Dias 1999). Schwartzman described the setting up of the largest Latin American S&T establishment in military-ruled Brazil, between 1968 and 1980. Scientific and technological research were endowed their largest federal appropriations until then. These funds were chiefly absorbed by public universities, which concentrate Brazilian research up to now. This accelerated growth in the S&T establishment was related to a development project based on economic self-sufficiency. The project was unsuccessful and research failed to stimulate relevant private industrial sectors (except in isolated cases, such as agriculture). It did fuel certain fields of domestic technology, such as construction engineering, concrete technology, hydro-electric equipment and petroleum prospecting (Magalhães 1994, Schwarzman 1991), typically developed in public corporations. However, the disjunction between national S&T research and the productive sector remains. Schwartzman believes that the project's failure was due to the poor response from the private productive sector. According to him, the high costs and low reliability of domestic technology were unattractive to private corporations.

Vessuri (1997) explained the relationship between import substitution policies in Latin America and the poor results in Research and Development (R&D). Vessuri stressed that these policies were implemented without a systematic concern for technological development. Most of the technology transfer to Latin America was done through equipment and procedures. R&D was ignored, as well as other forms of technology transfer that could foster technological learning. Moreover, the lack of IPR regulation made technology import cheap and attractive for corporations. The lack of protection for the production of capital goods and the inexistence of R&D incentives made the development of domestic technology expensive and risky. Vessuri believes this combination of factors explains the evolution of a non-competitive industry in the continent (Vessuri 1990, 1997).

As a result of the research-production disjunction in the continent, its scientific community became encapsulated in university environments. The excessive politicization and unionization as well as the difficulty to mature merit-based procedures at the universities are further consequences of this condition, feeding back into it and aggravating the isolation.

Matesco and Hasenclever (1998) have analyzed the economic determinants of Latin America's low innovative activity. They have also studied the S&T-productive sector disjunction. They reached three explanations: the first is related to the economic instability of the region. This would hinder the establishment of more permanent support mechanisms for technological development in the productive sector. The second explanation concerns the protective policies adopted for national industry. As a result, it became isolated from foreign competitors, thus deactivating the technological development chain based on competition. The third explanation concerns local workforce's low level of qualification (Matesco & Hasenclever 1998, Matesco 1994).

2. The basic requirements for biotechnological innovation

All the previous explanations are not only correct, but complement each other. They all attempt to explain: 1. why the knowledge produced in universities failed to become socially "useful"; 2. why industries failed either to produce their own technology or get it from technology generating environments, such as PRIs.

There is, however, a lower level of questions that concerns the mechanism through which knowledge becomes useful. From the point of view of researchers coming from industrialized countries, this is simply taken for granted. There are reasons to suspect, though, that deficiencies precisely in these mechanism are preventing Brazil – and probably the rest of Latin America – from overcoming its chronic innovation immaturity (Albuquerque (a), (b), Patel & Pavitt 1994).

Let us have a look, then, into how knowledge may become useful. Let us specifically look at how knowledge generated in a PRI may become useful to anyone outside the academic environment.

Crudely, we have three essential elements from production to use (Figure 1):

1. The producer – the scientist, researcher
2. A transfer mechanism
3. A consumer

Each one of these, however, may become disturbingly complex (Figure 2):

1. Why does the researcher produce potentially useful knowledge? Is it by chance (she bumps into something useful)? Is it because she decided, by herself, to respond to a demand submitted to her? Is it because she identified a demand (not submitted to her) and decided to respond to it? Is it because she belongs to an institution that, by definition, produces a certain type of useful knowledge? These questions create elements that precede item 1:
   - ➢ Random results/discoveries as the initial link in the chain
   - ➢ "someone" submits a demand – does this someone have access to any formal track to express such a demand? Is this someone expressing the demands of someone less organized to do so (is this a public organism representing the consumers of that "techno-scientific good")?
   - ➢ Identifying the demand: is the scientist responding to some sort of "procurement" program? What benefits does responding to this demand bring

to the researcher (or what punishment does it bring not to)? Prestige? Financial reward? Research funding? Public visibility? Greater power as public policy decision maker?

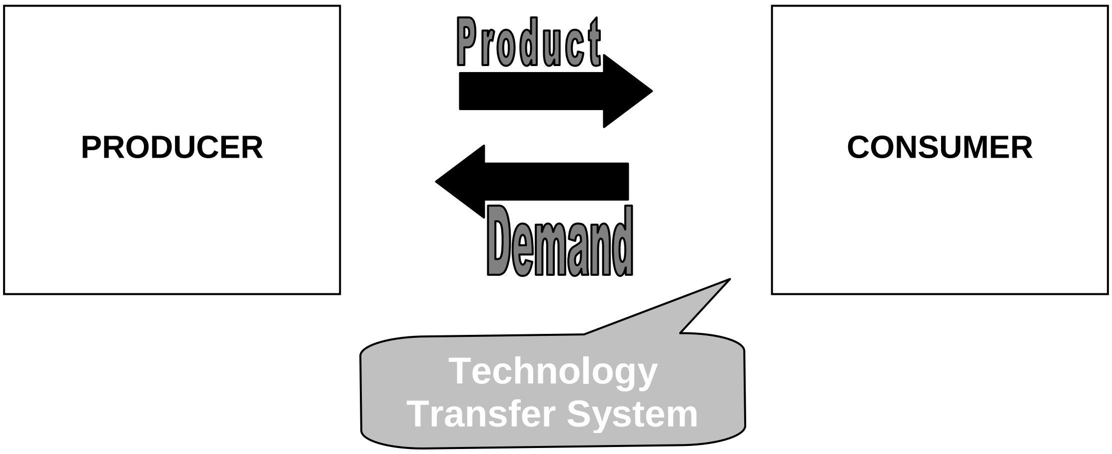

Figure 1: The basic system for knowledge use

- The scientist invented the demand: “the scientist” is an ambiguous term regarding social functions. To identify a demand, it is possible that the scientist (or her community) “invented” the demand. This is a very common situation in the health and environment sector: the scientist surveys a situation/object, “invents” a public demand, pushes it thought the legal channels that will make it a legitimate (and legal) social demand, and finally responds to it.

2. By the same token, the transfer mechanism unfolds into many other elements:
    - The “producer” (researcher / scientist) is not concerned with transfer issues because there are institutionalized systems for this purpose with solid relations with both ends: producer and consumer.
    - The producer has several transfer options
    - The producer freaks out because she cannot find the means to transfer her product to whom she imagines (or knows) will be her consumer.

3. The “consumer” is then multiplied into several items and identities:
    - Is the consumer is the general public, as in protection policies for endangered areas or species, and did they ELLECT someone to express their demand?
    - Does a Non-Governmental-Organization express the consumer’s demands (in which case we must ask how representative this NGO is and who they really represent)?
    - Is the consumer the general public and its demands are expressed through government organisms?
    - Is the consumer a governmental organism that needs a certain kind of information (the product) for decision-making purposes (such as: which is the best form to design an environmental protected area, what kind of technology is needed by rural reform beneficiaries, etc. – David 1998)?
    - Is the consumer “society at large”, expressing itself through Congress representatives, whose demand is vaguely “development” and, for this end, incorporates a number of private intermediary organizations?

All these issues explode in complexity at the moment we consider the organisms that implement those functions in their internal structures.

Finally, when society’s demand is something as general as “industrialization” or “biodiversity protection”, chances are that we will find public and private sectors intertwined as to interest, institutional organization and policy-making.

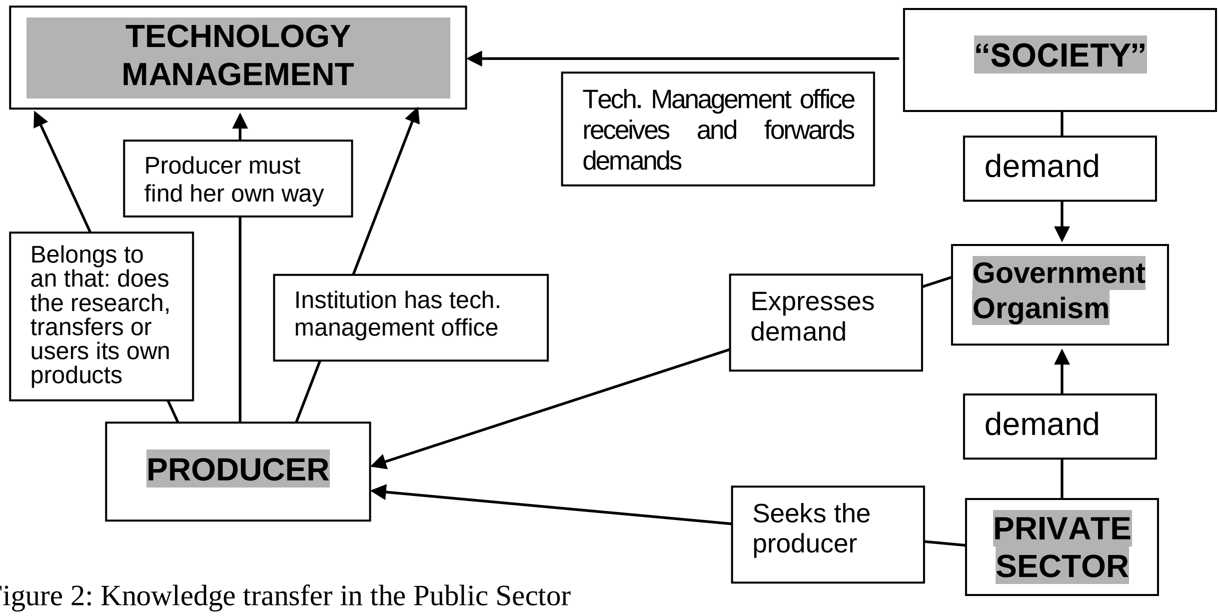

Figure 2: Knowledge transfer in the Public Sector

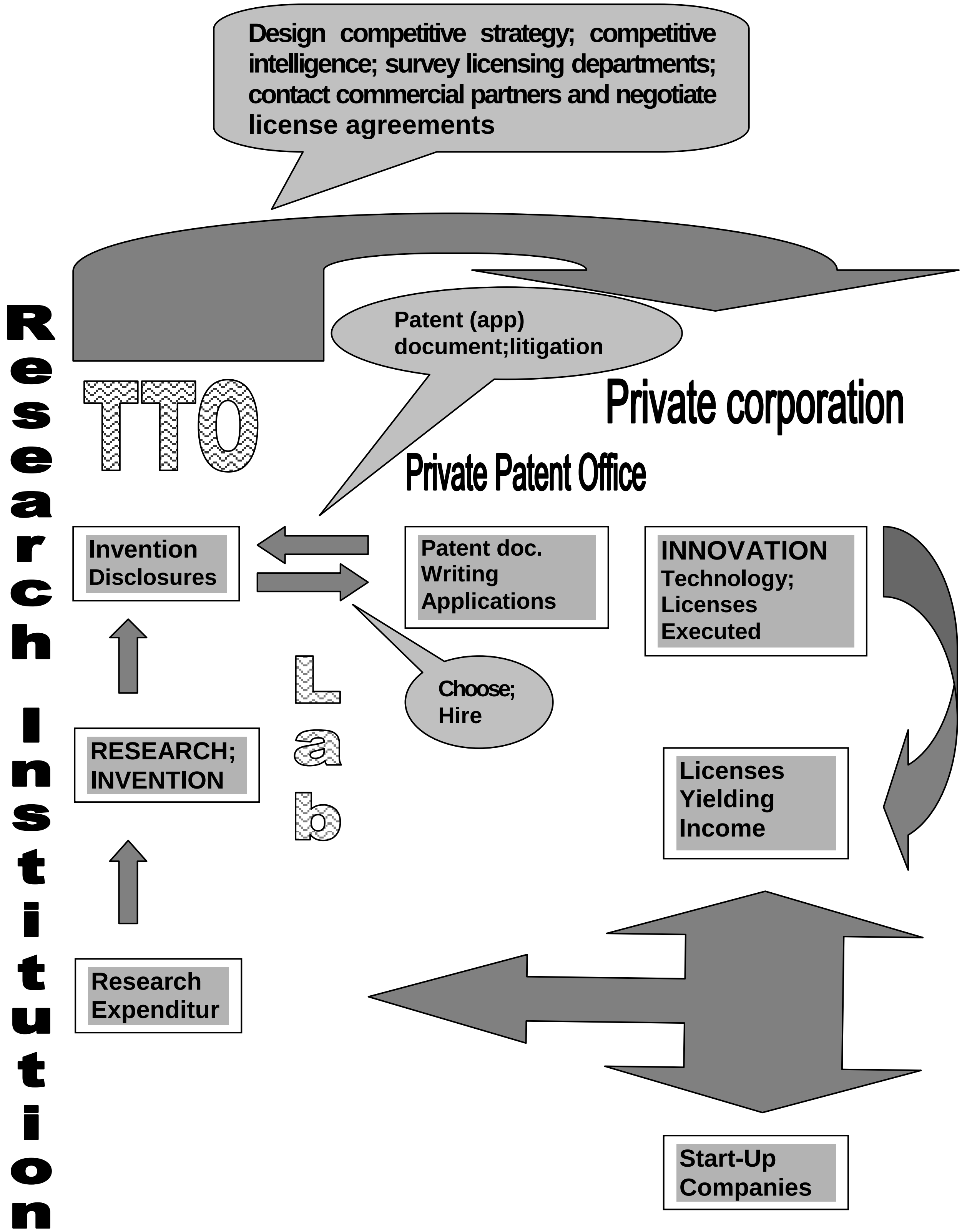

Figure 3: Tech-transfer from PRI to the private sector

Having dissected the various actors and their actions involved in turning research results into “useful knowledge” – or inventions that might become innovations -, it is time to consider what fuels the system.

“Let as assume a scientist who developed a useful product”, as economists would say. Where did the resources for her “useful research” come from?

1. The scientist has never needed to take action in order to get grants: her research was entirely funded by her institution.
2. The scientist obtained grants from a research funding agency.
3. Research was entirely funded by the commercial partner – the one who is committed and interested in PRODUCING the public research-generated innovation.
4. Research was funded by venture capital.

Are these the only alternatives? Certainly not. “Assume” a scientist whose institution provides well defined services to society and is supported by public funds to accomplish its tasks (such as EMBRAPA or FIOCRUZ). EMBRAPA, the Brazilian Agricultural Research Corporation established 275 cooperation agreements with foreign organizations. Many of these organizations contribute funds for collaborative research. Part of EMBRAPA’s federal appropriations comes from the ministry of Agriculture (to which EMBRAPA is associated). Another part comes from the Ministry of Science and Technology. Under this ministry, part of the funds come from the CNPq, the National Counsel for Scientific and Technological development and they are obtained by traditional application and merit based procedures to evaluate and grant the money.

We may find research that is funded by public appropriations up to a certain point of the innovation chain. This is the slowest, riskier and most expensive part of the “invention” process (see fig. 3). Having survived this stage, the commercial partner comes with the funds for the rest of the innovation research.

The great question here and in ALL industrialized countries is: who OWNS *public* interest, *publicly* funded research results, generated by a *public* research institution’s staff?

Concerns with technology transfer from universities have been growing since the 1980’s in most industrialized countries (Lederman 1994, Fujisue 1998; Licht and Ner-. linger 1998). The US are the most illustrative and developed case. Since 1980, the American Congress has passed eight policy programs to foster technology transfer. University Technology Transfer has developed into a professionalized and complex field. At least one journal, the Journal of Technology Transfer, is devoted exclusively to ‘‘technology transfer’’

(Bozeman 2000). Several professional organizations appeared. The Association for University Technology Managers is one of them. AUTM was created in 1994 and is now a growing organization with more than 2,700 members increasing at a rate of 10% per year. AUTM's members are representatives of universities, nonprofit research institutions, government, and industry who work in the fields of licensing, new business development, patent law, and R&D. ‘‘Technology transfer agent’’ is a job title now listed in many government employee and civil service manuals all around the world.

The American experience in fostering university technology transfer is illustrative of the requirements for setting up and developing the innovation chain. Until 1980, TT was not intensive in American universities. The lack of interest in inventive activity among faculty is attributed to the compulsory licensing of all public funded research production that prevailed. The Bayh-Dole Patent and Trademark Amendments Act of 1980, amended by Public Law 98-620 in 1984, eliminated this requirement and stimulated university TT. This legislation shifted the responsibility for the transfer of federally funded research inventions from the federal government to the research universities. According to Sandelin (1994), at least 60 percent of all invention disclosures at universities arise from federally funded research, and so university offices of technology transfer have defined their role on the basis of the Bayh-Dole Act.

Also since the early 1980’s, the rise of biotechnology R&D and, more generally, of research in the life sciences, stimulated inventive activity. TT increased and so did the number of research universities with offices of technology licensing. Incomes earned by these offices have been on the rise in the 1990’s (Mowery, Nelson, Sampat & Ziedonis 1999). Today, at least 70 percent of all license income earned by universities comes from the life sciences (AUTM 1998).

Since the Bayh-Dole, most American universities have created not only TT offices but also incentives to faculty inventors. Rogers et al (2000) report that most UTT offices are becoming more proactive in seeking innovation disclosures from faculty members, in patenting technologies, and in marketing the intellectual property rights to these technologies to private companies.

Universities that are relatively more effective in technology transfer are characterized by (1) higher average faculty salaries, (2) a larger number of staff for technology licensing, (3) a higher value of private gifts, grants and contracts, and (4) more R&D funding from industry and federal sources. Technology transfer effectiveness is more highly correlated with how early the University created its TT office (Rogers et al. 2000).

The decisive role of TT offices and university initiatives have been studied by Thursby & Thursby (2000) In a survey of industry licensing executives, personal contacts between their R&D staff and university personnel was identified as the most important source of university technologies. Journal publications and presentations at professional meetings were also important. The least important sources were marketing efforts by universities. Thursby & Thursby also showed that university refusal to transfer ownership to the commercial partner is the most significant hindering element in UTT.

Technology transfer from public research institutions (PRI) involves several steps and actors (Figure 3). The chain starts with the researcher-inventor, at her laboratory. A research product must be identified as an INVENTION. The conceptual transformation of a research result into an INVENTION is increasingly being the UTT agent's concern. It involves monitoring research activity and constantly contacting researchers to access their awareness about the commercial potential of their work. The first step in the process is an invention disclosure: information about a new technology developed by a faculty member, a graduate student, or a staff member in a PRI is conveyed to the TTO. The second step is patenting. It is the TTO's responsibility to devise the commercial strategy and, consequently, the basic aspects of the patent documents (claims and description). It is also the TTO's role to choose the patent agent that will represent the PRI by writing the patent document, applying for the patent in the Federal Patent and Trademark Office and defending the PRI's rights in litigation. Once a new technology is patented by a research university, the university owns the intellectual property rights and can license the patented technology to another organization. Once again it is the TTO's role to take action. The next step in the process is the contact and negotiation of a license agreement between the PRI and a commercial partner. After this licensing agreement is executed, and, given commercial uses of the licensee, the research university may begin earning income from the transferred technology.

Patent application and litigation must be done by local agents in each country in which the PRI decides to protect its intellectual property. Licensing, especially in biotechnology, is becoming increasingly international. TTO managers must be comfortable with different languages and cultures.

In biotechnology, it might take five or more years since the licensing agreement for any income to be earned by the PRI.

We reach the conclusion that not only it is hard to manage research's *products*, but also its *origins*. As to the "usefulness" of the product, interested parties may enter the chain at any point.

Figure 4 ketches the steps involved in pharmaceutical innovation, which we may use as a proxy to biotechnology innovation in general.

Brazilian institutions are equipped –in infra-structure as well as in expertise – and have been carrying out biotechnological innovation up to the pre-clinical stage. Intellectual protection may place before or after this point. A patent application document is a requirement to start negotiations with a commercial partner.

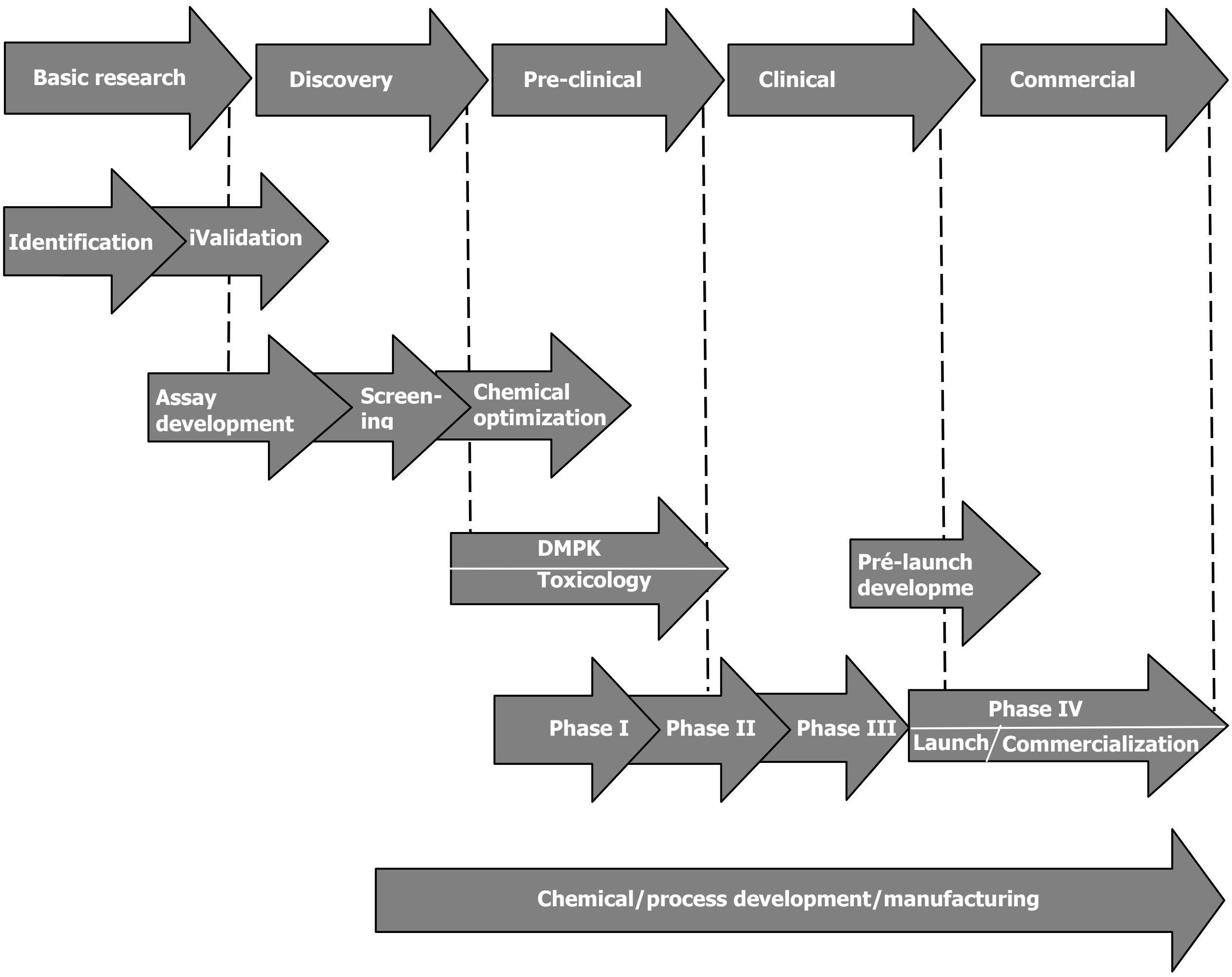

Figure 4 – Biotechnological innovation chain

The whole process, from screening to a "drug", might take more than 10 years and easily a few million dollars. It must be clear that bioprospecting drug discovery is a long term investment.

3. Our understanding of the gaps in the Brazilian system

If researchers are interested in producing useful knowledge, if industry and society at large is interested in using it, then, it is clear that there is something missing in (or obstructing) the system that transforms research results into useful knowledge.

One of the most dramatic and recent demonstrations of the "missing/obstructing something" was the PROBEM/BIOAMAZÔNIA/NOVARTIS scandal. The Brazilian government created the PROBEN (Programa Brasileiro de Ecologia Molecular para o Uso Sustentável da Biodiversidade da Amazônia) in a partnership between the Ministry of the Environment, the Science and Technology Ministry, universities, research institutes, private companies and governments from the Amazonian region (Secretaria de Coordenação da Amazônia http://www.mma.gov.br/port/SCA/fazemos/outros/probem.html). The program was coordinated by the social organization BIOAMAZÔNIA. Market studies carried out by their staff had indicated increasing relevance of natural products in the pharmaceutical industry and there was an atmosphere of optimism around the initiative (Bioamazônia Organização Social 2000 http://www.bioamazonia.org.br/).

BIOAMAZÔNIA's first action – taken without the approval of its Technical-scientific Counsel – was deeply upsetting to the Brazilian scientific community: on May 30, 2000, the institution signed a contract with the Swiss corporation Novartis Pharma AG, granting exclusive access to Amazônia's biodiversity to the company. The agreement gave Novartis full access to all information related to bio-prospecting. This included taxonomy, genetics, culture media, replication technology, among others. The company would have exclusive rights, including those of patenting and commercializing, over all the products developed from Amazonian micro-organisms, fungi and plants. In exchange, Novartis would pay US$1.200.000 and, for the duration of the agreement (three years), additional payments in case research with the screened material generated commercially relevant products. The pharmaceutical innovation chain analyzed above shows that it takes much more time than the contracted duration of the program to "discover" a drug. Besides that, the commercial product is frequently a modified form of the original organism or compound, in which case Brazil would lose its right to financial compensation. There is no legal or simple mechanism to prevent that. Bottom line: Brazil gave the world a wonderful lesson about how NOT to design international cooperative agreements in bio-prospecting.

The reactions to the Novartis episode were not restricted to the scientific community's protests: José Sarney Fo., Minister of the Environment, immediately barred the agreement. BIOMAZÔNIA's Administrative Counsel insisted on its interest in Novartis and elaborated adjustments to the original contract, which were submitted to Novartis in August 2000 (Bioamazônia Organização Social 2000 http://www.bioamazonia.org.br/). In October, the government announced the formation of an inter-ministerial commission to control all bio-prospecting activity in Brazil, the Conagen (Conselho Nacional de Gestão do Patrimônio Genético – *National Counsel for Genetic Resources Management*). According to bill 2.052, which established the Conagen, all new products derived from bio-prospecting must be sanctioned by this commission. It has the power to veto contracts, apply heavy fines and establish royalties to be paid to indigenous communities. Foreign corporations may only carry out research in Brazil if in association with a national institution. Biological material samples may only be sent abroad with Conagen authorization. All bio-prospecting agreements were temporarily suspended (MMA – sala de imprensa 2000).

According to press releases from corporations and government research institutions, bill 2.052's impact affected on-going research, other than BIOAMAZÔNIA, involving several million dollar investments (Traumann 2000).

The Brazilian government has, in reality, adopted a monopoly policy in regard to natural resource management. The results of this choice are not clear at this point but the PROBEN was aborted. New bio-prospecting initiatives are emerging, much more cautiously in spite of the press hype.

In a recent survey of TT in public research institutions, the INPI observed that most Brazilian PRIs lacked either a formal organism or the expertise to carry out the job. Even the most prestigious research university in the country, the University of São Paulo, suffers with lack of support and high quality personnel.

Except for strong and traditional applied research institutions such as FIOCRUZ and EMBRAPA, or innovative bio-prospecting programs such as CAT, biotechnology research in public institutions lacks the basic elements for technology transfer. Links and elements in the innovation chain are missing from one end to the other.

Step	**Problem**
From research to invention	Researchers are not trained to identify potential inventions in their research. Biotechnology

	researchers have no background in industrial innovation and do not understand its mechanisms.
Invention disclosure	When a research product is identified as an invention, researchers have no recognized institutional channels to take action. They lose a great deal of time searching for alternatives. There is no accord in the TT activities of universities and funding agencies. There is often conflict in their procedures. The researcher is at a loss and has no means to decide between different institutional strategies.
From invention disclosure to patenting	a) Specialized data base searches are never performed. The inventor, unskilled for the job, carries out most of it. b) In spite of the large number of industrial property agents in São Paulo, whether any of them is competent to handle biotechnology innovation is unknown.
From patenting to licensing	a) There is no licensing expertise. Either the commercial partner is involved from the beginning, or licensing efforts will be done with no strategy or knowledge of the licensing procedures. b) There are no studies concerning contract formats and contract negotiation strategies regarding bioprospecting activity (Lepkowski 1998, Melissaratos 1998).
From licensing to commercialization	Research institutions are not prepared for the reality of licensing success and royalty sharing. Strategies predicted in employment and funding agency contracts are contradictory. Funding agencies and institutions have no skill

	to handle commercial relationships with industry

The first bottleneck in PRI innovative activity is the lack of TT institutional structure and skilled personnel. It would be unfeasible to initiate high quality technology transfer programs even in a small number of Brazilian public research institutions.

It is clear that institutional solutions and strategies must be sought, but there is no consensus as to which would be more effective (Cruz 1999).

4. Our research lines

1) **The biological research community - scientific production and innovation: attitudes and needs**

There is wide awareness among Brazilian researchers as to the doubtful quality of patents as indicators of innovative activity (Furtado 1994). However, as in other studies, we must start with this approach.

Albuquerque (in press (a) and (b)) has studied the performance of Brazilian industry concerning technological innovation through an analysis of domestic patents and Brazilian residents' patents registered at the USPTO. The author studied 8309 patents registered at the INPI and 475 patents registered at the USPTO between 1980 and 1995. His study revealed the following features: a) a high proportion of individual patents; b) foreign corporations with important activities; c) a low level of involvement in R&D in private corporations; d) a lack of continuity in patenting activities. Albuquerque concluded that these features further corroborate the classification of the Brazilian innovation system as an immature one (Nelson 1982, Nelson & Winter 1977, 1993, Patel & Pavitt 1994).

Data and analyses from INPI support Albuquerque's conclusions. According to the Institute's "Patent Statistics", the Brazilian innovation system is highly concentrated at the State of São Paulo, followed by Rio de Janeiro, Rio Grande do Sul and Minas Gerais. Researchers and scientists constitute a small fraction of national inventors: researchers represent 5%, biologists represent 1% and physicists represent 1% of the national inventors

(INPI 2000). Low researcher participation in innovation is a common feature among developing countries. A study carried out by the International Service for National Agricultural Research (ISNAR) had identified a generalized lack of awareness among Latin American agricultural research institutions concerning IPR in biotechnology. This lack of awareness encompasses both the academic and the administrative sectors. According to this study, although there is an atmosphere of high expectation among researchers concerning the protection of their own innovations, 53% of proprietary technologies employed in these institutions were acquired informally.

The study has identified a number of problems regarding IPR, among which: 1. Remarkable lack of knowledge among researchers about IPR resources for their own work; 2. Researchers are unaware of the potential dangers of disseminating the final product of research involving proprietary technologies (and even a certain propensity to view IPR as an obstacle for research). 3. There is high expectation, among researchers, about generating innovation and protecting it, in spite of their lack of knowledge on the subject; 4. None of the examined institutions was equipped with legal structures to deal with IPR issues; 5. A high incidence of collaborative research agreements with no contractual or regulatory provision regarding the protection of eventual products.

ISNAR organized a workshop in September 1999 with scientific administrators from Mexico, Costa Rica, Colombia, Brazil and Chile, where these problems were analyzed. According to participants, problems correspond to actual needs, among them: access to detailed information about proprietary technologies; legal support to manage contracts and the use of proprietary technologies; technical support for the economic evaluation of biotechnological products; educating researchers about the basic aspects of IPR (Falconi & Salazar 1999).

The strategy we adopted to accomplish the profiling of "innovation literacy" among Brazilian researchers in the life sciences comprehends relating attitudes, opinions and facts concerning innovation and technology management to socio-academic variables. An evaluation of available data-bases indicated that the best one was the Directory of Research Groups, from the CNPq (the National Counsel for Scientific and Technological Development). The data base provided information on the researcher's institutional affiliation, address, production (scientific and otherwise), teaching activities, number of graduate students, research lines, research groups and principal research area. The Directory groups research into "areas", "major areas" and "sectors", which roughly correspond to scientific disciplines, concentration and application. We chose to electronically survey all the group leaders in the Biotechnology Sector whose principal area was one of the life sciences. There are 1127 individuals.

We have prepared a simple questionnaire constituted by 5 groups of questions, comprising a total of 41 choices. The design was based on: the actual information needed about opinions and attitudes; the comparability with the two other similar surveys undertaken in the United States; the format's simplicity (it has to be user friendly, to fit into one single web page and be easy to answer in a "reply" to sender fashion). The questionnaire will be applied in August 2000.

Further planned activities include focus group research with the presidents of Experimental Biology Societies.

2) Start-up initiatives and incubators: the challenges of "going commercial"

Brazilian biotechnological innovation is done now and in the predictable future in public institutions. Yet, the incipient but rising private biotechnology industry must also be considered. Portugal (1996) points out the large number of corporations and research institutes formed in Brazil between 1981 and 1992. The relationship between these new private companies and public institutions is noteworthy. Biobrás, for example, one of the first private biotechnological initiatives in the country (founded in 1976, specialized in human insulin and products for diabetics), is also involved with BIOAMAZÔNIA (Bioamazônia 2000) and develops collaborative projects with important public institutions, such as FIOCRUZ (Biobrás S.A. 2000, Projetos de Pesquisa, Instituto Oswaldo Cruz *http://dcc007.cict.fiocruz.br/projetos/protozoologia014.htm*).

This example of proximity between public research and the private sector is paradigmatic.

There are three major biotechnology research incubators in Brazil: the BioRio, at the Federal University of Rio de Janeiro's campus, the Biominas, at the Federal University of Minas Gerais' campus and the CIETEC, at the University of São Paulo, which is not specifically biotechnological.

There are research clusters designed to become financially self-sufficient in a determined number of years, explicitly expected to develop stable relationships with industry. One of them is the CAT the Center for Applied Toxinology, supported by the FAPESP.

The Science and Technology Policy program at the NUPES includes an inventory of the incubated and start-up initiatives in biotechnology in Brazil, tracking back their ties into the public research institutional system. The goal is to understand spin-off dynamics, identifying pitfalls and successful shortcuts.

3) Intellectual property regulation, commercial agreements and bioprospecting: public policy, legislative action and international relations

For developing countries and, especially, for tropical countries with great bio-diversity, there are two significant sectors regarding biotechnological capability: agriculture and pharmaceutical industry. Latin American countries need biotechnology and are in the process of devising policies to establish bio-prospecting[1] initiatives (Falconi 1999). Two strategies stand out at present, represented, in one hand, by Costa Rica, and on the other, by the ICBG (International Cooperative Biodiversity Groups) program.

Costa Rica has adopted a policy to protect its bio-diversity and acquire biotechnological capability at the same time. The Instituto Nacional de Biodiversidade (INBio) is responsible for the application of this policy. The INBio was created in 1989 as a non-profit private institution.

INBio has a library of chemical substances of potential commercial interest. The institution basically brokers the commercial exploitation of the country's biotic richness. All income beyond costs is to be used to protect and manage the country's natural resources. In October 1991, Merck Pharmaceutical celebrated an agreement with INBio according to which it would pay one million dollars for the opportunity to screen INBio's samples. INBio trusts that the contractual arrangements are sufficiently strict to inhibit Merck from benefiting from the collaboration without honoring the sharing commitment. It is foreseen that royalties will be paid for every product directly or indirectly derived from INBio, with no time limit.

Four universities and one institute from Mexico, Argentina and Chile are part of the ICBG (International Cooperative Biodiversity Groups) program. This is an American government supported program granted to the University of Arizona. The program provides the funding for the "Bioactive Agents from Dryland Biodiversity of Latin America" project. Besides the "source countries" in Latin America and the "host country", represented by the University of Arizona, the project involves three commercial partners. The project organized traditional information with the involvement of local communities, who participated in

[1] Bio-prospecting is the biotechnological exploration of a country's natural resources.

exchange for techniques they needed to cultivate their plants. The team created a data bank to organize all the information and they produced 6.900 extract samples from collected plants. Most of them have already been subjected to primary and secondary assays. They developed cheaper biological activity screening procedures in order to provide alternatives for the source-countries. They determined the chemical structure of selected compounds, besides many other research and training activities.

The contract includes protection mechanisms against possible pitfalls in the relations with the commercial partners. Among them are confidentiality of all information about the plants and source-country monopoly in the collection and manipulation of plant material. The eventual patents would be registered by the program and preferentially offered to the commercial partners for licensing. The eventual royalties will be divided among inventors, collectors and conservation activities in source-countries. The commercial partners have also agreed with other forms of payment, such as high power computers and publication funds for the host-country institution, and specimen collections and microbiological training for the source-countries. Publications are always collaborative. The group is realist about the program's chances of commercial success, which are small. Today, for each drug approved for commercialization, 5000 compounds have been screened. The chief goal of the program is to build scientific and technological capability in, and technology transfer to the source-countries (Timmermann 1999).

Other Latin American countries have set up institutions to foster biotechnological research, to promote technology transfer, to bring together university government supported research and private firms, and to develop legal procedures for bi- or multi-national agreements in which all partners benefit. Examples of these institutions are the CONABIO (CONABIO 2000), in Mexico and the Humboldt Institute, in Colombia (Instituto Humboldt 2000).

Brazilian scientists are also aware of the dangers of neglecting the biotechnological exploration of the country's natural resources. Amazônia is of special concern. Camilo Viana, president of SOPREN (Sociedade para a Preservação dos Recursos Naturais da Amazônia) and professor at the Federal University of Pará, recently protested against the government's tolerance of Amazônia's biodiversity exploration by foreign corporations. He mentioned a few Amazonian products already patented by these companies (O Liberal. January 27, 2000). Alfredo Homma, from EMBRAPA, compiled a list of Amazonian plant products patented by foreign organizations (including universities) (Homma in press, 1998, 1999). Samuel Almeida, researcher from the Museu Emilio Goeldi's Botany Department, insisted that

Brazilian authorities must develop legal instruments to regulate the access to national biodiversity (O Liberal. 26 de Janeiro de 2000). These scientists are discussing bio-piracy – the illegitimate appropriation of intellectual property of indigenous knowledge, be it traditional or scientific (Otávio 1999 (a), (b)).

Our research program is both monitoring on-going regulation of the "Protection Law" and participating, as required, as consulting agent in technology management initiatives.

4) Technology transfer - tools for the new millennium: how Brazilian government, funding agencies, research institutions and companies are facing the challenge

This part of our activity is less investigational and more participative. Our team is: 1. providing information about the needs of the scientific community, both legal-institutional and educational; 2. connecting different initiatives in the country; 3. surveying successful initiatives from other countries to help set up local strategies.

At this point, all we know is that there is great need from scientific institutions, sufficient funds from federal and state organisms to set up technology management initiatives and a huge lack of expertise.

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