SCIENCE-TECHNOLOGY-INDUSTRY NETWORK
“THE COMPETITIVENESS OF SWISS BIOTECHNOLOGY”: A CASE STUDY OF INNOVATION

By

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INTRODUCTION

This study proposes to analyse in an exploratory way the state of innovation and production systems in Swiss biotechnology and especially its innovative capacity and related factors. As biotechnology as such cannot be considered as an industrial sector but rather as a set of technologies developed in the field of life sciences, the direct link with science makes innovative capacity a major determinant of competitiveness.

While large multinationals, such as biopharmaceuticals, may not need local technology suppliers, the presence of a local industry of research-based firms and technology suppliers is critical, because the industry is, by itself, a major source of growth and social progress. As in many other technologies, innovation in biotechnology was initially undertaken not by incumbents but by new companies. These companies were mainly university spin-offs and were usually created through collaboration between scientists and managers, backed by venture capital (VC). The purpose of this collaboration has been to mobilise fundamental knowledge created in universities and to transform it into commercially useful techniques and products.

By observing how research and development (R&D) activities are organised in the field of biotechnology, we try to identify the relations existing between universities and the biotechnology industry, but also the relations between biotechnology firms among themselves. Hence we first present an overview of some recent knowledge production models before joining the approach to strategic alliances, where it is argued that the constitution of coalitions and networks represents a key competitive advantage.

We will subsequently explore the “cluster” approach. In fact, data show that a process of clustering is taking place in Europe where a small number of local clusters are capturing a dominant majority of biotechnology firms and of public research organisations.

Furthermore, we will examine the role of the state and local governments in creating a favourable innovation climate. We will ask for example if the Swiss Priority Programme Biotechnology (SPP Biotechnology) has contributed to strengthening the relations between universities and industry, and if yes, in what terms.

Therefore, in chapters 1, 2 and 3, we will give an introduction to the economic approaches we refer to in our study, i.e. knowledge production models, strategic alliances and clustering in biotechnology. The aim is to reveal the importance of the networks inherent in these clusters for all actors involved in the process of technological innovation.

Then, after presenting the Swiss science and technology (S&T) policy in chapter 4, we will analyse institutional factors affecting Switzerland’s industrial competitiveness in biotechnology, e.g. the structure of its research system, the access to capital sources, the regulation of intellectual property rights (IPR) in biotechnology, and other institutional factors like public perceptions and the overall regulatory stance (chapter 5). Additionally, the review of the data available in the field of Swiss biotechnology activities aims to situate Switzerland’s position in the global market.

Chapter 6 consists of a number of interviews with researchers from Swiss universities, chief researchers from companies specialised in biotechnology, and persons in charge in federal institutions. This stage which constitutes the heart of our study will give us information about how persons and ideas circulate in the field of biotechnology, thus identifying the existence or non-existence of knowledge networks. Moreover, we will obtain information about the different institutional factors influencing the competitiveness of Swiss biotechnology.

To conclude, a synthesis of the results found through the numerous interviews conducted with key actors of the Swiss biotech scene is given in chapter 7. Hence, we will obtain a general picture of biotechnology in Switzerland allowing us to better appreciate its situation.

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1 Knowledge production models

Several models actually exist for the explanation of the knowledge production process and therefore for a better understanding of the role of innovation and particularly technological advancement, fundamental for our economic prosperity and social stability. In a more or less chronographic order of publications, we can find in literature among the more recent ones first the model of National Systems of Innovation (NSI) (e.g., Freeman, 1987; Lundvall, 1988 and 1992; Nelson, 1993, and Edquist, 1997). This concept of the NSI appeared explicitly in a number of contributions in the second half of the eighties, reflecting new developments in innovation research. The most fundamental new insight of innovation studies at this time was that innovation is an interactive process where agents and organizations communicate, co-operate and establish long-term relationships. Even if this approach was not a completely new one, as it was already implicit in earlier contributions by for instance Freeman, Nelson and Rosenberg, the perspective started to become generalized and was made explicit. Another often cited approach appeared in the early 1990s known as the model of the new mode – Mode 2 – of the production of knowledge (Gibbons *et al.*, 1994). For Gibbons and his colleagues there is enough evidence to show that a new mode of knowledge production has emerged which affects not only the institutional forms in which knowledge is produced but also which knowledge is produced, the mechanisms of quality control and the corresponding reward systems. One very important element of this new mode is meant to be "transdisciplinarity", which seems to become in our days a model for the explanation of knowledge production of its own (Thompson Klein *et al.*, 2001). Third, there is the model of a Triple Helix of university-industry-government relations proposed by Etzkowitz and Leydesdorff (1995, 1997, and 2000).

As university-industry-government relations can be considered as a driving force in the technological innovation process, this study relies directly on those interactions. For example, the model of the Triple Helix helps us to reveal how the different institutional actors interact and while doing so, advance the process of knowledge production. To get the model operational, we try to discover the real practice of these interactions, going beyond the existing formal relations between these three institutions. In this field, the study of biotechnology represents a particular interest already because of its beginning, bringing university, industry and government together in its development, but also because of its wide technical, economical and social implications. As this project refers to Switzerland as a whole in the field of biotechnology, we'll be able to identify some of the main actors of the process of technological innovation in this country and to follow the practice of these interactions.[1]

1.1 National Systems of Innovation (NSI)

What is meant exactly by considering the concept of National Systems of Innovation? The OECD proposes us in its paper entitled "National Innovation Systems" (OECD, 1997)[2] a whole range of definitions amongst we can find the one given, for example, by Freeman (1987) who states that an NSI can be considered as:

"… the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." (Freeman, 1987)

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[1] For an identification of university-industry-government relations in the field of microsystems in the French speaking part of Switzerland, see Harayama, Mack and Zarin-Nejadan (2004).
[2] See also for a typology of knowledge flows in national innovation systems and its main indicators (p. 45).

Furthermore, we can find in Gu (1996), in her work about an analytic framework for NSI:

"…, a national innovation system is a system constituted by various actors, most of them organized, who influence technological innovation. It operates through various interactions taking place within the context of the institutional establishment of the system, and it is significantly influenced by national policies. A national innovation system is "national" to the extent that it has identifiable national and societal specificities. It is a "system" in as much as we can identify the importance of institutional support for the learning and innovation process. The concept of a 'national innovation system', thus focuses attention on 1) learning efficiency, and 2) the capacity and efficiency of the institutional set-up to support learning." (Gu, 1996, p. 6)

It seems that there has been a growing interest for the concept 'national system of innovation' since the 1980s, partly as a result of current economic trends as described by Nelson and Rosenberg:

"The slowdown of growth since the early 1970s in all of the advanced industrial nations, the rise of Japan as a major economic and technological power, the relative decline of the United States, and widespread concerns in Europe about being behind both have led to a rash of writing and policy concerned with supporting the technical innovative prowess of national firms. At the same time, the enhanced technical sophistication of Korea, Taiwan, and other NICs (Newly Industrialized Countries) has broadened the range of nations whose firms are competitive players in fields that used to be the preserve of a few and has led other nations who today have a weak manufacturing sector to wonder how they might emulate the performance of the successful NICs. There clearly is a new spirit of what might be called "technonationalism" in the air, combining a strong belief that the technological capabilities of a nation's firms are a key source of their competitive prowess, with a belief that these capabilities are in a sense national, and can be built by national action." (Nelson and Rosenberg, in Nelson (ed.) 1993, p. 3)

Freeman (1987) was the first major publication where the concept of NSI was explicitly used. The following collaboration between Freeman, Nelson and Lundvall in the IFIAS-project on technology and economic theory (Dosi *et al.*, 1988) is considered as having been important for the development of this concept. Porter (1990), for example, does not use the concept but his analysis of national competitive advantage is characterized by an approach which is close to the one of NSI. Mc Kelvey (1991) compares these contemporary approaches while Freeman (1995) puts the concept in a historical perspective. At other levels of aggregation, innovation systems can be found, for example, in Carlsson (1995), where the focus is on technology and sector specific systems and in Baraczyk, Cooke and Heydenreich (1996), where the focus is put on regional systems.

Although efforts to understand NSI have been made, the situation seems to remain not very satisfactory, mainly because of a lack of a coherent analytical framework (Gu, 1996). The conceptualization of NSI starts with the work of a group of economists at Aalborg University (Lundvall, 1992), Denmark, highlighting two fundamental components as constituting the core of the NSI-analysis: learning and the institutional set-up.

"First it is assumed that the most fundamental resource in the modern economy is knowledge and, accordingly, that the most important process is learning. The fact that knowledge differs in crucial respects from other resources in the economy makes standard economics less relevant..." (Lundvall, in Lundvall (ed.) 1992, p. 1)

This assumption, called the learning assumption by the Aalborg group, suggests that one key element in the concept of a 'national innovation system' is knowledge deriving from learning, with important parts of the knowledge base being tacit and emanating from routine-based learning-by-doing. In fact, when referring to "learning", it is referred to the formation of new skills at the level of the individual and to the formation of new competencies at the level of organisations and networks. In the latter case, according to Lundvall (1997), the competencies are embodied in procedures, routines and codes of behavior shared by the individuals belonging to the organization. Moreover, when the focus of an analysis is better to understand economic development, successful innovation is more important than efficient allocation of existing resources. From this point of view, it also becomes clear that specific information and knowledge at a certain point of time may be less important than the learning capability of the economic agents itself. Consequently, such a learning-centered approach implies that learning efficiency becomes an important key factor in successful long-term economic development. But this clearly is in contrast with classical development economics, which has tended to identify the efficient allocation of production factors (capital and labor) as the key to economic development.[3] Assuming that the concept of NSI is focused on learning, an analysis of such a system should focus thus on process in opposition to a focus on the consequences of learning, in fact well taken into account in a learning-centered approach. The second assumption made is that support from the institutional set-up is considered to be crucial to the learning process.[4] Lundvall therefore states:

> "Second, it is assumed that learning is predominantly an interactive and, therefore, a socially embedded process which cannot be understood without taking into consideration its institutional and cultural context. Specifically, it is assumed that the historical establishment and development of the modern nation state was a necessary prerequisite for the acceleration of the process of learning which propelled the process of industrialization, in the last centuries." (Lundvall, in Lundvall (ed.) 1992, p. 1)

Hence, the conceptual framework of the NSI seeks to identify the elements, which influence the capacity and efficiency of a national innovation system that means the institutional set-up within which innovation occurs, and how this supports learning and therefore the creation of knowledge. Given the assumption that the institutional support is a critical causal factor for learning, those cultural and social elements, which are crucial to an innovation system, have to be considered as intrinsic rather than extrinsic parameters. The suggested framework of the NSI thus considers the nation state as a special kind of institutional context, involved in establishing the institutions necessary for industrial development, by means such as industrial strategies, laws and regulations, and direct government expenditure. It's worth noting here that the nation state itself, as one of the economic actors, is considered to have a great influence on the pattern of the whole innovation system, and on the learning process and degree of learning efficiency, which takes place within such a system. As a consequence, interactive learning is assumed to embrace the feedback from policy formulation and the responses of economic actors, which leads to a process of policy and institutional learning by society in a whole. These processes then affect, and are affected by, the efficiency of technological learning of all the economic actors. (Gu, 1996, p. 6)

1.2 Mode 2

Another model that we can find in literature is the model of the so-called "Mode 2" of the production of scientific knowledge, with scientific knowledge being described as a complex of ideas, methods, values and norms, and which is considered having profound implications for both competitiveness and sustainability in contemporary society.[5] Gibbons *et al.* have therefore identified five characteristics that when appearing together, are integral enough to

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[3] In the neo-classical growth theory, however, some take into account the learning-by-doing effect, like it is the case for Arrow (1962), Sheshinski (1967) or Romer (1986).

[4] Concerning institutions, understood as norms, habits and rules, they are deeply ingrained in society and they play a major role in determining how people relate to each other and how they learn and use their knowledge (Johnson, 1992).

[5] This part is based on Gibbons *et al.* (1994).

constitute a new form of production of knowledge.[6] The first characteristic is that contemporary research is being carried out in the context of application; problems are formulated in dialogue with a large number of interests from the very beginning. Second, in Mode 2 there are multiple stakeholders who bring an essential heterogeneity of skills and expertise to the problem solving process, not without influence on the organizational structures. The third characteristic of Mode 2 is the already mentioned transdisciplinarity, defined as knowledge emerging from a particular context of application having its own theoretical structures, research methods and modes of practice but which may not be locatable on the existing disciplinary map (Gibbons *et al.*, 1994, p. 168). Another important criteria is accountability in opposition to individual responsibility, which in fact still remains valid. It refers to a kind of institutionalized responsibility or a way to broaden the horizon of those for whom someone is producing knowledge. Finally, there is the criterion of quality control, arguing that a societal value needs to be integrated into the definition of what means "good science", indeed difficult to grasp. Following Gibbons and his colleagues, there is sufficient empirical evidence to indicate that this distinct set of cognitive and social practices has begun to emerge, different from those that govern "Mode 1", the traditional, familiar, discipline-oriented and linear form of knowledge production. Following Gibbons and his colleagues, Mode 1 has grown up to control the diffusion of the Newtonian model of science to more and more fields of investigation and guarantee its conformity with what is considered sound scientific practice. The changing conditions in the economic and political environment, mainly as a consequence of globalization, appearing in the natural and social sciences but also in the humanities and to summarize roughly under the meaning of 'science going to the market', can then be described in terms of a number of attributes which when taken together have apparently sufficient coherence to suggest the emergence of a new mode of knowledge production. This set of attributes is then used to allow the differences between Mode 1 and Mode 2 to be specified.[7]

According to Gibbons *et al.*:

"The new mode operates within a context of application in that problems are not set within a disciplinary framework. It is transdisciplinary rather than mono- or multi-disciplinary. It is carried out in non-hierarchical, heterogeneously organised forms, which are essentially transient. It is not being institutionalised primarily within university structures. Mode 2 involves the close interaction of many actors throughout the process of knowledge production and this means that knowledge production is becoming more socially accountable. One consequence of these changes is that Mode 2 makes use of a wider range of criteria in judging quality control. Overall, the process of knowledge production is becoming more reflexive and effects at the deepest levels what shall count as 'good science'." (Gibbons *et al.*, 1994, p. vii)

By contrast, Mode 1 problems are set and solved in a context governed by the, largely academic, interests of a specific community; Mode 1 is disciplinary and characterized by homogeneity, and organizationally, it's hierarchical and tends to preserve its form; concerning the type of quality control, Mode 1 is less broadly based, not so complex and rather one-dimensional.[8]

[6] For a deeper discussion see Thompson Klein *et al.* (2001, pp. 69-71).
[7] In fact, Gibbons *et al.* argue that while Mode 2 may not be replacing Mode 1, Mode 2 is almost completely different from Mode 1.
[8] For a more detailed study about quality control, see, for example, the SNSF Priority Programme "Switzerland: Towards the Future" with its research project "The Production of Socially Robust Knowledge" headed by H. Nowotny and carried out by P. Gisler, M. Guggenheim, A. Maranta and C. Pohl. The project is based upon three case studies relating to two different research areas: environmental research and biotechnology.

Why have Gibbons and his colleagues decided to use the term “transdisciplinarity” rather than “multidisciplinarity” or “pluri-disciplinarity”? And what do they want to convey with it? Gibbons and Nowotny explain that the main point is that today an intellectual endeavor is not arising anymore within disciplines as it was common once, but rather within a context of application going beyond a single discipline and consequently transgressing disciplinary boundaries (Thompson Klein *et al.*, 2001, pp. 69-70).[9] Moreover, the fact that the number of stakeholders involved in shaping social reality has permanently increased, as shown by, for example, the growing importance of NGOs, only underlines the meaning of the prefix “trans”.[10] When saying that knowledge production becomes “more reflexive” in Mode 2, Gibbons *et al.* argue that working in the context of application increases the sensitivity of scientists to the broader implications of what they are doing. In addition, all participants become more reflexive as the issue on which research is based cannot be answered in scientific terms alone, therefore including different individuals and groups that have been seen as traditionally outside of the scientific and technological system. These individuals and groups have got the possibility to become now active agents in the definition and solution of problems and also in the evaluation of performance. As a consequence, “good science” gets new dimensions to be determined. But how would you like to define “good science”? In trying to find an answer on this difficult question, Nowotny explains in Thompson Klein *et al.* (2001, p. 71) that an important element to integrate into the definition of good science has to be a societal one. Thus, following Nowotny, we should start to speak about “value-integrated” when speaking about scientific quality and not any longer only about “value-added” quality. Hence, we intend to qualify this approach as “bottom-up”, influencing the process of knowledge production from its early beginning and at its “deepest levels”, already before a certain problem might be defined.

All these attributes of Mode 2, while not present in every instance, do when they appear together seem to have a coherence, which allows to give a recognizable cognitive and organizational stability to the mode of production. Therefore, while in Mode 1 cognitive and social norms are simply adjusted to one another and produce disciplinary knowledge, new norms are emerging in Mode 2 that are appropriate to transdisciplinary knowledge. Through all these stages of knowledge production, from the emergence of an idea to the commercialization of a final product, individual and collective creativity find themselves in a varying relationship of tension and balance. And although Mode 1 and Mode 2 are distinct modes of production, they permanently interact with one another. Specialists from one discipline may enter the transdisciplinary way of producing knowledge, but might return after a while to their original disciplinary base, while others will choose to follow a trail of complex solving problems that are set by a series of application contexts, characteristic of Mode 2.

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[9] For a more detailed explanation, see Gibbons *et al.* (1994, pp. 27-31).

[10] Several attempts have been made to distinguish “pluri-” from “inter-” and “trans-”disciplinarity. According to the definition given by Jantsch (1972), pluri-/multidisciplinarity is characterised by the autonomy of the various disciplines and does not lead to changes in the existing disciplinary and theoretical structures. Although cooperation on a common subject exists, the different disciplinary perspectives are maintained. Interdisciplinarity is characterised by the explicit formulation of a uniform, discipline-transcending terminology or a common methodology, thus working on different topics within a common framework that is shared by the disciplines involved. Concerning transdisciplinarity, “the ultimate degree of co-ordination in the science/innovation system” (Jantsch, 1972, p. 222), it arises only if research is based upon a common theoretical understanding accompanied by a mutual enhancement of disciplinary epistemologies. Cooperation here leads to a clustering of disciplinary rooted problem-solving and creates a transdisciplinary homogenised theory or model pool. See Gibbons *et al.* (1994, pp. 28-29). For a more detailed (and also visual) analysis of all different forms, see Jantsch (1972, p. 222 ff).

As a result of the process of massification of education and research[11], the number of sites where competent research[12] can be carried out has increased.[13] These constitute according to Gibbons and his colleagues the intellectual resources for, and social underpinnings of, Mode 2. In fact, it is the development of rapid transportation, as well as information and communication technologies, which have created the capability allowing these sites to interact. As a consequence, Mode 2 is critically dependent upon the emerging ICTs, but favoring only those who also can afford them. The outcome of this explosion in the number of interconnections and possible configurations of knowledge and skill can be described as a "socially distributed knowledge production system" where communication increasingly takes place across existing institutional boundaries. The result is described as a "web whose nodes are now strung out across the globe and whose connectivity grows daily" (Gibbons *et al.*, 1994, p. 10).

One interesting point to note here is that, following Gibbons, Mode 2 shows no particular inclination to become institutionalized in the conventional pattern. While it is argued that Mode 1 has become the mode of production characteristic of disciplinary research institutionalized largely in universities, Mode 2 is institutionalized in a more heterogeneous and flexible socially distributed system including many different partners alongside universities. In fact, institutional differences between, for example, universities and industry, seem to be less and less relevant in transdisciplinary context. Instead, preference is given to collaborative rather than individual performance, with individuals working in open, flexible types of organization in which they may work only temporarily. Moreover, being considered as the response to the needs of both science and society, Mode 2, with its different attributes as described above and its inherent way of producing knowledge, is supposed to be irreversible. But the question one might ask here is whether Mode 2 is considered as being already the final mode in the certainly non static but evolutionary way of producing knowledge. So do we have to expect one day a Mode 3?

Even if technological innovation depends increasingly upon using specialized knowledge[14], often seen as a key factor in determining a firm's comparative advantage, its acquisition is often difficult and too expansive for individual firms to imitate entirely in-house.[15] Therefore, firms have become involved in a complex array of collaborative arrangements involving universities (and their related research groups), governments (through government laboratories and research institutes) and other firms, where supply and demand of knowledge are mediated by a market mechanism which is not seen as a narrowly commercial one. Nevertheless, it is to note, that besides the formal relations, there is also an important informal network, strengthened by rapid transportation and electronic communications, where scientific knowledge circulates among practitioners and scientists. As knowledge is produced

[11] While the massification of education refers primarily to the growth in the number of students seeking a university-type education, the growth of mass patterns in research both resembles and differs from those in education. These patterns involve, for example, working relationships between people located in various institutions, and include many participants from outside the university. Research in Mode 2 also requires different ways of funding from traditional discipline-based research. As a consequence, a multitude of new institutional arrangements emerges, linking government, industry, universities and private consultancy groups in many different ways. Hence, a profit-making mentality is often adopted in university research. For a deeper discussion, see Gibbons *et al.* (1994, pp. 70-89).
[12] With competency resulting from an excess of highly educated people which couldn't be absorbed within their disciplinary structures.
[13] It is to note that in parallel with this expansion in supply of specialised knowledge has been the expansion of the demand for specialised knowledge of all kinds, not easy to be imitated.
[14] Frequently linked to a particular context of application.
[15] For example, when trying to adopt a new production process or adapting an old one.

by configuring human capital, the ability to do so lies at the heart of many economies of scope, regarded as essential to survival in today's marketplace. Furthermore, as it's well known, to have its full economic impact, the diffusion of innovation becomes necessary. Within Mode 2, this diffusion is now even a matter of this spread of knowledge, typical for Mode 2.

To conclude, Gibbons and his colleagues summarize:

"The core of our thesis is that the parallel expansion in the numbers of potential knowledge producers on the supply side and the expansion of the requirement of specialist knowledge on the demand side are creating the conditions for the emergence of a new mode of knowledge production. The new mode has implications for all the institutions whether universities, government research establishments, or industrial corporations that have a stake in the production of knowledge. The emergence of markets for specialised knowledge means that for each set of institutions, the game is changing though not necessarily in the same ways or at the same speed. There is no imperative for all institutions to adopt the norms and values of the new mode of knowledge production. Some firms and universities are already a long way along the path of change and this is manifested in the types of staff they recruit and in the complex range of collaborative agreements that they enter. However, the institutional goals to be achieved, the rules governing professional development and the social and technical determinants of competence will all need to be modified to the extent that the new mode of production becomes established." (Gibbons *et al.*, 1994, p. 13)

Overall, we consider the Mode 2 model of the production of knowledge as rather being descriptive and therefore not adding much to an analytical research tool. Even though this might not be its intention, it is often cited in parallel with the NSI or the Triple Helix model. The lack of accuracy (we might ask if this has to be a part of transdisciplinary research in our days and in future) and hence the missing capacity in establishing a more or less robust science about any kind of knowledge production and technological innovation, which could be useful in defining the best way for producing knowledge, is also regrettable. In fact, questions concerning "good" science or "socially robustness" further complicate the issue. Moreover, reducing the reasons for the emergence of the new mode of knowledge production to the expansion of specialist knowledge on both the supply and demand side seems to be reductive. Also the context of application was always a central element and transdisciplinarity an important and useful, even if may be not well seen tool for innovation. To conclude, we rather suggest to consider Mode 2 as an empirical case study inside the framework of the NSI or, more general, the Triple Helix model. Latter will be considered now in more detail.

1.3 The Triple Helix[16]

The ongoing convergence and the eminent crossing-over between universities, industry and government in the process of knowledge production and technology transfer, has been represented and explained by Leydesdorff and Etzkowitz through the model of the Triple Helix. This model refers to a spiral (in opposition to the traditional linear) model of innovation that captures various mutual relationships among institutional settings (academic, private and public) at different stages of the knowledge production process. The collaboration between these three institutional spheres increases more and more, with a spiral pattern of linkages emerging at different stages of the innovation process, to form the so-called "Triple Helix".[17]

[16] This part is based on Etzkowitz and Leydesdorff (2000).
[17] See for this definition of the Triple Helix model Viale and Ghiglione (1998).

Following Leydesdorff and Etzkowitz, the Triple Helix model improves on the national systems of innovation model by declaring "governance" as a variable[18], making it possible to study the different levels of government (European, national, regional, and local) in a coherent framework. In fact, it is argued that systems of innovation can no longer be stabilized, since they remain deeply in transition. Equally, 'Research, Technology & Development' (RTD) systems are not supposed to stay in a steady state. Concerning the Mode 2 model, the Triple Helix model shares with it a focus on a dynamic network of relations and interactions among institutions taking part in research activities. Because knowledge and information flows are considered as an emerging coordination mechanism of society in parallel and in interaction with existing economic exchange relations and political control mechanisms, the political economy tends to become more and more knowledge-based. Whereas each innovation is seen as an instance of interaction, innovation systems build recursively on the interactions at interfaces between technologies, markets, institutions, etc. Because of their complexity, these interactions (their driving force might be specified as the expectation of profits, with "profit" meaning different things to the various actors involved (*infra*) (Leydesdorff, 2000b)) are expected to generate non-linear dynamics, making an algorithmic model necessary for studying all the existing relations. Another important difference in comparison to the NSI approach is that, following the Triple Helix thesis, the university is supposed to play an enhanced role in innovation in a knowledge-based economy. The model is therefore analytically different from the NSI approach, which considers the firm as having the leading role in innovation.[19] Moreover, whereas the NSI approach concentrates on the analysis of co-evolutions between, for example, technologies and institutions, and markets and technologies (Nelson, 1994), the Triple Helix thesis focuses on the interactions among these various interfaces. Questions to be answered are therefore how organizational rigidities among them are controlled and dissolved or when these reorganizations can be considered as structural adjustments to technological developments (Leydesdorff, 2001, p. 4).

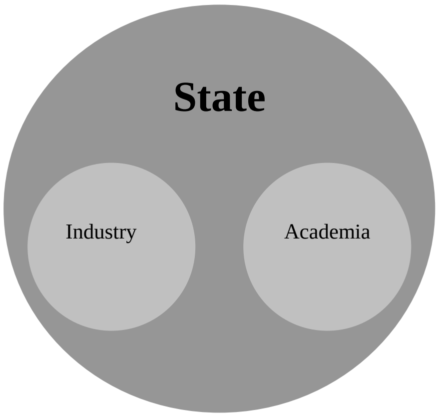
The evolution of innovation systems, and the conflict over which path should be taken in university-industry-government relations, are reflected in different perspectives on these inter-institutional arrangements. Leydesdorff and Etzkowitz distinguish therefore between three different main configurations among the general Triple Helix model. The following figures (Etzkowitz and Leydesdorff, 2000) shall be helpful to the understanding of the different models.

First, there is the etatistic model (Triple Helix I) of university-industry-government relations, with the state in a predominating position. This model is largely viewed as a failed developmental model concerning economic and technological development. Strong versions could be found in the former Soviet Union and in Eastern European countries. In fact, in this configuration the nation state encompasses academia and industry and directs the relations between them. (See figure 1-1.)

[18] For example, the European Union (EU) can be considered as experimenting with a set of arrangements balancing authorities between national governments and supra-national regulation. See for a more detailed discussion Leydesdorff (2000a).

[19] The model is also different from the "Triangle" model of Sábato (1975) in which the state is privileged (see Sábato and Mackenzie, 1982).

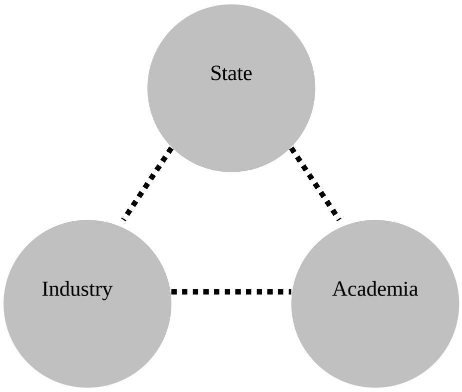
Figure 1-1: Etatistic model of university-industry-government relations



Source: Etzkowitz and Leydesdorff (2000).

A second policy model[20] (Triple Helix II) is the one, which consists of separate institutional spheres with strong borders dividing them and highly circumscribed relations among the spheres. The role of the sate, in comparison to the Triple Helix I model, is largely reduced, entailing a kind of laissez-faire policy (figure 1-2).

Figure 1-2: "Laissez-faire" model of university-industry-government relations



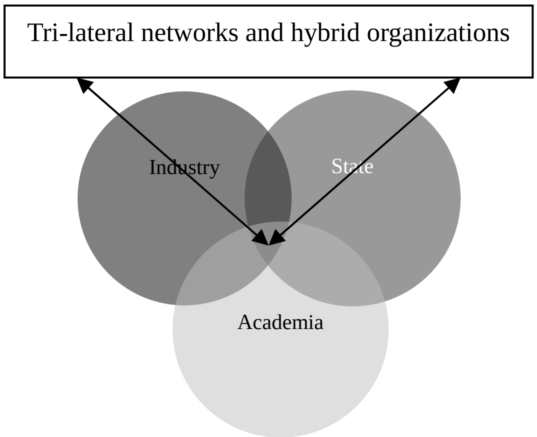
Source: Etzkowitz and Leydesdorff (2000).

Finally, there is the further developed "Triple Helix III" model that can be expected to generate a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations (such as university hi-tech spin-offs, or venture capital societies set up by universities) emerging at the interfaces.[21] This knowledge infrastructure of university-industry-government relations is not static. In fact, it works in terms of expectations whose mutual exchange in communications (institutionalized or not) can be considered as a distributed overlay on top of the different institutions. As this overlay partially integrates the underlying arrangements (e.g., national systems of innovation), but in a distributed network mode, taking interactive and recursive terms into account

[20] It is to underline here that it is right the question of "policy" models as they tend not only to describe the relation between different actors engaged in the process of knowledge production, but also or even primarily to propose a normative orientation and policy guidance.
[21] So when talking in future about the Triple Helix, it is normally referred to the Triple Helix III.

(characteristic for a non-linear model), the system remains incomplete (as always reconstructed) and consequently in flux (figure 1-3).

Figure 1-3 : Triple Helix model of university-industry-government relations



Source: Etzkowitz and Leydesdorff (2000).

The common objective of most countries who all try to attain more or less some form of the Triple Helix III model, is to create a system of innovation consisting of university spin-off firms, tri-lateral initiatives for knowledge-based economic development, and strategic alliances among SMEs, government laboratories, and academic research groups. These institutional arrangements are often encouraged, but not controlled, by government, whether through new “rules of the game”, direct or indirect financial assistance, or new actors like foundations to promote innovation.

According to Leydesdorff and Etzkowitz, the Triple Helix as an analytical model adds to the description of the variety of institutional arrangements and policy models an explanation of their dynamics. In their opinion, models like “national systems of innovation”, “research systems in transition” (Cozzens *et al.*, 1990; Ziman, 1994), “Mode 2” or “the post- modern research system” (Rip and Van der Meulen, 1996), describing S&T policies, indicate all a permanent change and reorganization in university-industry-government relations, and the enhanced role of knowledge in the economy and society. In fact, each theory might be able to appreciate a different subdynamic, that is, specific interactions inside the system (Leydesdorff, 1997). These subdynamics of innovation systems, interacting or not, are continuously and reflexively reconstructed, for example through discussions and negotiations among the different actors involved. For example, NSI can be more or less systemic[22] and their dynamic may consist of increasingly complex collaborations across national borders (between different “national” systems of innovation) and among researchers and users of research from various institutional spheres. The Triple Helix hypothesis is supposed to add to those systems of reference like the NSI, that these arrangements can be expected to remain in transition, offering thus the opportunity to adjust the actor’s expectations. Furthermore, enabling an analysis at the network level, the Triple Helix model makes it possible to compare among different configurations of institutional relations (for example, between industry and government).

[22] Leydesdorff and Etzkowitz admit that the degree of systemness remains an empirical question. For a test on “systemness”, see Leydesdorff and Oomes (1999).

It is interesting to note here that, referring to Leydesdorff and Etzkowitz, the so-called "Mode 2" is not new. In fact, the practical impetus to scientific discovery is certainly long-standing, and therefore Mode 2 ought to be considered as the original format of science before its academic institutionalisation in the nineteenth century. Thus, the question to be answered should be why Mode 1 has arisen after Mode 2, the original organisational and institutional basis of science. But questions about the origins of "science" and its exact definition certainly need to be answered before continuing to investigate in this way – but this is not a matter of this paper.

Finally, several implications of the Triple Helix model can be drawn. Following Leydesdorff and Etzkowitz, the Triple Helix indicates not only the relationship of university, industry and government, but also internal transformation within each of these spheres induced by these interactions. Its overlay provides a model at the level of social structure for the explanation of Mode 2 as a historically emerging structure for the production of scientific knowledge, but also its relation to Mode 1. First, arrangements between industry and government no longer need to be conceptualised as exclusively between national governments and specific industrial sectors. Strategic alliances go beyond traditional sector divides and governments act not only at national or regional level, but increasingly also at international levels (EU, NAFTA, etc.). Second, the driving force of the interactions can be specified as the expectation of profits while "profit" (in monetary terms or not) having different meanings to the various actors involved. For example, success in research might provide a university a certain reputation with consequences in the number of students. Third, the basis of the model in terms of expectations leaves room for uncertainties and chance processes as nothing is programmed in advance. The institutional carriers, that is, the interacting subsystems, are expected to be reproduced as far as they have been functional until now, but negotiations can be expected to lead to experiments, which may thereafter also be institutionalised. Fourth, the increase in the higher education and academic research sector (whether in the number of students, publications or institutes, where scientific research is carried out) has provided society with a realm in which different possible combinations of interaction between institutions or involved actors can be entertained and recombined in a more or less organized manner. Fifth, the Triple Helix model also tries to explain why the existing tensions of the system need not to be resolved.[23] In fact, it is argued that a resolution would hinder the dynamics of a system, which lives from the perturbations and interactions – one might think here about the Schumpeterian "creative destruction" – among its subsystems. And sixth, the important question of the exchange media – economic expectations (in terms of profit and growth), theoretical expectations, evaluations of what can be realized given institutional and geographic constraints – have to be related and converted into one another. As a consequence, the helices (university/industry/government) communicate recursively over time in terms of each one's own code (and aims). According to Leydesdorff and Etzkowitz, the new mode of knowledge production generates and "Endless Transition" of the system of innovation that continuously redefines the border of the "Endless Frontier" (Bush, 1980).

[23] To be precise, it is the neo-evolutionary model (in opposite to the neo-corporatist one) of the Triple Helix which is meant here. The evolutionary interpretation assumes that within specific local contexts universities, industry and government are learning to encourage economic growth through the development of loosely coupled reciprocal relations and joint undertakings that persist over time and induce changes in the way agents come to conceive their environment and how to act in it. For further details on these two different interpretations of the Triple Helix model, see Viale and Ghiglione (1998).

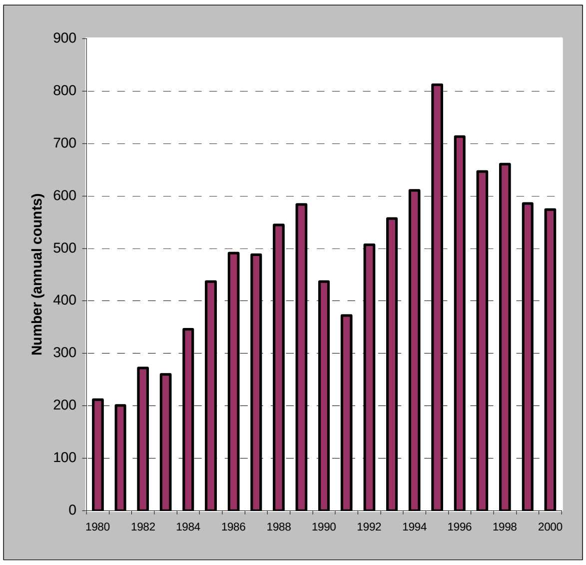
1.4 Conclusions

To conclude, we regard the Triple Helix model as an appropriate model to identify the existing relations and mechanisms in the process of knowledge production and innovation. We leave it to others to discuss the relative importance of the constituting institutions, i.e. universities, governments and industry, and we hardly agree with Etzkowitz/Leydesdorff on the desired importance of the model which is considered giving concrete indications about research policy or economic policy in general. It can positively contribute to the understanding of real facts, their causes and consequences, and its up to society as a whole to change in a certain direction, i.e. the way of producing knowledge – including the influence on this mechanism –, which might be in fact close to Mode 2. In our opinion, compared to the NSI approach, the model of the Triple Helix takes into consideration a more complex analysis of the knowledge production process. Furthermore, it avoids the “nation” circumscription, broadening thus the field of analysis, important under a globalized economy. We therefore consider the Triple Helix model as a further development of the NSI approach, adjusted to a globalized situation.

2 Strategic Alliances

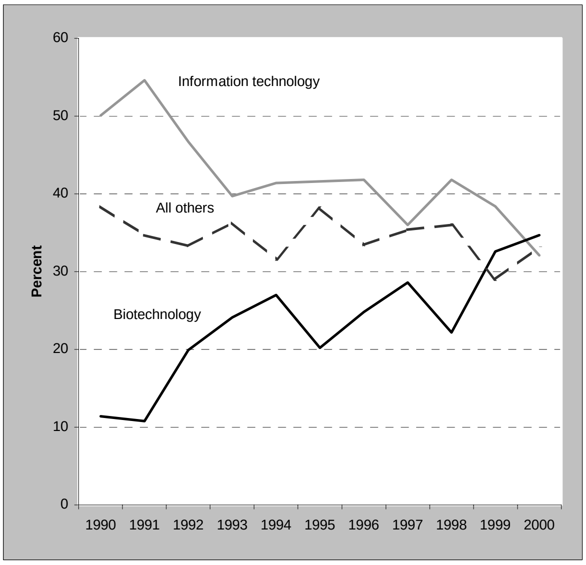
All major players involved in the creation, diffusion, and commercialization of R&D activities have experienced transformations in how innovation activities are financed, organized, and performed (Jankowski, 2001). General risks of conducting scientific research and commercializing its results have been compounded by the increased speed and multidisciplinary nature of technological developments. In such an environment, strategic alliances between firms have become an important tool for achieving sustainable competitive advantage allowing partners to share R&D costs, pool risks, and benefit from access to firm-specific know-how and commercialization resources (Hagedoorn *et al.*, 2000; Vonortas, 1997). Furthermore, changes in policy and market trends in all advanced economies, contributing to a national and global economy increasingly dependent on knowledge-based competition and networking, have fostered a new setting for collaborative research since the early 1980s. Indeed, the past two decades have shown an extraordinary increase in alliances. In 2000 alone, 574 new technology or research alliances were formed in six major sectors: information technology (IT), biotechnology, advanced materials, aerospace and defense, automotive, and (non-biotech) chemicals, according to the data available from MERIT-CATI[24] (Hagedoorn, 2001). (See figures 2-1 and 2-2.)

Figure 2-1: International strategic alliances from 1980 to 2000



Source: National Science Board (2002).

Figure 2-2: International strategic technology alliances, by technology shares



Source: National Science Board (2002).

One can see that while the number of new international strategic alliances has somewhat leveled off since the mid-1990s, the share of those in the biotechnology sector has been increasing steadily.

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[24] The CATI (Cooperative Agreements and Technology Indicators) database is compiled by the Maastricht Economic Research Institute on Innovation and Technology (MERIT) in the Netherlands. The data consist of interfirm cooperative arrangements, where the counts are restricted to strategic technology alliances, such as joint ventures for which R&D or technology sharing is a major objective, and other research corporations. To note that CATI is a literature-based database with newspapers, journal articles and books as its key sources.

2.1 Definition and theory

What is meant exactly when speaking about "strategic alliances"? Gulati (1998) defines them as:

"…voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services. They can occur as a result of a wide range of motives and goals, take a variety of firms, and occur across vertical and horizontal boundaries." (Gulati, 1998, p. 293)

Moreover, following Singh (2002), there are two general types of alliances, that is equity-based and non-equity-based. Equity-based alliances include minority stock investments, joint ventures and at the extreme end, majority investments. Non-equity-based alliances tend to be governed mainly by a contractual arrangement that specifies the responsibilities of each party, the mode of operation of the alliance, and considerations involved in expansion or termination.

Organizational scholars have studied the basis for hierarchical controls within organizations and have considered them as a mechanism to manage uncertainty (Gulati and Singh, 1998, p. 781 ff). Earlier research on contract choices in alliances and the degree of hierarchical controls they embody has been influenced principally by transaction cost economists, who have focused on the appropriation concerns in alliances, which originate from pervasive behavioural uncertainty and contracting problems (for example, Pisano, Russo, and Teece, 1988; Pisano, 1989; Balakrishnan and Koza, 1993).[25] In this perspective, researchers have proposed that hierarchical controls are an effective response to such concerns at the time an alliance is formed. As a result, the greater the appropriation concerns, the more hierarchical the governance structures are to be expected for organizing the alliance (Gulati and Singh, 1998, p. 782).

While appropriation concerns originating from contracting obstacles constitute an important concern, once firms decide to enter an alliance, there is another set of concerns that arises from anticipated coordination costs (Gulati and Singh, 1998, p. 782). These costs refer to the anticipated organizational complexity of decomposing tasks among partners along with ongoing coordination of activities to be completed jointly or individually across organizational boundaries and the associated necessary extent of communication and decisions.[26]

One important question – if not the most important question when conducting research on alliances – is *why* firms enter strategic alliances? Considering all the costs of establishing an alliance, together with a high degree of failure of alliances as shown by many empirical studies (*infra*), there must be however enough reasons in favor of entering some new form of collaboration. From an extensive review of the alliance literature, Gulati and Singh (1998)

[25] The transaction cost approach to the theory of the firm was initiated by Ronald Coase (1937, 1960). It refers to the cost of providing for some good or service through the market rather than having it provided from within the firm. To summarize, transaction costs are costs of search and information, bargaining and decision, and policing and enforcement.
[26] Note that this concept is different from transaction cost economists' coordination costs, which refer to the agency costs caused by the growth of organizations and which provide "decreasing returns to the entrepreneur function" (Coase, 1937, p. 340).

were able to identify eight rationales of all the value creation logics of the partners engaging in an alliance (Contractor and Lorange, 1988; Hagedoorn, 1993), i.e.:

1) sharing costs (and risks);
2) access to financial resources;
3) sharing complementary technology;
4) reducing the time span of innovation;
5) joint development of new technology;
6) access to new markets;
7) access to new products, and
8) sharing production facilities.

Hamdouch (2002) proposes a formalization of the coalitions' building processes among firms, illustrated through two industry cases (airlines and biopharmaceuticals). Accordingly, given the scarcity of strategic partners within and across interrelated industries, the attraction of the partners presenting the most "strategic bilateral or multilateral value" follows a "pre-emptive process" which responds to the logic of the "first-mover's advantage" (Hamdouch, 2002, p. 2). This partners' pre-emption then relies on the phenomenon of "Increasing Returns to Coalition" (IRC) superposing on the other sources of increasing returns.

2.2 Critiques of prior research on alliances[27]

Three related themes run across prior efforts analyzing the behavior of firms in alliances and the performance consequences from such collaborations. First, the unit of analysis usually adopted is the firm or the alliance, that means researchers have tried to identify the attributes of firms that influence their tendency to enter alliances or to identify the characteristics of these alliances.

Second, researchers have been examining the formation and performance of alliances in an "asocial context" (Gulati, 1998, p. 294). The criticism here expressed by Gulati is that the external environment is normally summarized within measures of competitiveness in product or supplier markets. From a transaction costs point of view (*supra*), this means that the lower the competition, the more likely that a firm will be exposed to 'small numbers bargaining' and other forms of opportunistic behavior (Williamson, 1985).

Finally, previous research on alliances has focused mainly on firm- and industry-level factors that drive firms to enter alliances. Scholars have particularly focused on the existing competence (or lack thereof) that may push firms to enter into new collaborations, but it seems that they have paid less attention to factors that may lead to the availability of and access to alliance opportunities.

Furthermore, the focus on the firm or alliance as the unit of analysis and the description of external context in competitive terms does not take into account the actions of other firms or the relationships in which they themselves are already embedded. It also ignores the interactive elements of the market, whereby actors discover market information through their interactions in the market (Hayek, 1949; White, 1981). In fact, as demonstrated by sociologists, the distinct social structural patterns in exchange relations within markets shape the flow of information which in turn presents both opportunities and constraints for firms

[27] This part draws on Gulati (1998, pp. 294-295).

(White, 1981; Burt, 1982; Baker, 1984). Hence, much of the research on strategic alliances is characterized by an “undersocialized account of firm behavior” (Gulati, 1998, p. 295) as it neglects the influence of the social context in which firms are “embedded” on their behavior and performance. This social context includes a whole range of elements that can then be classified as structural, cognitive, institutional, and cultural (Zukin and DiMaggio, 1990).[28]

2.3 Research partnerships

It is possible to classify and analyze collaborations according to different criteria. By type of members, one can find a range of business, university, and government combinations. Concerning the activities, business alliances can concentrate on manufacturing, services, marketing, or technology-based objectives. This technology-based collaboration consists of joint research activities, technology co-development, contract research, and technology exchange, e.g. licensing and cross-licensing (National Science Board, 2002, p. 4-33). A subset of these wide interactions are strategic research partnerships (SRPs). They focus on joint R&D activities in contrast to contract research or other exclusively financing or exchange transactions. To mention that SRPs can take the form of formal joint ventures or more informal agreements.

While in the early 1970s the majority of research partnerships were equity-based research corporations, more than 85 percent of research partnerships did not involve equity investments by the mid-1990s (Hagedoorn *et al.*, 2000). In fact, this is attributed mainly to a higher degree of organizational flexibility of non-equity agreements. Nevertheless, it seems that SRPs of any type represent a flexible tool for pursuing upcoming technologies. Moreover, these partnerships can evolve into other types of agreements or acquisitions, or they might serve as an entry into new geographic markets over time.

Gulati and Singh (1998, pp. 792-793) present a typology of alliance structure that defines three distinct types of alliance governance structures, i.e. joint ventures, minority investment, and contractual alliances, including their specific levels and forms of hierarchical controls. This typology shall then allow to understand the choice among alternative governance structures.

Joint ventures occur when partners create a separate entity in which each owns a portion of the equity. In such alliances, a separate administrative hierarchy of managers provides an independent command structure and authority system with well-defined rules and responsibilities for each partner. Hence, such an autonomous unit might enable the creation of an incentive system, because each partner is concerned about the value of its equity in the joint venture.

In the case of minority alliances, firms work together without creating a new entity. One partner or a set of partners takes a minority equity position in the other (or others). The form of control appears to be weaker, with a degree of hierarchical control to be situated between that in joint ventures and that in contractual alliances (Herriott, 1996). In general, hierarchical supervision is created by the investing partner joining the board of directors of the partner that received the investment. In this type of alliance, a concern for the value of its equity should provide appropriate incentives for an investor.

[28] For a further discussion on the social context and the implications of social embeddedness on firm behavior and performance, see Gulati (1998, pp. 295 ff).

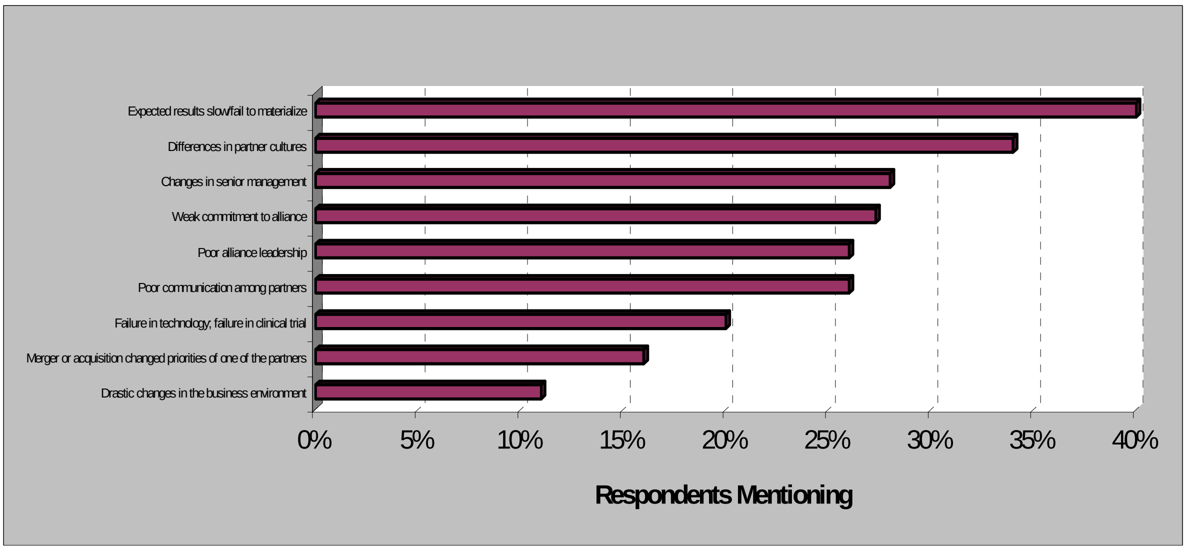
Contractual alliances do not involve the sharing or exchange of equity, and they do not lead to the creation of new organizational entities. They include unidirectional agreements such as licensing, second-sourcing, and distribution agreements and bi-directional agreements such as joint contracts and technology exchange agreements. While elements of hierarchical control can arise in some contractual alliances, they do not seem to be common and do not occur on a systematic basis.

2.4 Alliance failures

While the rate of alliance formation continues to be high, studies have indicated that over 50% of alliances and partnering agreements in biotechnology and life sciences are not considered to be successful (PricewaterhouseCoopers, 2002). Respondents in a survey organized by PricewaterhouseCoopers (2000) were asked to identify the reasons contributing to past failures of alliances. Referring to the summary of this study, 40% of respondents cited the failure or slow speed at which results materialized from the alliance as a main reason for the demise of the alliance. This reason was followed by differences in partner cultures, cited by 34% of all respondents, before changes in senior management, cited by 28% as a reason for failure. (See figure 2-3.) Note that the size of a company can influence the frequency at which a factor is cited. Accordingly, poor communication among partners was cited by 36% respondents from large companies (more than 300 employees) in contrast to 24% of respondents from smaller companies (less than 300 companies).

According to PricewaterhouseCoopers (2000), failing to achieve expected results, while the most commonly cited reason for failure, merely represents an outcome of other underlying drivers of failure. Moreover, it seems that some of these drivers, e.g. failure in technology, merger or acquisition changed priorities, and drastic changes in the business environment, have to be considered as being outside the control of management in charge of establishing and executing the alliance and therefore being uncontrollable. However, most of the drivers are supposed to be within management's control, leaving significant potential to reduce failure rates of alliances.

Figure 2-3: Alliance failures



Source: PricewaterhouseCoopers (2000).

3 Innovative Clusters

Innovation through the creation, diffusion and use of knowledge presents a key driver of economic growth. At the same time, the increasingly complex interactions of our globalized knowledge-based economy at the local, national and world levels among individuals, firms and other knowledge institutions influence in a more and more significant way the innovation performance. Thus, there is significant body of evidence, economic analysis and previous studies which demonstrates the importance of "clusters" to economic growth.[29]

3.1 Definition and concept

Following Porter (1990), clusters are defined as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also co-operate". Silicon Valley in the United States is probably the best known example of a cluster, but many other examples in different regions around the world and various sectors exist (Cooke and Morgan, 1998).

Why do companies and other actors involved in the process of innovation, despite the trend towards globalization, prefer to "cluster"? Referring to the results of previous studies (*supra*), summarized to some extent in a report on biotechnology clusters published by the British Department of Trade and Industry (DTI, 1999, pp. 9-11), companies benefit from sharing knowledge and reduce costs by jointly sourcing services and suppliers. Frequent interactions facilitate formal and informal knowledge transfer and encourage collaboration between complementary institutions. Local training institutions and a sound infrastructure can provide further benefits for companies. Moreover, rivalry between firms can stimulate competitiveness. To note also that life quality and other non economic factors can be just as important in determining growth. Finally, a critical mass effect will normally attract further companies, investors, services, and suppliers into the cluster, as well as creating a pool of skilled labor.[30]

On the other hand, the role of governments in the creation of clusters appears to be less clear and easy to define. In fact, there seems to be a general understanding (e.g., DTI, 1999, p. 10; Cooke and Morgan, 1998, p. 189) that clusters are business driven and that they form due to a variety of reasons, like the prior existence of related industries or institutions. Hence, "clusters often emerge and begin to grow naturally" (Porter, 1990, p. 655). Nevertheless, governments are able to create the necessary conditions which encourage the formation and growth of clusters. Following the view expressed by the British DTI (1999), government support for clusters cannot constitute a complete industrial policy, but should rather be part of a wider set of policies that include national and non-sectoral policies and programs that support innovation and competitiveness. Referring to Porter (1990), government at all levels can effectively play a role in reinforcing emerging clusters, i.e. through investments to create specialized factors, such as university technical institutes, training centers, data banks, and specialized infrastructure.

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[29] See in particular: Porter (1990); Krugman (1991); Cooke and Morgan (1998); Swan *et al.* (1998); Fujita, Krugman, and Venables (2001).

[30] In looking for reasons why firms locate in clusters, Prevezer (1997, p. 258-260) highlights benefits and costs of industrial clusters. Concerning benefits, one can distinguish between benefits on both the supply side, in making the supply of particular products easier, and on the demand side, through access to customer specification and to markets.

3.2 Theoretical approaches

The OECD has published two major contributions about innovative clusters, i.e. "Boosting Innovation: The Cluster Approach" (OECD, 1999) and "Innovative Clusters: Drivers of National Innovation Systems" (OECD, 2001a). While the former reported the available thinking in research and policy by a small number of analysts who wished to explore the topic in an internationally comparative context, the latter volume placed more emphasis on the innovation theme connected to the examination of clusters. As improvements in methods, conceptualizations and empirical analyses are part of this volume, the following synthesis of clusters will be mainly based on it.

Referring to the work of the OECD cluster focus group presented in OECD (2001a), the cluster approach can be seen as a part of the concepts of the national innovation system (NIS) approach (Freeman, 1987; Lundvall, 1988 and 1992; Nelson, 1993, and Edquist, 1997).[31] Moreover, the inherent logic that innovations could result directly from ongoing interactions among scientific, commercial, educational and public institutions – thus departing clearly from earlier linear concepts of innovation – was extended by offering a novel hypothesis that an industrial cluster could be thought of as a reduced-NIS (OECD, 2001a, p. 8). In fact, it is assumed that a national economy consists of several reduced-form innovation systems, represented by various distinct industrial clusters. It is to note that the final aim of this simplification is to allow a greater focus on the actions and policies that can stimulate processes of innovation.

Seen as a part of innovation systems approaches, clusters are supposed to reflect the systemic character of modern innovation and interactive innovation processes, with innovation increasingly depending on interactions among interdependent actors, e.g. firms and other types of organizations. These interactions "among actors in the value chain" (OECD, 1999, p. 13) are based on trade linkages, innovation linkages, knowledge flows or the sharing of a common knowledge base or factor conditions.[32] The concept advanced here is "value chain clusters" which are considered as key sources of innovation (OECD, 2001a, p. 8 ff), and used to define members of a cluster. Moreover, value chain methods shall contribute to clarify the understanding of which elements (institutions) of the chain are essential for the effective diffusion of technology.[33]

It is to note that questions about the relevance of value chain institutions will depend on the cluster under study. In fact, as each cluster has its specific value chain length and relative maturity, conclusions will differ. Short value chains, such as those in biotechnology, have less cumulative opportunities for the introduction of product or process innovations of the kind that occur along the lengthier value chains of intermediate suppliers as it is the case for the ICT cluster. The reason for this is that short value chains rely almost completely on

[31] For a short presentation of the concept of national innovation systems, see section 1.1.

[32] The activities performed in competing in a particular industry can be grouped into different categories that constitute, when taken together, the "value chain". These activities can be divided into those involved in the ongoing production, e.g. marketing, delivery, and servicing of the product (primary activities) and those providing purchased inputs, technology, human resources, or overall infrastructure functions to support the other activities (support activities). See Porter (1990, p. 40 ff).

[33] Referring to recent studies of innovation, firms that trade with each other along the value chain as suppliers or customers can be considered as the most significant elements of this chain responsible for innovation (Bergman and Feser, 2001; Cooke, Boekholt and Toedtling, 2000).

laboratory-based knowledge and innovations, therefore also influencing the kind of knowledge (implicit or explicit) which is produced (OECD, 2001a, p. 10).[34]

Further questions revealed by the OECD cluster focus group (2001a, p. 11) concern labor mobility, the firms' absorptive capacity of available innovations, and innovative networks. Indeed, related transfers of human capital and in particular implicit (tacit) knowledge might occur within the same industrial cluster, but can also be applied in many different sectors or clusters, hence "propagating innovations *across* clusters". Second, as clusters and alliances can be considered as a possible platform for developing competency mixes, the capacity of individual firms to absorb and embed new technologies becomes a key asset. Finally, as innovative networks (i.e. clusters that are not purely based on value chains) cut across different value chain clusters, they include sectors that share similar technologies but produce different goods and services in more than one value chain. Consequently, innovations created through networks are likely to accumulate in value chain clusters if one considers knowledge spillovers.

3.3 Lessons from innovative clusters

Besides being an analytical instrument, the cluster approach offers a framework for addressing or removing systemic imperfections in the functioning of an industrial cluster or reduced-NIS. In practice, the cluster approach can be a useful framework for developing and applying new forms of governance, not based on direct intervention but indirect inducement. Furthermore, the approach focuses upon assisting networks and creating the institutional setting that provides incentives for market-induced cluster formation but also for the revitalization of already existing clusters. Finally, it can also be seen as a tool for knowledge and innovation management in the case of policy makers. However, there is neither a standard cluster approach, nor a fixed policy recipe for implementing the cluster approach in practice (OECD, 2001a, p. 405 ff).

Cluster analyses reveal that every country or region has a unique selection of clusters and specializations with different characteristics and role in economy. History, the types of knowledge, the particular stage in the cluster's life cycle and networking practices are among those factors responsible for cluster specificity and for differences between clusters. The cluster approach allows a better understanding of the structure and specialization of individual economies, including the role that different clusters play in the wider economy. The examination of different clusters also reveals the heterogeneity of the economic activities, in terms of size, connectedness, R&D intensity, share of innovative products, etc. As individual clusters are likely to differ on many aspects, cluster specificity implies the need for customized sets of policies to promote innovation in clusters.

It has to be outlined that clusters of which all individual elements are to be found in a confined area are rather the exception. In fact, it might even be counterintuitive to expect "complete" clusters (OECD, 2001a, p. 408) at the regional or national level as the relevant knowledge base is extremely internationalized. Another important aspect here is the scale of individual countries. It seems that in relatively large economies like the United Kingdom (Charles and Benneworth, 2001), cluster-based innovation systems are likely to emerge at a regional scale. These regional innovation systems then contain a particular set of

[34] For a distinction between "implicit" and "explicit" knowledge, see Mack (2003).

characteristics that differentiate them from scaled-down national innovation systems. As they draw heavily on national inputs that may lie outside the region, such clusters cannot be restricted to a specific region, but are often trans-regional.[35]

Emerging technology-based clusters, such as in the ICT or biotechnology sector, seem to be international in character from the outset. Hence, these clusters can be described as mixed local and global phenomena, also called the "global-local paradox" by Larosse *et al.* (2001). In fact, most countries are not able to replicate complete value chains within their national borders, which is even more obvious for the smaller, open economies. The consequence of this is that these clusters normally specialize in certain segments. More mature clusters (e.g. agro-food, construction) on the other hand are expected to function mainly at a national or regional level. Nevertheless, this does not mean that all parts of the value chain have to be present at those levels. By the way, admitting that innovation in so-called low-tech clusters is knowledge-based as well, requires nonetheless an open mind towards the role that non-technological knowledge (e.g. organizational and market knowledge) but also cultural phenomena play in innovation. Therefore, just looking at R&D intensities is probably not enough when facilitating innovation.

Cluster innovation policies (OECD, 2001a, p. 411 ff) are about creating the necessary framework conditions for facilitating innovation. They should identify barriers to innovation and build relationships and networks, thus needing an appropriate mix of analysis and action. How this is realized will differ across clusters and countries, but important variables are the way in which dialogue among industry, research and governments is institutionalized, the size of the economy, the policy culture, the level of government intervention and the degree of industrial and technological specialization. The cluster approach not only provides an assistance in identifying networks and linkages between industries (Romanainen, 2001), but it also serves as a working tool for policy makers to create in advance platforms and programs for cross-disciplinary and/or cross-industry interaction.

As shown by the different case studies presented in OECD (2001a), policies influence the way clusters emerge and the way their innovative capacities develop over time. Nevertheless, not all policy initiatives and regulations affecting innovation in clusters were originally initiated to support innovation. In fact, clusters and innovation in clusters can be equally influenced by other types of policy making as by explicit cluster policies. On the other hand, this also implies that some policies might have a negative effect on the emergence or further development of clusters.[36] For example, as cluster innovation policies generally start from analyzing the systemic imperfections in clusters, it might well be the case that some forms of policy making are counterproductive from an innovation point of view. In conclusion, it is important to look at a wider array of policies and their interactions in policy systems. Cluster policies are not a separate type of policy but also include other policy fields and therefore call for interdepartmental co-ordination.

However, the cluster approach does not offer standard policy recipes to increase the innovativeness of a particular cluster. Its translation into practical policy tools is extremely

[35] Indeed, regional or national economies cannot be automatically defined as regional or national innovation systems if the only qualifying criteria is a geographical boundary. Some regions might have attributes which foster the development of clusters but not every region functions automatically as an innovation system.

[36] One example is the biotechnology sector. Regulatory restriction on new applications of genetic technologies, due for example to societal disagreement and a fear of the unintended consequences of innovation, can have negative effects on the cluster emergence or development.

cluster-specific as different innovation dynamics require different actions. The principal task of policy makers promoting innovation in clusters is to facilitate the networking process and create an institutional setting which provides incentives for market-induced cluster formation and forms of co-operation.[37] Examples of innovation policy measures include: raising awareness of the benefits of knowledge exchange and networking; initiating network brokers and intermediaries to bring actors together; facilitating the informal and formal exchange of knowledge; setting up programs and projects for collaborative R&D; and ensuring links between universities and industry. At the same time, non-innovation policies might also be used to stimulate innovation, such as competition policies, education policies, fiscal policies, environmental policies, and regional policies.

The choice which instrument and analytical tool to use, and when, depends not only on the particularities of a certain cluster, but also on the stage in the cluster's life cycle. Moreover, there might be a danger of favoring already existing clusters, and to give less attention to the identification and facilitation of emerging innovative clusters. Another risk in cluster analyses and cluster policies lies in the risk of focusing only on high-tech or vanguard clusters (e.g. ICT or biotechnology), thus neglecting low- or medium-tech clusters. However, these clusters might be a combination of a unique mix of strongly localized factor conditions and development trajectories built up over a long time.[38] But this means also that the creation of a knowledge-based economy should not be equated with an exclusive focus on high technology, but rather building on existing strengths. As a consequence, working with standard policy models and using a "one-size-suits-all" approach (OECD, 2001a, p. 415) can be counterproductive.

To conclude, one can say that using and making operational the cluster approach is a process of experimentation, variation, customization and codification (OECD, 2001a, p. 416). Furthermore, cluster-based policy making shows up to be a multidimensional issue combining theory and practice. It is a balancing act between bottom-up and top-down initiatives; between supporting established mature clusters and newly emerging clusters; and between international, national and regional levels of policy making, thus considering, if necessary, cross-border co-operation for cross-border clusters. Finally, the general need to increase accountability of cluster-based policies should also be taken into account.

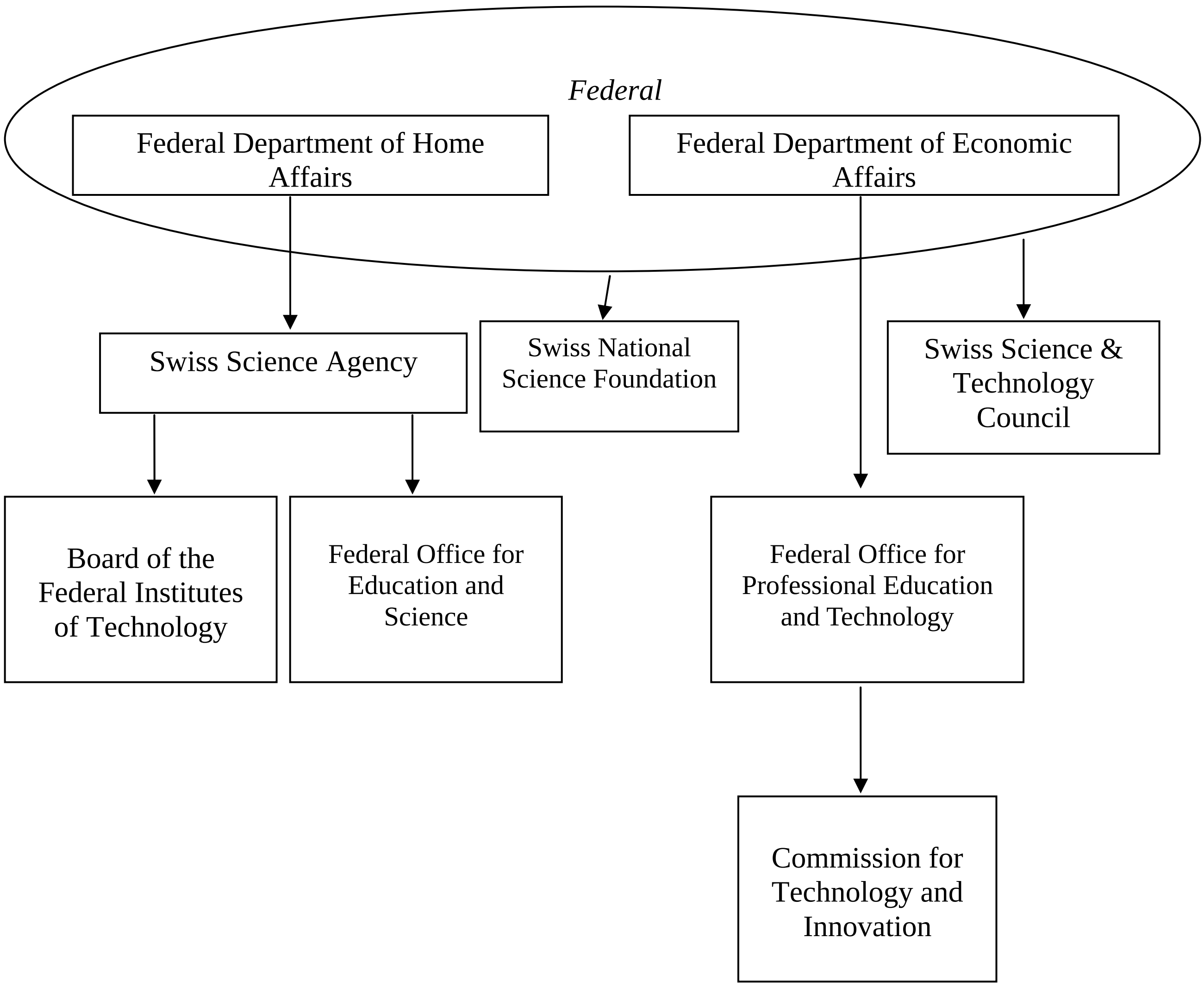
[37] Balancing competition and supporting co-operation is probably one of the major difficulties while facilitating innovation in clusters.
[38] Krugman (1991) underlines that whereas much attention has been focused recently on high technology clusters, concentration and localization of industries has been typical of many not particular highly technological industries.

4 Science & Technology policy in Switzerland[39]

4.1 Introduction

The Confederation's responsibilities in the field of S&T are exercised through two federal ministries: the **Federal Department of Home Affairs** and the **Federal Department of Economic Affairs**, governmental entities that are part of the Federal Council. (See figure 4-1.) This dual authority indicates the extent to which the two federal departments share a common interest in active involvement in S&T policy. On the one hand, the Federal Department of Home Affairs safeguards national interests pertaining to the development of the science and technology base, and on the other hand, the Federal Department of Economic Affairs promotes the economic aspects and interests of vocational education and the promotion of economic activity in the S&T sector. The competences of the two offices differ but their respective missions complement each other and converge in the pursuit of a coherent and effective national S&T policy.

Figure 4-1: Structure of S&T policy



[39] This chapter was mainly conceived by J. Bart Carrin.

The **Swiss Science and Technology Council** (SSTC) is the advisory body of the Federal Council for all matters relating to science, training, research and technology policy. Formerly known as the Swiss Science Council, the agency underwent restructuring in 1999[40], as part of a package of reforms aimed at streamlining governmental institutions active in research and S&T in view of a more efficient, simplified and transparent operation of the relevant authorities. The SSTC undertakes technology assessments and identifies the information required for policy-making to the attention of the Federal Council, and suggests measures for their implementation. It is an independent panel that is now exclusively composed of scientists.

The SSTC recently submitted a nine-point program to the Federal Council, the government's executive branch, outlining its vision of a productive science and technology policy, and proposing solutions to the problems that presently keep Swiss innovation and research trapped in a state of mediocrity. The recommendations include unifying Switzerland's fragmented higher education system, installing a modern tenure-track system, shoring up support for long-term basic research, and increasing the science and technology budget by 10% a year from 2004 to 2007[41].

Also mandated by the Federal Government, the **Swiss National Science Foundation** (SNSF), mostly financed by the Confederation, supports research undertaken inside and outside universities, and promotes young scientific talent through the awarding of research grants and fellowships.

The **Swiss Science Agency** (SSA) was created in 1990 with the purpose of improving the coordination and coherence of policy in the fields of science, research, and higher education, and helping intensify contacts between universities and industry, both on the national and international levels. It is headed by the State Secretary of Science and has the task of implementing the strategies developed by the Federal Department of Home Affairs for higher education and S&T, and it coordinates these strategies with the other federal offices, the cantons and private industry. Subjugated to the SSA, are the **Federal Office for Education and Science** (FOES) and the **Board of the Swiss Federal Institutes of Technology** (BFIT). The FOES is responsible for preparing and implementing laws on education, science and research. Also, in the field of higher education, it subsidizes the cantonal universities. The BFIT is the highest authority for the two Federal Institutes of Technology (ETH Zurich and EPF Lausanne) and the four federal affiliated research institutes[42]. It defines the basic objectives of these institutes and allocates resources accordingly. Operational management is delegated to the institutions.

The **Federal Office for Professional Education and Technology**[43] (FOPET) was established in 1998 following a new mandate by the Federal Department of Home Affairs in the framework of the restructuring process. The FOPET is responsible for training policy at the Universities of Applied Sciences (HES)[44] and the integration of the HES into a "Swiss higher education system". The FOPET is also in charge of creating direct links between applied

[40] Following the November 15, 1998 message from the Federal Council to Parliament on education, research and development.
[41] For full report, see http://www.swtr.ch/swtr_en/pdf/Neunpunkte/9PointProgr_eng.pdf.
[42] Paul Scherrer Institute; Federal Institute for Forest, Snow and Landscape Research; Federal Laboratory for Materials Testing and Research; Federal Institute for Environmental Science and Technology.
[43] Preceded by the Federal Institute of Industry, Arts&Crafts, and Labor.
[44] *Hautes Écoles Spécialisées* in French, or *Fachhochschulen* in German.

research and its industrial exploitation, a task it exercises through an attached office, the **Commission for Technology and Innovation**[45] (CTI).

In 1992, the SNSF launched a new research policy instrument named **Swiss Priority Programs** (SPP). The objective of the SPP was to concentrate national research capacities in areas of strategic importance in order to promote inter-institutional research and closer cooperation between academia and industry. The programs lasted for 8 to 10 years and were given funds between CHF 60 and 110 million. Since 1992, eight *priority programs* were launched. The programs "Environment", "Biotechnology"[46], "Information and Communication Structures", and "Switzerland: Towards the Future" were managed by the SNSF. The BFIT assumed responsibility for the programs "Optics", "Materials", and "Microsystems and Nanosystems", all of which terminated in 1999, as scheduled. In a report entitled "The Future of Priority Programs of the Confederation after 1999" published in 1998, the SNSF concludes that "the *highlights* and *accomplishments* of the SPP show that this instrument of encouragement has, in general, lived up to the expectations expressed at the time of its introduction in 1992." However, though the SPP have contributed to the creation of ties between industry and academia and interdisciplinary research, the long-term sustainability of a coordinated network of centres of competence in the university and research domains has proven to be improbable. It is for this reason that, at the recommendation of the SNSF, the SSP were gradually phased out, and evolved towards a new concept, the **National Centres of Competence in Research** (NCCR).

The SNSF took the initiative of introducing the NCCR in November 1998. The primary goal was to create a new instrument of research promotion in order to strengthen interdisciplinary research and the application of research results to strategically important fields of research. The ambitious program, which is coordinated by the SNSF, saw the creation in the year 2001 of 14 NCCR, in 8 pilot institutions around the country, and is expected to run over a period of 8 to maximum 12 years, with refinancing planned after four and eight years. In its final stage the program could include up to 25 NCCR.

Federal funding for the NCCR is voted by Parliament, and completed by funding from the institutions themselves, and from third parties. (See table 4-1.) As a rule of thumb, it appears that the SNSF contributes about half of the resources.

Table 4-1: NCCR financing (first four years)

(in million CHF)

Overall resources for the 14 NCCR	**529**
SNSF funding (federal funds)	224.8
Self-funding by home institutions	84.69
Self-funding by project participants	174.69
Third-party funding	44.82

Source: SNSF (2001).

Significant resources were allocated to life sciences (see table 4-2 for the four NCCR active in life sciences research). The already well-established tradition and infrastructure of life-

[45] See section 3.3 for details.
[46] For an in-depth look at the SPP Biotechnology, see section 3.4.

sciences research in the country, as well as its tremendous potential contribute to the generous funding attributed to its further development. Other areas of focus are telecommunications, micro- and nanotechnologies, material and environmental sciences. The aspiration of the SNSF to rejuvenate Switzerland's technology portfolio with the foundation of 14 new research centers is hoped to accelerate the anticipated reversal of the "brain drain" into a much-needed "brain gain", and to consequently fortify the country's position as a world leader in R&D.

Table 4-2: Life sciences NCCR at a glance

NCCR[47]	"Molecular Oncology"[48]	"Genetics"[49]	"Structural Biology"[50]	"Neuro"[51]
Start	May 2001	July 2001	May 2001	June 2001
Staff (full-time equivalent)	47	60-70	90-100	120
SNSF funding	20.2 million	18.5 million	14.4 million	16.4 million
Self-funding by home institution	8.6 million (ISREC)	2.4 million (Uni Geneva)	6 million (Uni Zurich)	6 million (Uni Zurich)
Self-funding by project participants	2.3 million	25.9 million	9.5 million	45.5 million
Third-party funding	5.5 million	-	-	4 million (Serono SA)

ISREC: Swiss Institute for Experimental Cancer Research, Lausanne.
Where applicable, figures are expressed in CHF.

Source: SNSF (2001).

4.1.1 Public support of R&D

The acceleration of technological innovation makes R&D a key factor of economic competition. Traditionally, Switzerland is one of the leading industrialized countries concerning innovation (measured by the number of patents) and private R&D expenditures. In fact, when comparing Swiss R&D expenditures with other OECD countries, Switzerland figures among the top if calculated as a percentage of GDP or per capita. In 2000, the gross domestic R&D expenditures of Switzerland as a percentage of GDP amounted for 2.64%, ranking the country on the 5th position among OCDE countries just behind Sweden, Finland, Japan and the US. In comparison, R&D expenditures represent 2.21% of the GDP for all OECD countries and 1.86% for the EU (OECD, 2001b).[52]

Nevertheless, public intra-muros R&D expenditures (Confederation and cantons), in an international comparison, are rather weak, which can be explained to some degree by the moderate level of military research in Switzerland (Schönenberger and Zarin-Nejadan, 2001). Indeed, nearly three quarters of the overall R&D expenditures are carried out by the private

[47] For complete list of all 14 NCCR and further details: www.snf.ch.
[48] For further details: www.nccr-oncology.ch.
[49] For further details: www.unige.ch/frontiers-in-genetics.
[50] For further details: www.structuralbiology.unizh.ch.
[51] For further details: www.nccr-neuro.unizh.ch.
[52] See appendix 3.

sector and almost one quarter by academia.[53] The latter represents the place where public research is carried out: it's composed by the ten cantonal universities, the two Federal Institutes of Technology with its independent research institutions, and the seven Universities of Applied Sciences (HES). To those, one has to add some extra-academic research institutes which also carry out public research. However, it's worth to note that the Confederation supports financially the cantonal universities and also the extra-academic research institutes. Moreover, as already mentioned, it also finances the SNSF and the CTI.

Concerning public support of private R&D, the country's position is not very shining (Schönenberger and Zarin-Nejadan, 2001). Actually, for tax incentives, Switzerland is ranked 14th among 23 countries; regarding public R&D subsidies on private R&D spending, the country is placed 17th among 27 countries. Like in most OECD countries, current private R&D expenditures are fully deductible from taxable benefits (Zarin-Nejadan, 2004). Nevertheless, several instruments encouraging this type of investments, and which exist in all other industrialized countries, are not existent in Switzerland. For example, Australia allows a deduction of 150% of all R&D expenditures. Ten OECD countries allow tax credits, which means that R&D expenditures are deductible from taxes on companies' benefits. Other countries offer special tax credits for SMEs. Finally, some countries allow a 100% amortization of equipment goods and constructions attributable to R&D during the year of acquisition (Canada, Denmark, Spain, Ireland and UK).

4.1.2 Message 2004-2007

The recently published White Paper (Federal Council, 2002) on education, research and technology for the period from 2004 to 2007 (Education, Research and Technology Message) contains the Swiss Government's proposals to Parliament for the current four-year financial period. The government proposed a 6% spending increase during this period, but retained the option of reducing this rate as a contribution to stabilization of the national budget. The best-case scenario has foreseen total investments in education, research and technology amounting to CHF 17.3 billion. Finally, in December 2003, the Swiss Parliament approved credits amounting for CHF 16.6 billion for the 2004 to 2007 period, hence staying even under the worst-case estimation of the government. (See table 3-3.)

The White Paper's proposals focus principally on financial issues. However, the government renews its call for all concerned parties to intensify the reform process begun in the 2000 to 2003 quadrennial, in the current four-year period. The main thrust of the Paper essentially does not differ significantly from the previous "Message":

Firstly, the higher institutes of education are to collaborate between one another more closely than before. The goal remains to create and consolidate *networks* of tertiary education[54], in an effort to better exploit the existing potential that lies within, and to harmonize study courses in line with the principles laid out in the Bologna Declaration. The ultimate vision of the government is increased modularisation of education and the removal of incompatibilities between institutions and the use of new teaching techniques. This revision lies mainly in the hands of the Swiss University Conference and must be attained through its own innovation and cooperation projects.

[53] See appendix 4 and 5.
[54] Cantonal universities, Universities of Applied Sciences, Federal Institutes of Technology.

Secondly, the substantial increase in allocated funds (credit commitments) to the SNSF (the country's prime instrument for the promotion of research) will be used to benefit independent basic research. The government has laid out a plan outlining an action program on four levels. Finally, the CTI sees a 45% increase in its budget. The extra funds are to strengthen the CTI's authority in evaluating innovative products and technologies. (See table 4-6, section 4.3.) The government made additional proposals for bolstering innovation and technology transfer through intensified support for new enterprises in the start-up phase. The "CTI Start-up" program is to be continued, and priority will be given to the promising future technologies (life sciences, nanotechnology, IT etc.). Furthermore, external communications will need to be drastically improved, as there is a need to heighten the awareness of science and technology among Swiss youth. Finally, "Discovery Projects" are to be promoted. These are projects with great market potential which carry high financial risks. The government also wishes to see a closer collaboration between the SNSF and the CTI (Vision, 2003).

Table 4-3: Credit commitments in the period 2004-2007

(in billion CHF)

	Planning period 2000 to 2003	Planning period 2004 to 2007	Increase
ETH Domain (ETHZ, EPFL and 4 research institutions)	6.9	**7.8**	0.865 (12%)
Swiss National Science Foundation (SNSF)	1.4	**1.9**	0.495 (34%)
Commission for Technology and Innovation (CTI)	0.308	**0.447**	0.139 (45%)
Universities of Applied Sciences (HES)	0.854	**1.1**	0.245 (29%)
Professional Training	1.7	**1.7**	0.052 (3%)
Cantonal universities	2.1	**2.3**	0.201 (10%)

Source: Federal Council (2002), and related AF; SSA (2004).

4.2 Higher education system in Switzerland

4.2.1 Federal government versus Cantonal government

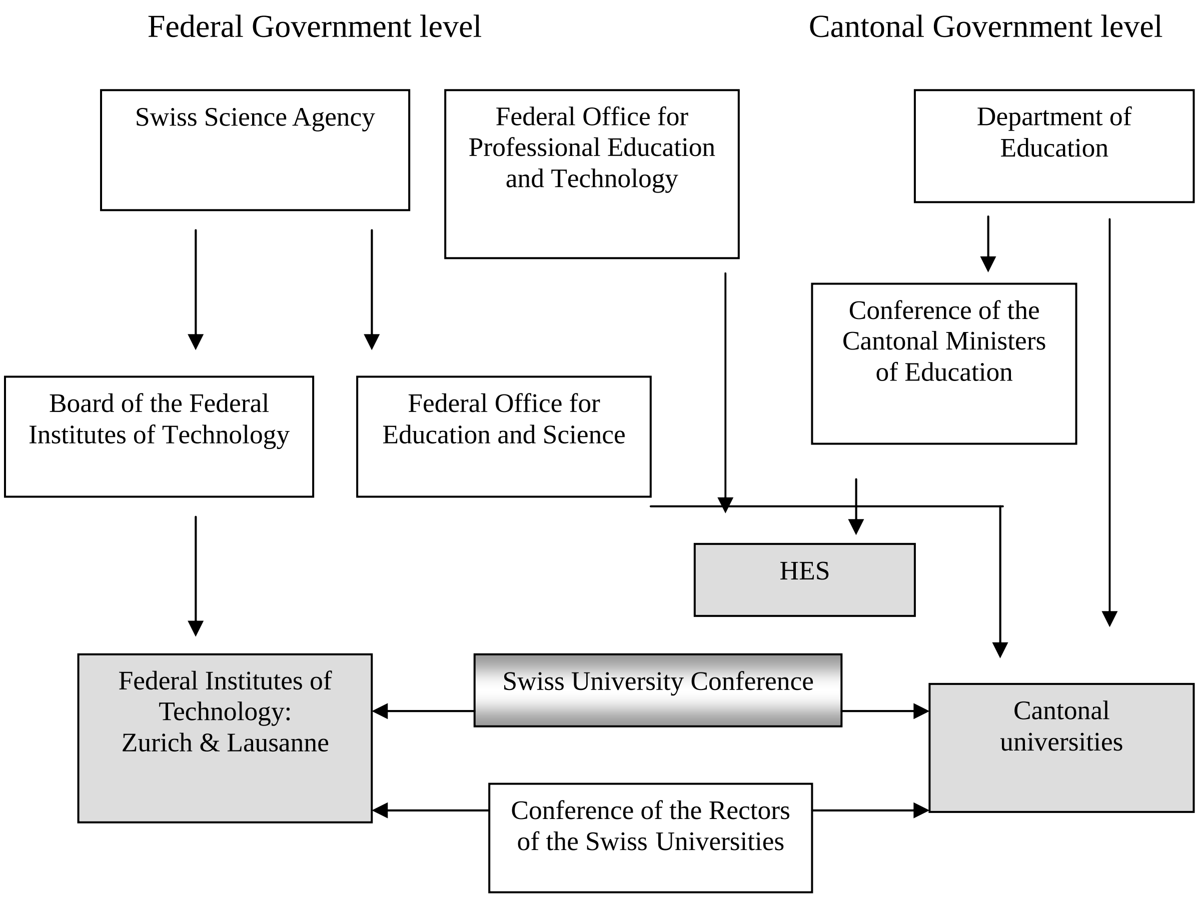
Switzerland's education system is amongst the most decentralized in the world. This is due not only to the well-known cultural and linguistic diversity of Switzerland but, equally important, results from the fact that policy-making in modern Switzerland is based on three fundamental principles: direct democracy, federalism, and *subsidiarity*. Subsidiarity in a compound political system with several levels of decision-making means that policies are always made at the lowest possible level, and that the higher level should only legislate when there is agreement that overall regulation is necessary. These three complementary political concepts, as practiced by the Swiss, are regarded as key factors to the country's democracy, stability and prosperity. The occasionally conflicting interpretation and application of subsidiarity in Swiss educational policy has led to extensive diversity in educational structures. Therefore, one cannot really talk of a *single* Swiss educational system, but rather of a compound structure of cantonal, federal, and mixed bodies responsible for its coordination and management. (See figure 4-2.)

Today, there are twelve "traditional" universities, plus seven regional Universities of Applied Sciences (HES or Fachhochschulen). In addition, there exists a large number of Advanced Vocational Colleges, offering a professional rather than an academic education in a wide range of subjects. In comparison with other OECD countries, Switzerland thus distinguishes itself with a very high density of institutes of higher education[55].

The Federal Government plays a dual role in the administration of education: Switzerland's federal constitution authorizes the Confederation on the one hand to subsidize the cantonal universities, and on the other to set up its very own institutions of higher education, in particular the two Federal Institutes of Technology. The Confederation, by virtue of being the sole representative of *all* cantons, also safeguards higher education on a national scale by promoting increased coordination among universities and the harmonization of programs. The relevant advisory and coordinating bodies at national and cantonal level will be discussed in the following section.

4.2.2 Higher education structure in Switzerland

Figure 4-2: Structure of higher education



[55] www.swiss-science.org, 2000.

Cantonal Universities

Switzerland can claim over 500 years of academic continuity: the first Swiss university was founded in Basle in 1460. Over the centuries to follow, nine other universities were founded across Swiss territory. Of these "traditional" universities, there are 7 fully-fledged Cantonal universities[56], 2 small cantonal university-level institutions[57] and one university specializing in business management, public administration and law[58].

The **Swiss University Conference** (SUC) is an organization whose tasks are shared by the Confederation and the cantons, and which brings together two representatives of the Confederation, two representatives of each canton hosting a university, and two representatives from the non-university cantons. The SUC underwent a face-lift recently, when, in view of the broad reforms in education-, research- and technology-policy[59] in 1998, it was given decision-making powers that would allow it to play a much more active role than before. In effect, the SUC changed from being a mere *coordinating* agency to a *governing* body allowed to apply and enforce the policies defined in common by the Confederation and the cantons. The reforms came into force at the start of the 2000-2003 quadrennial. The SUC is subject to the Federal Act of Financial Assistance to Universities[60], which gives it a wide range of competences that strive at coordinating and harmonizing national and cantonal interests in the domain of higher education, and empower the SUC to define and carry out Swiss university policy, encourage the development of institutions of higher education, and formulate recommendations and directives to the attention of the entities in charge of the institutions of higher education as well as the institutions of higher education themselves. The reformed SUC is testament to how the original concept of a completely decentralized university system in Switzerland has evolved towards a cohesive, centralized structure in which the Confederation's participation has significantly increased.

Federal Institutes of Technology

The Swiss Federal Institutes of Technology (FIT) in Lausanne (EPFL) and Zurich (ETHZ), founded in 1853 and 1854 respectively, together with the four affiliated federal research institutes, are institutions falling under the responsibility of the Swiss Confederation, dedicated to higher learning and research. More specifically, the FIT's objectives consist in training engineers and architects, stimulating basic and applied research, engaging in industrial and business collaboration and partnerships, and providing post-graduate and further education. The four affiliated research centres' efforts are primarily concentrated on application-oriented research.

The FIT uphold their autonomy and identity on the basis of the FIT Federal Law[61]. This law stipulates that the EPFL and ETHZ are autonomous establishments that independently administer their affairs and are guaranteed the liberty of setting their own educational agenda, as well as their research programs and choice of curricula. Swiss Federal Law provides that

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[56] University of Bern, University of Basle, University of Fribourg, University of Lausanne, University of Geneva, University of Neuchâtel, University of Zurich.
[57] University College of Lucerne, Università della Svizzera italiana (founded in 1996).
[58] University of St. Gallen.
[59] These reforms were an initiative of the government, spearheaded by Secretary of State Charles Kleiber.
[60] Revised LAU 414.20 from 8.10.1999 according to the Plan for the 2000-2003 period, enacted 1.4.2000.
[61] "Loi Fédérale sur les écoles polytechniques fédérales 414.10", dating from 4.10.1991.

"*the autonomy of the FIT is subject to restrictions insofar as a long-term planning and the coordination of education and research require it*."

Universities of Applied Sciences (HES)

In 1995, the Swiss federal parliament decided to restructure the vocational institutes that are supervised by the federal authorities (engineering, economics and management, and design). In order to make better use of its resources, the government created seven regional Universities of Applied Sciences[62]. Reforms were carried out with the intention of upgrading the quality of HES curricula and presenting an accreditation and diploma-awarding system worthy of a university-level institution. Today, the HES schools are comparable to those elsewhere in Europe, placing the system at international university level, and the curricula taught and diplomas awarded by the HES are established so as to be Euro-compatible. Since their inception in 1995, the HES have been in a continuous process of development with the aim of harmonizing structures and profiles, and defining and providing a common level of professional education.

The status of the HES is dictated by the Federal Law on Universities of Applied Sciences[63], which states that the HES are institutes of education on the same level as the existing Swiss universities. The main characteristic is that it puts education for professional practice at its core.

For the establishment and operation of the HES, CHF 540 million are allocated every year. The Cantons provide two thirds of this and the Federal Government one third. The coordinating body for the HES is the **Swiss Council for the HES**, which is in turn set up by the **Swiss Conference of the Cantonal Ministers of Education**. The **Federal Commission for the HES**, on the other hand, decides on proposals to establish an HES as well as on requests for accreditation. The Federal Government ultimately approved the opening of the seven regional HES after a rigorous selection process. During the development phase, which ended in 2003, the government enlisted scientific experts to evaluate all degree programs over which it has control. Only those schools which satisfy its standards receive the right to federally approved degrees.

4.3 Governmental institutions and programs

Commission for Technology and Innovation (CTI)

For over 50 years, albeit under different names, the CTI sponsors dynamic enterprises to transfer novel ideas into commercial products and services. After World War II, the federal government launched a series of economic policies[64] and subsidizing schemes with the aim of boosting the economy and creating jobs. The Federal Office for Economic Affairs and the subordinated predecessor[65] to the FOPET were responsible for the implementation of articles in federal law pertaining to issues related to R&D and patenting, leading to the creation of the Commission for the Encouragement of Scientific Research (CERS). The CERS became the

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[62] HES Bern, HES Central Switzerland, HES Eastern Switzerland, HES Northwestern Switzerland, HES Southern Switzerland, HES Western Switzerland, HES Zurich.

[63] "Loi Fédérale sur les Hautes Ecoles Spécialisés (HES) 414.71", dating from 6.10.1995.

[64] Loi fédérale sur les mesures préparatoires en vue de combattre les crises et de procurer du travail (823.31).

[65] Office Fédéral de l'industrie, des arts et métiers et du travail (OFIAMT).

CTI following the enactment of legislation 832.312 on the granting of subsidies for the encouragement of technology and innovation, in 1982.

Since the year 2000, the CTI enjoys the official status of "federal agency for applied research and development". In fact, it remains the key instrument of the Swiss federal government's technology policy. Subordinated to the Federal Department of Economic Affairs (see figure 4-1), the CTI plays a significant role in Switzerland's economic policy, which distinguishes it clearly from other governmental agencies in the field of research policy. The principal raison d'être of the CTI, as defined by the Swiss Chambers of Parliament, is to promote innovation, technology and competitiveness particularly in favor of small and medium-sized enterprises (SMEs), and thus to maintain and improve Switzerland's leading edge position in the global economy.

The CTI addresses the above mentioned challenges by proposing a comprehensive package of support services to SMEs eager to develop products based on their research findings, but often lacking the financial resources, manpower, infrastructure and access to relevant information to do so. To remedy these shortcomings and simultaneously better exploit the sub-optimal use of knowledge in the higher education sector, CTI encourages and supports cooperation of enterprises, research and higher educational institutions in joint R&D projects, and the efficient transfer of technology between them, hence, its motto "*science to market*". CTI aims to facilitate the access of SMEs to the federal institutes of technology, universities and HES, as well as European and international research programs. Through the rapid development and commercialization of innovative ideas, CTI thus also aspires to create new jobs in Switzerland and ensure the security of existing ones. CTI focuses its activities on the following fields: biotechnology and life sciences, nanotechnology and microsystems, and information and communication technology.

The CTI has some 25 members, including four permanent experts, whom are all prominent figures from industry and scientists with industrial backgrounds working for the CTI on an honorary basis. Together, they form a team in which matters are treated expeditiously, yet with maximum efficiency and flexibility, and a minimum of bureaucracy. CTI policy is based on a "bottom-up" or grass-roots approach, meaning that collaborative R&D projects are not instigated by any government agency. Rather, projects are initiated by enterprises and/or in conjunction with R&D or higher educational institutions. Government subsidies are paid for the expenses of public R&D or higher educational institutions participating in the projects[66], and industry covers its own expenses, generally 50% of the total project costs. This investment ensures that CTI projects have a clear market focus, thus increasing the probability that projects yield results that will be effectively used.

In 1999 the CTI spent over CHF 60 million on project-based R&D funding, nearly double the figure of 1996. (See table 4-4.) Between 1986 and 2000, the CTI has sponsored some 2700 projects, providing funds exceeding CHF 680 million and paying CHF 600 million in salaries to nearly 10'000 project workers between 1986 and 1999. That SMEs benefit considerably from CTI's aid is illustrated by their increasing participation in the programs of CTI. Indeed, between 1996 and 1999, some 1900 enterprises benefited from CTI support, of which 90% were SMEs. And in that same period, more than 1000 projects received funding totaling CHF 600 million, two thirds coming from private industry.

[66] ETHZ, EPFL, cantonal universities, and HES included.

Table 4-4: Project based federal R&D funding by CTI

(in million CHF)

1992	1993	1994	1995	1996	1997	1998	1999
36.1	35.4	36.5	32.5	32.6	40.4	57.3	61.7

Source: Vock (2000).

The CTI's budget stood at around CHF 80 million annually for the quadrennial 2000-2003. The breakdown of this budget can be seen in table 4-5.

Table 4-5: CTI budget 2000-2003

(in million CHF)

CTI Activities	Budget 2000-2003	Budget per year
CTI standard projects	120	30
CTI-HES: competence building	80	20
CTI Start-up	10	2.5
MedTech	20	5
Softnet	30	7.5
Application-oriented education research	10	2.5
EUREKA	40	10
Intelligent Manufacturing Systems (IMS)	10	2.5
TOTAL	320	80

Source: Vock (2000).

The support of standard projects is the core business of the CTI and thus consumes the major part of its budget, over one third. However, support is also given to theme-oriented projects with future potential, in the form of several programs such as SOFTNET[67], MEDTECH[68] or the recently created "CTI Biotech" promotion campaign. CTI-HES deals with the reform of the HES and the establishment of competence centers and applied R&D[69]. CTI Start-up[70] encourages the foundation of enterprises in the high-tech sector.

The CTI Biotech campaign, headed by Prof. Oreste Ghisalba (see sections 4.4 and 6.1.5), was launched in 2003. Its main two goals are the promotion of the fast growing Swiss biotech industry by further optimization of know-how and technology transfer and by targeted and

[67] SOFTNET encourages the development, commercialization and application of software made in Switzerland.
[68] MEDTECH was launched with the intention of boosting knowledge transfer and networking in the field of medical technology.
[69] The CTI should become the main financing institution for research at the HES, just as the SNSF is now for the "traditional" universities.
[70] KTI Start-up is its original German name.

efficient support for the creation of new biotech companies, and the facilitation and optimization of the economic exploitation of innovative techniques and products emerging from basic and application-oriented biotech R&D. Some of the strategies and priorities of the CTI for the 2004-2007 period in the field of biotechnology are: to facilitate the transition of projects from SNSF funding to CTI funding; to fund so-called “discovery projects”, highly innovative projects with high risk but outstanding business potential; to improve the collaboration between universities, the Swiss Federal Institutes of Technology and the Universities of Applied Sciences; to offer scientific expert support and coaching on a management, technical and financial level for start-ups; and to optimize structural conditions for Swiss Biotech.

CTI Start-up was initiated in 1995 by the FOPET[71] as one of the activities for CTI. The principal idea was to boost the spirit of enterprise at the junction between universities and industry. Switzerland, in comparison with other industrialized countries and particularly with the US, is not known for bold entrepreneurship and taking risks. In fact, comparatively few new enterprises are founded that offer marketable products with a future. With this challenge in mind, CTI Start-up was established.

CTI Start-up offers active support and expert advice from the idea to the finished, marketable product, and places particular focus on the especially difficult start-up phase of founding a company. The initiative selects and qualifies new enterprises for venture capital financing, and facilitates contacts with universities and industry in order to further the development of innovative and marketable technology. Financial and logistical support is granted mainly to projects in the field of so-called "markets of the future". These include software, information technology, microelectronics, biotechnology and medical technology, but assistance is also extended to other projects with high growth potential.

Qualified projects are granted the "CTI Start-up label". This seal of approval gives the start-up company access to CTI support and venture capital. Label carriers also stimulate the interest of potential investors, simplifying their decision. After the successful completion of the setting up of a company, CTI start-up remains present and active by intermediary of its "business angels center". "Business angels", experienced Swiss businessmen who take a central role in the guidance of a start-up's first steps into the business world, offer knowledge and experience to young entrepreneurs and also share the financial risk of the project.

It is important to underline the fundamental characteristic which differentiates the CTI from the non-governmental TLOs: while the underlying principle of TLOs is the valorization of research results through the effective transfer of technology from university to industry, CTI seeks first and foremost to boost the creation of jobs in the high-tech industry by promoting entrepreneurship and providing financial and logistical support in the realization of this goal.

CTI Start-up's formula for encouraging the creation of new high-tech companies in traditionally risk-averse entrepreneurial Switzerland has proved successful. Since its inception, more than 300 applications have been evaluated, of which 78 have been presented to the Industrial Board. CTI Start-up has thus far contributed to the creation of over 450 jobs, generating an estimated turnover of over CHF 100 million. These trends are indicative of the increasing effectiveness of the CTI's initiative in terms of companies and jobs created. The

[71] "Bundesamt für Berufsbilding und Technologie" (BBT) is its original German appellation.

growing number of projects submitted to the industrial committee is an indication of the value of the CTI Start-up label in the eyes of the scientific and research community.

The government's White Paper on education, research and technology for the period from 2004 to 2007 calls for the continued support of CTI and its activities, and foresees a significant boost in funding for the commission. (See table 4-6.) With reference to payment credits, the CTI sees its budget increased by 28% compared to the previous period. The supplementary resources demand a broader range of responsibilities, the most important of which are listed below:

- To increase the encouragement of and support to entrepreneurship and the creation of enterprises; to further develop the CTI Start-up initiative.
- Priority to be given to:
    - Life sciences
    - Nanotechnology and microsystems technology
    - Information and communications technology
- Widening the scope of activities in the field of international collaborations, specifically in the frameworks of ESA (European Space Agency), EUREKA and the IMS.
- To develop core competences of R&D in the HES.
- To encourage more high-risk projects ("discovery projects"), with potential for high commercial value.
- To educate the youth on science and technology.

Table 4-6: CTI budget / Payment credits for the period 2004-2007

(in million CHF)

	2003	2004	2005	2006	2007	2004 – 2007	2000 – 2003	Growth	(%)
Commission for Technology and Innovation :	**79**	**84**	**100**	**102**	**109**	**395**	308	87	(28)
Entrepreneurship Promotion	2,5	8	8	9	9	**34**			
Technology Development	22	20	23	22	23	**88**			
New technologies (biotechnology, MedTech, nanotechnology, microsystems, Information and Communication Technologies)	20	22	29	26	27	**104**			
CTI-HES	20	22	26	31	36	**115**			
International Activities (EUREKA, IMS, international research programs, SpaceTech)	14.5	12	14	14	14	**54**			

Source: CTI (internal source, 2004).

4.4 SPP Biotechnology

The Swiss Priority Programme Biotechnology (SPP Biotechnology) was launched in 1992 with public funds. A total of six research modules in biotechnology[72] and complementary activities in continuing education, information, communication, technology assessment, and technology transfer were designated to receive state support over a period of 10 years, ending December 2001. The main objective of SPP Biotechnology was to consolidate strategic, applied biotechnology research in Switzerland. More specifically, the Swiss Parliament set out the following goals to be achieved by the priority programme:

- To strengthen research in promising areas.
- To emphasise application-oriented or problem-solving research.
- To ensure the international competitiveness of Swiss biotechnology R&D.
- To encourage joint projects in fundamental research, applied research and development.
- To provide favourable conditions for innovation in existing or newly created centers of excellence in biotechnology.
- To create national and international networks of collaborators in universities, other public research institutes, industry and administration.
- To build the infrastructure necessary for biotechnology information communication, biosafety research and technology transfer involving, in particular, SMEs.

The 10-year priority program gave birth to 18 spin-offs employing over 300 people, and attracted investments topping CHF 40 million from the private sector and CHF 60 million in venture capital. In addition, numerous patents, licenses and transfers were facilitated thanks to the program. Furthermore, three offices were created in the framework of SPP Biotechnology; the Swiss Agency for Biotechnology Information and Communication (BICS), the Center for Biosafety Assessment, Technology and Sustainability (BATS)[73], and the technology transfer office Unitectra[74] (see section 5.2.1).

Prof. Oreste Ghisalba, a veteran of the pharma-industry with Novartis, directed the programme during its ten-year span. An interview with Prof. Ghisalba was conducted for the purpose of this paper, and an analysis of it can be found in section 6.1.5.

[72] "Bioelectronics and Neuro-informatics", "Food Biotechnology", "Proteins for Medical Applications", "Bioengineering and Biocatalysis", "Biotechnology of Higher Plants".
[73] www.bats.ch.
[74] www.unitectra.ch.

5 The Case of Swiss Biotechnology

5.1 Definitions

When breaking “biotechnology” into its root words, one can find *bio*, i.e. the use of biological processes, and *technology* – to solve problems or make useful products. Using biological processes goes back on a longstanding history. In fact, mankind started growing crops and raising animals 10,000 years ago to provide a stable supply of food and clothing. The biological processes of microorganisms have been used for 6,000 years to make useful food products, e.g. bread, cheese, wine and beer, and to preserve diary products. But during the 1960s and ‘70s the understanding of biology reached a point where it became possible to use the smallest parts of organisms, i.e. their cells and biological molecules, in addition to using whole organisms (BIO, 2004). A recent timeline of some major events in biotechnology is presented in table 5-1.

The terms “biotechnology” and “biotech industry” are often used in a causal and imprecise way. Therefore, increasing the precision and the common understanding of the following concepts is necessary (Rosenberg (1999) in Audretsch (2001)):

- **Biotechnology**
  A group of techniques and technologies that apply the principles of genetics, immunology and molecular, cellular and structural biology to the discovery and development of novel products. The definition given by the European Federation of Biotechnology is as follows: “Biotechnology is the integration of natural sciences and engineering sciences in order to achieve the application of organism, cells, parts thereof and molecular analogues for products and services.” (Unitectra, SPP BioTech, 2001, p. 7). Hence, it is not surprising that a better handle of the meaning of the word “biotechnology” can be obtained by using its plural form: “biotechnologies”.
- **Biotechnology Industry**
  The Swiss industry is composed of around 240 private companies (Unitectra, SPP BioTech, 2001) that apply various biotechnologies to develop commercially viable products. This number is composed of 120 “biotech companies” (or entirely “dedicated” biotech companies), which have their business focus on modern biotechnology, and 120 “other companies with biotech activities”, including firms whose activities in modern biotechnology represent only a part of their activities. Another 19 companies are classified as “biotech consulting companies”. Referring to Ernst & Young in Swiss Biotech Report (2004), the total number of Swiss biotechnology companies by the end of 2003 is 227, whereof 139 dedicated biotech companies (ten more than in 2002; see Ernst & Young, 2003) and 88 biotech suppliers. The biotech industry is typically an input in the health care, food and agriculture, industrial processes, and environmental cleanup industries.
- **Pharmaceutical Industry**
  This industry is composed of private companies whose products involve design, discovery, development and marketing of new agents for the prevention, treatment and cure of disease. Pharmaceutical firms rely heavily on scientific research. The industry may be evolving towards a new name, the “biopharmaceutical industry”, which reflects the strong reliance of pharmaceutical companies on biotechnology.
- **Medical Research**
  This relates to science-based inquiry, both basic and applied, where the goal is the improvement in health and the eradication or mitigation of disease and disability.

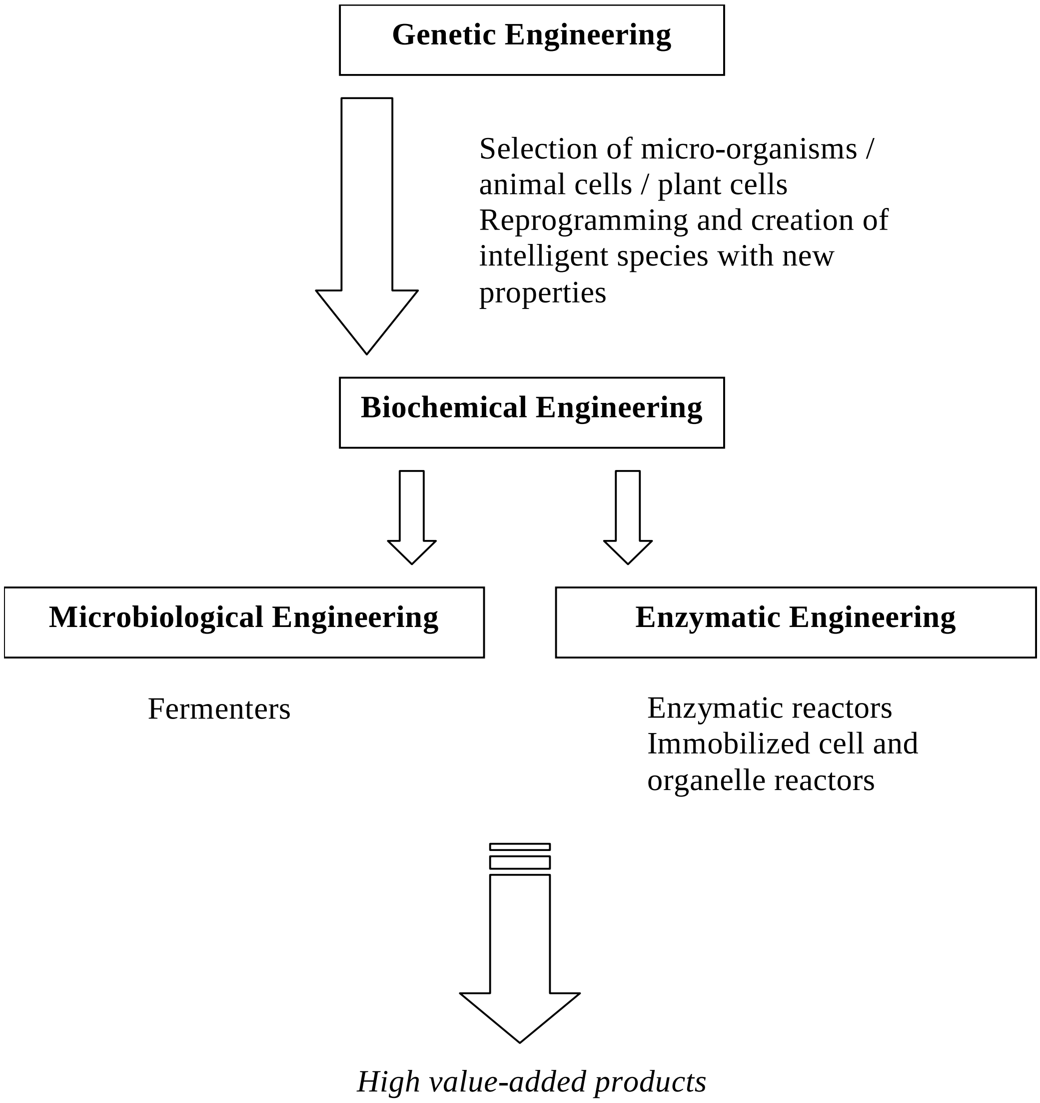
Table 5-1: Recent biotechnology timeline

1865	Science of genetics begins: Austrian botanist and monk G. Mendel studies garden peas and discovers that genetic traits are passed from parents to offspring in a predictable way. He proposes the basic laws of heredity but his publication in 1866 in a local natural-history journal was largely ignored for more than 30 years.
1902	The term *immunology* first appears.
1906	The term *genetics* is introduced.
1919	First use of the word *biotechnology* in print.
1938	The term *molecular biology* is coined.
1941	The term *genetic engineering* is first used.
1953	J. Watson and F. Crick describe the double helical structure of DNA, which marks the beginning of the modern era of genetics.
1966	The genetic code is cracked.
1969	An enzyme is synthesized in vitro for the first time.
1970	Discovery of restriction enzymes that cut and splice genetic material, opening the way for the gene cloning.
1971	First complete synthesis of a gene.
1972	Initial work with embryo transfer.
1977	First expression of human gene in bacteria.
1978	Recombinant human insulin first produced.
1979	Human growth hormone first synthesized.
1980	The US Supreme Court, in the landmark case *Diamond vs. Chakrabarty*, approves the principle of patenting organisms. The US patent for gene cloning is awarded to S. Cohen and H. Boyer.
1982	Recombinant DNA (rDNA) animal vaccine approved for use in Europe. First biotech drug approved by US FDA: human insulin produced in genetically modified bacteria.
1983	The polymerase chain reaction (PCR) technique, which uses heat and enzymes to make unlimited copies of genes and gene fragments, is conceived. The first artificial chromosome is synthesized. The first genetic markers for specific inherited diseases are found. First whole plant grown from biotechnology: petunia.
1984	The DNA fingerprinting technique is developed. The entire genome of the human immunodeficiency virus (HIV) is cloned and sequenced.
1985	Transgenic plants resistant to insects, viruses and bacteria are field-tested for the first time. The US NIH approves guidelines for performing gene-therapy experiments in humans.
1986	First recombinant vaccine for humans hepatitis B approved by FDA. First anticancer drug produced through biotech: interferon. The first field tests of transgenic plants (tobacco) are conducted.
1987	First approval for field test of modified food plants: virus-resistant tomatoes. First authorized outdoor tests of a recombinant bacterium that inhibits formation on crop plants: Frostban.
1988	Harvard molecular geneticists are awarded the first US patent for a genetically altered animal – a transgenic mouse. US Congress funds the Human Genome Project, aiming to map and sequence the human genetic code as well as the genomes of other species.
1989	Plant Genome Project begins.
1990	First product of rDNA technology in the US food supply: Chy-Max™, an artificially produced form of the chymosin enzyme for cheese-making. The international Human Genome Project is formally launched.
1992	American and British scientists unveil a technique for testing embryos in vitro for genetic abnormalities. First European patent on a transgenic animal issued for transgenic mouse sensitive to carcinogens.
1994	First FDA approval for a whole food produced through biotechnology: FLAVRSAVR™ tomato.
1995	Gene therapy, immune system modulation and recombinantly produced antibodies enter the clinic in the fight against cancer.
1997	First animal cloned from an adult ewe: a sheep named Dolly in Scotland. First weed- and insect-resistant biotech crops commercialized: Roundup Ready® soybeans and Bollgrad® insect-protected cotton.
1998	Human embryonic stem cell lines are established. The first complete animal genome, for the *C. elegans* worm, is sequenced. A rough draft of the human genome map is produced, showing the locations of more than 30,000 genes.
1999	Dolly, the cloned sheep born in 1997, suffers from DNA damage and shows premature ageing.
2000	First complete map of a plant genome developed: *Arabidopsis thaliana*. Rough draft of the human genome sequence is announced.
2001	First complete map of the genome of a food plant completed: rice.
2002	The draft version of the complete map of the human genome is published, and the first part of the Human Genome Project comes to an end. Biotech crops grown on 145 million acres in 16 countries, a 12% increase in acreage grown in 2001. More than one-quarter of the global acreage was grown in nine developing countries.
2003	Worldwide biotech crop acreage rises 15% to hit 167.2 million acres in 18 countries. Dolly, the cloned sheep born in 1997, is euthanized after developing progressive lung disease.
2004	A group of Korean researchers report the first human embryonic stem cell line produced with somatic cell nuclear transfer (cloning). The FDA approves the first anti-angiogenic drug for cancer, Avastin.

Source: modified and expanded from BIO (2004).

Figure 5-1 offers an overview on the main ways of applications of biological techniques.

Figure 5-1: Main ways of applications of biological techniques



Source: adapted from Douzou *et al.* (2000).

5.2 Biotechnology in Switzerland

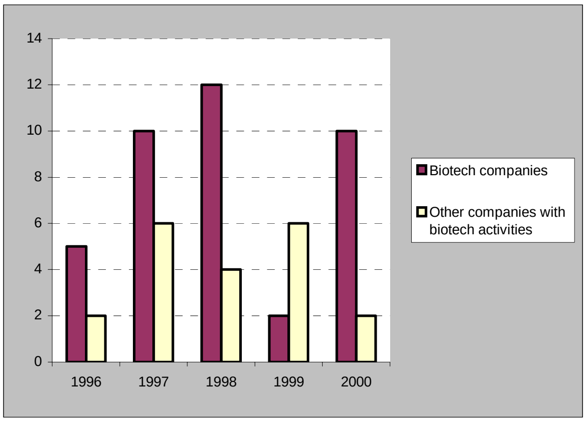
Geographically, the large majority of all Swiss companies active in biotechnology are situated in one of the three main areas, i.e. Basle, Lake Geneva region (Lausanne/Geneva), and Zurich.[75] The role played by the universities (Universities of Basle, Zurich, Lausanne and Geneva) and Federal Institutes of Technology (EPF Lausanne and ETH Zurich) has to be underlined, particularly in the field of the creation of new ventures or technology transfer policies (Unitectra, SPP BioTech, 2001, p. 7 ff). Moreover, the proximity of the major pharmaceutical companies in Basle, Novartis and Roche, or the multinational biotech company Serono in the French speaking part of Switzerland, represents another important factor of localization.

[75] See appendix 6.

Another role in the development of the Swiss biotechnology sector can be attributed to the SPP Biotechnology (1992-2001) of the SNSF, which contributed to the creation of 18 new companies. Also noteworthy are the Novartis Venture Fund and the Nestlé Venture Capital Fund, which represent two important instruments in supporting innovative ventures, particularly in the life sciences.[76] (See Figure 5-2). Finally, in 2001, the SNSF launched the first 14 NCCRs, thus giving Switzerland a new tool with which to further improve its international competitiveness in the world of research. In the field of life sciences, four NCCRs have been initiated, i.e. the NCCR Genetics, the NCCR Neuro, the NCCR Structural Biology, and the NCCR Molecular Oncology (SNSF, 2001).

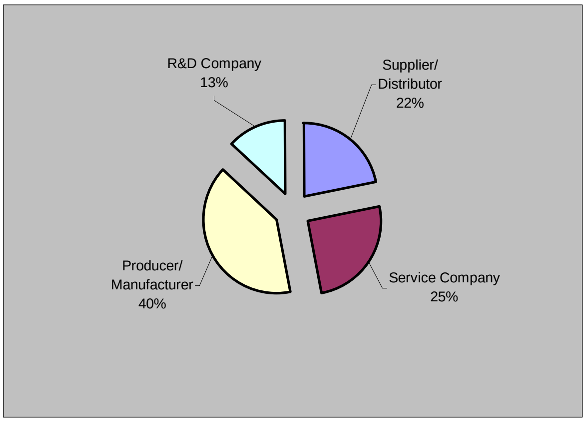
Of all Swiss biotech companies, 40% are manufacturers of biotechnology goods and 22% are suppliers. Service companies (25%) have activities in DNA synthesis, analytical services, planning and engineering of plants, etc. The remaining 13% (R&D companies) are typically start-up companies which do not as yet sell their own products, but carry out R&D projects either on their own or in co-operation with other companies. (See figure 5-3.)

Figure 5-2: Newly established companies (1996-2000)



Source: Unitectra, SPP BioTech (2001).

Figure 5-3: Biotech companies by type of activity (2000)



Source: Unitectra, SPP BioTech (2001).

Table 5-2 lists the broad range of market segments covered by the different biotech companies in Switzerland:

Table 5-2: Number of companies in different fields of activity

Note: Some companies appear in more than one type.

Laboratory equipment	56	Bioelectronics/Bioinformatics	11
Bioreactors/Equipment/ Engineering	36	Environmental treatment/Waste disposal	9
Pharmaceuticals/Therapeutics/Vaccines	32	Cell culture	8
Reagents/Biochemicals	31	Chemicals	7
Consulting	25	Food	7
Diagnostics	24	Agriculture	6
Contract R&D/Contract Manufacturing	22	Biomaterials	5
Platform technologies	18	Medical devices	5
Bioseparation/Down Stream Processing	15	Cosmetic/Health/Beauty products	3
Analytical services/Quality control	13	Veterinary	3

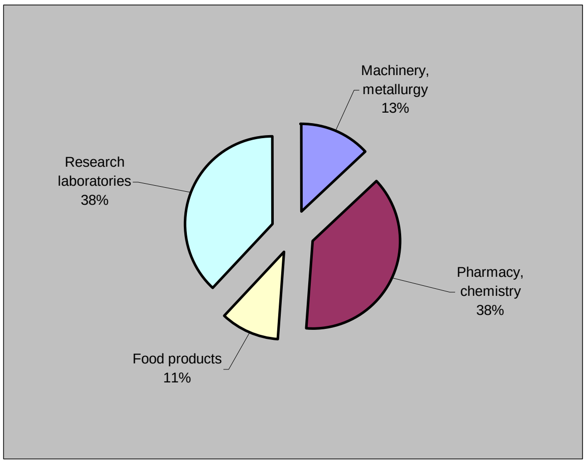
Source: Unitectra, SPP BioTech (2001).

[76] See also section 5.3 for more information on venture capital (VC).

In 2000, Swiss private companies have been asked for the first time about their R&D participation in biotechnology, i.e. what is the expenditure devoted to R&D in biotechnology?[77] (SFSO, economiesuisse, 2001) Referring to this survey, 4% (CHF 300 million) of the total amount (CHF 7710 million) devoted to intramural R&D is committed to biotechnology. Four economic branches (research laboratories, pharmacy and chemistry, machinery and metallurgy, and food products) ensure almost the total R&D work in this research field. (See figure 5-4.)

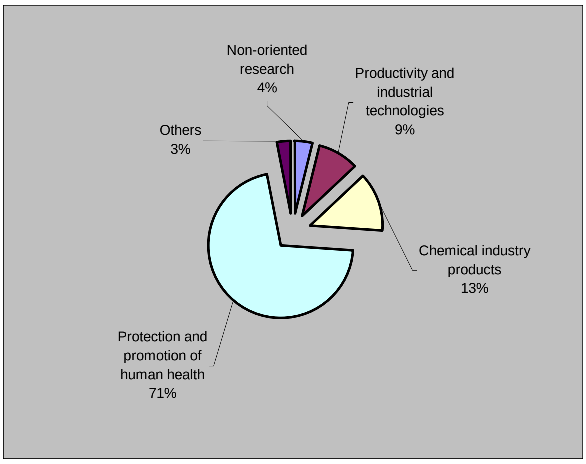
In this same survey, the "protection and promotion of human health" is advanced as being the main target of R&D. 71% of intramural expenditures are devoted to that aim, followed by "chemical industry products" (13%) and "productivity and industrial technologies". (See figure 5-5.) The economic branches strongly active in R&D work dedicate an important part of their financial resources to the "protection and promotion of human health". The branch "machinery and metallurgy" allocates 94% of its R&D expenditures in biotechnology to this objective, "research laboratories" spend 84%, and "pharmacy and chemistry" 68%, while the branch "food products" contributes with just 10% of its total R&D expenditures. The latter favors "productivity and industrial technologies" and "non-oriented research" (SFSO, economiesuisse, 2001, p. 10).

Figure 5-4: Intramural R&D expenditures in biotechnology by economic branch (2000)



Source: SFSO, economiesuisse (2001).

Figure 5-5: Intramural R&D expenditures in biotechnology by target (2000)



Source: SFSO, economiesuisse (2001).

5.2.1 Swiss biotech organizations[78]

Unitectra is the technology transfer organization of the universities of Bern and Zurich and the Swiss National Science Foundation's SPP Biotechnology. Founded in 1999, and based on Biotectra (the technology transfer office established by the SPP Biotechnology in 1996), Unitectra is a non-profit making limited company owned by the universities of Bern and Zurich. Its mission is the promotion and support of co-operation and knowledge and

[77] Since 1983, the Swiss Federal Statistical Office (SFSO) and economiesuisse (the largest umbrella organization covering the Swiss economy) organize every four years a survey on expenditure and human resources devoted to R&D by Swiss companies.
[78] See also section 4.4.

technology transfer between private enterprise and the partner universities as well as other research and educational institutions or other third parties. In particular, Unitectra assists research collaborations, the protection of intellectual property, licenses, the creation of spin-off companies, and the education and training on technology transfer related aspects (Unitectra, SPP BioTech, 2001, p. 11). Other technology transfer agencies are ETH transfer at the ETH Zurich, EPFL SRI at the EPF Lausanne, PACTT for the University of Lausanne and the CHUV (University Hospitals of Lausanne), Unitec at the University of Geneva, and WTT at the University of Basle.[79]

The SBA (Swiss Biotech Association, former VSBU/ASBC) was founded in March 1998. More than 100 companies represent this association which is the industry association of enterprises and institutions active in all areas of biotechnology. Its primary goals are to act as a central platform for the further development of the Swiss biotech sector, to be a partner in the planning of biotech activities, but also in the integration of the Swiss biotech scene into the European scene and into global regulatory compliance, and to act as a catalyst of technology transfer throughout the industry.[80]

The "Swiss Biotech" internet portal (www.swissbiotech.org) is a DEA/seco initiative which aims the promotion of biotechnology in Switzerland. Seco's export/investment promotion area has developed the portal in collaboration with representatives from industry, financial institutions and the world of science together with experts from the Confederation and the cantons. The Swiss Biotech label was created in order to enforce the Swiss Biotech scene at home and abroad and to guarantee a uniform image. Swiss Biotech, which created the label and founded the marketing organization, has the following members:

- Bioalps, a canton Geneva, Vaud, Neuchâtel, Valais and Fribourg association promoting and reinforcing exchanges between scientific, economic, financial and political circles bearing a relation with life sciences;
- Biopolo, a non-profit association sustaining the integration process of the life sciences in Ticino;
- BioValley Basel, the Swiss pillar of the BioValley initiative (see section 6.1.1), has the non-profit making purpose of mainly promoting and assisting companies and institutions active in the field of life sciences;
- SWX Swiss Exchange;
- SBA;
- Zurich Mednet, a public information resource and business development network serving the medical and biotechnology community of the Greater Zurich Area.

The portal is managed and developed by the SBA.

To mention also the "Swiss Life Sciences Database" which allows free access to a directory and information platform comprising data of life sciences and biotechnology companies and institutes in Switzerland including company description, additional information and categorization. The database is sponsored by seven partners including Bioalps, BioValley Basel, the Greater Zurich Area, Swiss BioteCHnet (a partnership of the Swiss Universities of Applied Sciences that are active in the field of biotechnology), SWX Swiss Exchange, the

[79] For useful addresses on biotechnology in Switzerland, see Swiss Biotech Report (2004, p. 31).
[80] See www.swissbiotechassociation.ch.

State Secretariat for Economic Affairs (seco), and Venture Valuation (an independent company specialized in the assessment, valuation and monitoring of start-up companies).[81]

5.3 Innovation in biotechnology

The major determinants of market structure in the international biopharmaceutical industry include a number of factors, i.e. the research system under study and its linkages, industrial structures, financing of innovation, intellectual property, and public perceptions. These factors play an important role in determining the activities and structure of the biopharmaceutical industry and the innovation system (OECD, 1998). Regulatory aspects are addressed separately.

The development of biotechnology presumes a strong science base and the ability to form horizontal links with many other disciplines. University-industry links, accompanied by a gradual blurring of the boundaries between academia and industry (Ronchi, 1998), constitute important channels for the development of new technologies. Significant private sector involvement in biomedical research highlights the fact that with the introduction of modern biotechnology, research outputs are more easily transferred to the private sector making the distinction between basic and applied research less clear. Moreover, recent public policy has deeply changed the constraints and incentives which influence the development of new medical technologies and products. Thus, the aim is to encourage academic and research institutions to work with private firms to improve basic research, technology development, and technology transfer.

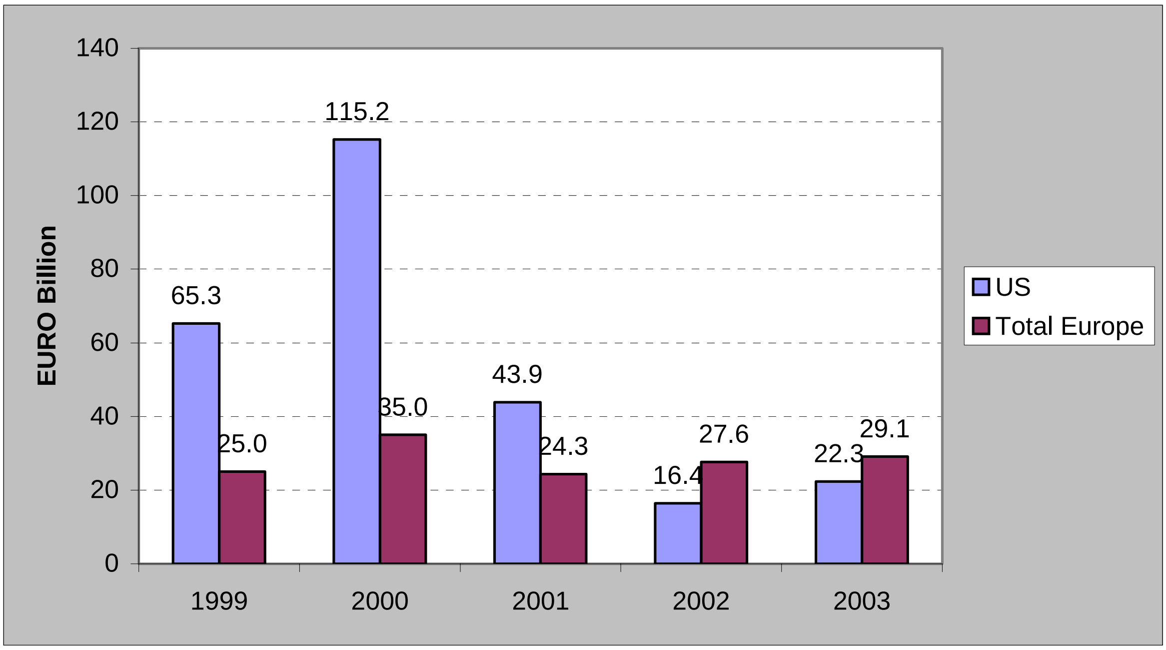
Kanavos (1998) examined the factors affecting industrial structures for innovation, studying especially those specific to the pharmaceutical sector, such as the “three-tier demand system” (patient, doctor and reimbursing agency), and implications such as the close dependence on the actions of governments or economies of scale in research and marketing. Referring to Kanavos, it might appear that the future of the pharmaceutical/biopharmaceutical industry in OECD countries depends on generous pricing of newly patented products and further mergers of firms lacking the size required to stay in the top of the league. On the other hand, mergers and acquisitions may reduce research options and the probability of technological advances, since new entrants are vital for any industry. Hence, an important task for public policies is to strengthen the innovative potential of SMEs, especially in Europe and Japan, where the entrepreneurial spirit should also become more aggressive.

The financing of innovation in biotechnology presents substantial differences across countries. An important aspect of finance is the facility for start-up biotechnology companies to reach the stage where they can seek listing in capital markets and hence raise capital. The small size of these companies and the fact that in their early years they often do not have a product on which to trade, makes listing not easy. The availability of venture capital (VC) is generally invoked as a fundamental element of American leadership in biotechnology. The United States have the largest pool of venture capital, essential for the initial phases of biotechnology product development. Flexible listing requirements and early “exit routes” through which to realize capital gains are part of a set of facilities encouraging investment by “business angels” and venture capitalists in companies who need start-up and early-stage finance. European venture capital still lags behind US volumes in terms of raised funds.

[81] See www.swisslifesciences.ch.

However, it exceeded the US in 2002 in terms of invested funds despite the fragmentation of markets and regulations which in some countries make it more difficult for early investors to realize capital gains via the “exit route”. (See figure 5-6.)

Figure 5-6: Total funds invested 1999-2003



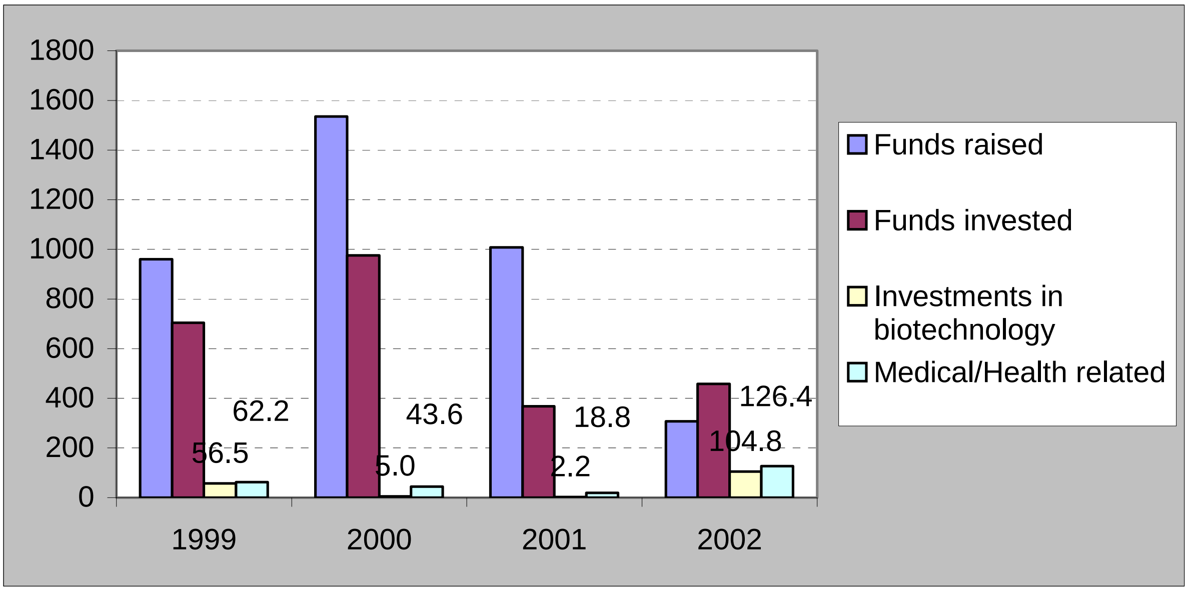
Source: based on data from EVCA (2002), PricewaterhouseCoopers (2004).

In general, the VC market has changed a lot over the last years. After the boom of the 1990s, investors are much more reluctant today. The main European VC companies are located in the UK, France and Germany. In Switzerland, many small VC companies have disappeared from the market. In case of an upturn of the market, 10 to 20 authentic VC companies are supposed to survive in the long term (seco, 2003, p. 36).[82] The capital raised by private equity managers in 1999 totaled CHF 960 million, over two-and-a-half times the amount reported for the previous year. In 2000, this amount increased again, reaching more than CHF 1.5 billion of raised funds (EVCA, 2001). A first downturn (-34%) was observed in 2001 with total funds raised amounting to CHF 1008 million, before decreasing even more in 2002 (-70%) to reach CHF 307 million. It seems that the 2000 to 2001 decrease was principally due to lower realized capital gains, while the 2001 to 2002 decrease was almost totally due to a reduction in the amounts raised by independent funds (EVCA, 2003). Total investment amounted to more than CHF 700 million in 1999, and reached almost CHF 1 billion in 2000. In 2001, investment made fall down to CHF 368 million, before increasing again in 2002 (+25%) to reach CHF 458 million. Hence, for the first time in five years, the amount invested exceeded the funds raised during the same year. It is to mention that over 50% of the investments made in 2002 were in the biotechnology and medical/health related sectors (EVCA, 2001 and 2003). (See figure 5-7.)

[82] Switzerland’s private equity, venture capital and corporate finance industries are represented by the Swiss Private Equity & Corporate Finance Association (SECA).

Figure 5-7: Funds raised and invested in Switzerland

(in million CHF)



Source: based on data from EVCA (2001 and 2003).

Despite the availability of a number of sources of finance for biotechnology, including initial public offerings (IPOs) and R&D limited partnerships, these sources are subject to uncertainty. Thus, strategic alliances between biotechnology and pharmaceutical companies have become a popular and less risky way of financing innovation in the former. Finally, national governments and supra-national institutions, such as the European Commission, also play an important role in financing innovation or in establishing for example an appropriate legislative framework for the transfer of technology from national laboratories to the private sector for development.

An emphasis has to be put on the ever-increasing importance of intellectual property rights (IPR). Moreover, the evolution of internationally harmonized regimes for intellectual property is of great significance for biotechnology as it enters the age of genomics. In a research-intensive industry, effective protection of intellectual property rights is fundamental. Patenting in biotechnology, especially in connection with human genes and/or living organisms, has become highly controversial, both within countries and in the international context. Apart from the question of patent legislation itself, several side-issues exist which are related not to the nature of the legislation but to its implementation, e.g. the backlog of applications which increases both costs and uncertainty, enforcement, or licensing requirements.

Public perceptions and attitudes can affect in an important way the economic and regulatory conditions (*infra*) under which an industry operates (Allansdottir *et al.*, 2002, p. 83). Their impact can be felt through supply channels (e.g., the attraction towards young graduates and scientists, perceived social utility of related research, and perceived risk factors with respect to financial conditions), the economics of the production or on the demand for the products and techniques that this industry puts on the market. For example, in assessing public acceptance of innovation and the potential impact of biotechnology, one must be aware of the different views of consumer groups, on the one hand, and specific patient/disease groups, on the other. Hence, the degree of public acceptability of an innovation, particularly in the field of biotechnology/pharmaceuticals, will depend on the degree to which a drug or new technology meets “real” needs (OECD, 1998, p. 13).

5.3.1 Overall regulatory stance

Regulation is normally specific to the field of application and the technology. In general, there cannot be any clear sentence over its role as short-term effects may be different from long-term ones. Nevertheless, regulatory framework conditions can have a major impact on the competitiveness of biotechnology (Allansdottir *et al.*, 2002, p. 83).[83]

One of the main reasons for government intervention in the health-care industry is uncertainty, as well as ensuring equity, equality of access, and transparent provision of information for consumer awareness. In this context, regulation – including both authorization for release products, and post-release monitoring – can be considered as an instrument for reducing and protecting people from the risks linked to such uncertainty. Hence, developing regulatory guidelines for new technologies means striking a balance between public concern over unknown technological risks and guidelines that promote research on promising new treatments. Indeed, governments have to reconcile their role in promoting and maintaining an internationally competitive research-based industry with their regulatory objectives in health and safety policy, without neglecting public expenditure goals (OECD, 1998, p. 14 ff).

Biotechnology, as applied to the development of human therapeutic products, has certainly provided and will continue to supply innovative technologies to support the discovery of new diseases and therapies. Thus, to realize the potential in this technology, without underestimating its risks, governments have to create policies to advance innovation through regulatory practices, economic incentives, investment in research and development, and a clear commitment to provide for their citizens the benefit of these technological progresses.

Biotechnology-derived pharmaceuticals are exposed to the same regulatory rules as traditional pharmaceuticals. The speed of approval is crucial for marketing and capture of market share as biotechnology companies are extremely sensitive in this respect due to the capital constraints they face. Adding to the costs of biotechnology companies, long approval times increase the need for funds, and consequently call for the formation of strategic partnerships. This shows in what way the regulatory environment can influence the financial requirements and hence the structure of a whole industry.

Cost containment and efficient use of resources are central elements in health-care reforms across OECD countries. At the same time, the emphasis on cost control is expected to influence the dissemination of biopharmaceutical products, due to their high cost. In fact, very few OECD governments allow the pharmaceutical industry to freely determine prices of commercial goods. For this reason and as the effort to contain costs increases, an effective mechanism is needed to guarantee a certain price level for the industry. Finally, the challenge for biotechnology is twofold. First is whether it can deliver therapies for a wide range of diseases, thus confronting short to medium-run cost concerns with possible long-run cost reductions. Second is whether the new technology will make it possible to move towards

[83] Referring to Gaskell *et al.* (2000), the European public discriminates quite clearly among the fields of application of biotechnology. It is rather neutral about agricultural biotechnology but opposed to both genetically modified food and the cloning of animals. On the other side, perceptions of medical and environmental biotechnology are very positive.

effective prevention of disease, in which case the long-term benefits, in terms of increased quality of life, will exceed the short-term costs.

To conclude, one can observe a permanent tension between regulation and innovation in the field of modern biotechnology. Governments are confronted with the problem of managing a complex process, with a range of policy instruments, uncertainties about their effects, and a continuing flow of new scientific knowledge and potential innovations. Through harmonization, standardization, mutual acceptance of test results and data, further economy of effort and the facilitation of collaboration and trade are reachable. Finally, market access and economies of scale encourage and facilitate corresponding internationalization of the industry, and thus the whole innovation process. To summarize, the roles of government can be seen as promoter of research and innovation, controller of costs, market access and reimbursement conditions, and "intelligent facilitator" (OECD, 1998, p. 17).

Referring to USTR (2002, pp. 392-395), Switzerland has taken a pragmatic, case-by-case approach to biotechnology products since voters defeated in 1998 a referendum (Gene Protection Initiative) to ban biotechnology research and release of biotechnology products into the environment, in part due to concerns about the impact of this proposal on Medical research. Nevertheless, biotechnology products remain somewhat controversial. In general, approval of biotechnology products has been slower than in the United States and the European Union which has led to situations where products approved elsewhere were banned in Switzerland (USTR, 1999, p. 385 ff). Foods and additives that have been genetically engineered need approval for consumer marketing through certification by the Swiss Federal Office of Public Health (SFOPH) and the manufacturer of a genetically engineered food product must submit detailed information concerning the modifications.

5.4 International comparisons[84]

On top of the statistics already presented on strategic alliances (chapter 2) and venture capital (*supra*), some more statistics on biotechnology are given in this section. They concern patents, bibliometrics, trade, and government funding for biotechnology R&D.

5.4.1 Biotechnology and patents

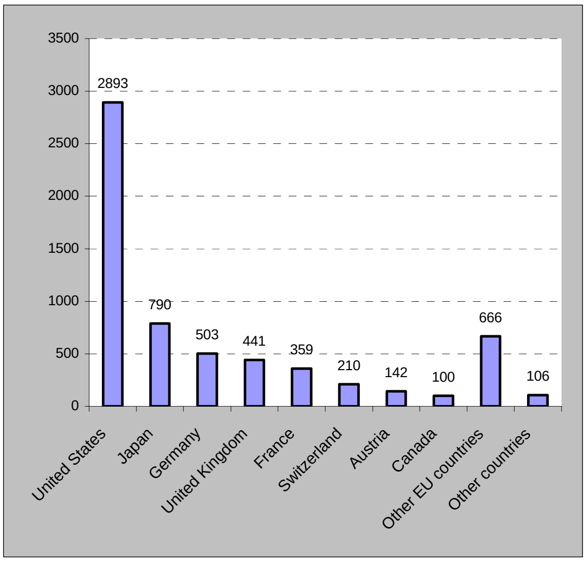
The absolute number of USPTO[85] and EPO[86] biotechnology patents has grown significantly in comparison with the total number of patents (van Beuzekom, 2001, p. 10 ff). Between 1990 and 2000, the number of biotechnology patents increased by 15% at the USPTO, compared to an increase of just 5% for all patents taken together. A similar trend can be observed at the EPO, with an increase of 10.5% for biotechnology patents between 1990 and 1997, compared to 5% for patents overall. It is to mention that at both the USPTO and the EPO the top six biotechnology "patenters" are identical (i.e. OECD, US, EU, Japan, Germany, UK), with differences starting at the seventh position onwards where a clear geographical bias appears.

National shares of all biotechnology USPTO patents have changed between 1990 and 2000 for only two countries in a significant way. The US increased its share by 9%, while that of

[84] This part is based on van Beuzekom (2001).
[85] United States Patent and Trademark Office.
[86] European Patent Office.

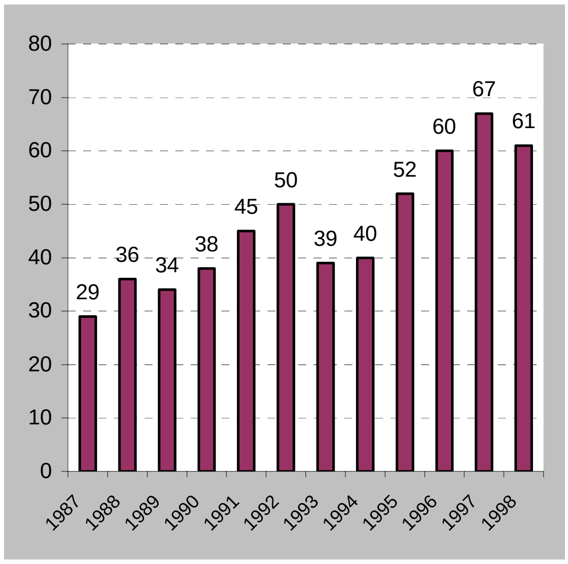
Japan declined by 11%. At the EPO, national shares of all biotechnology patent applications between 1990 and 1997 have not changed noticeably the only exception being Japan with a decline of 6%. One should also mention that USPTO growth rates of biotechnology patents are positive in all countries for the 1990-2000 time period, also in the large majority of countries which applied at the EPO for the 1990-1997 period. Nevertheless, it is interesting to note that in 2003 a decrease of 5.3% was registered at the EPO (EPO, 2004) for patent applications filed under the International Patent Classification (IPC) C12 class comprising biochemistry and genetic engineering.[87] Figure 5-8 shows the number of European genetic engineering patents (granted and pending) for the period 1978-1994. Figure 5-9 represents Swiss patent applications to the EPO in the field of biotechnology between 1987 and 1998.

Figure 5-8: European genetic engineering patents, granted and pending (1978-1994)



Source: IIP[88] in Cueni and Engler (1997).

Figure 5-9: Swiss patent applications to the EPO in the field of biotechnology (1987-1998)



Source: OECD, MSTI database, May 2003 in SFSO (2003).

5.4.2 Biotechnology and bibliometrics

One possible measure of scientific output by a country in a particular field such as biotechnology and applied microbiology is the share of publications in scientific journals. The share of such publications for most selected countries (European countries, as well as for Canada, Japan and the United States) has remained stable over time even though the number of biotechnology articles more than doubled, from 1574 in 1986 to 3261 in 1998 (van Beuzekom, 2001, p. 14 ff). It is noteworthy to mention that the United States and Japan account for about a third of all publications in these fields. (See figure 5-10.)

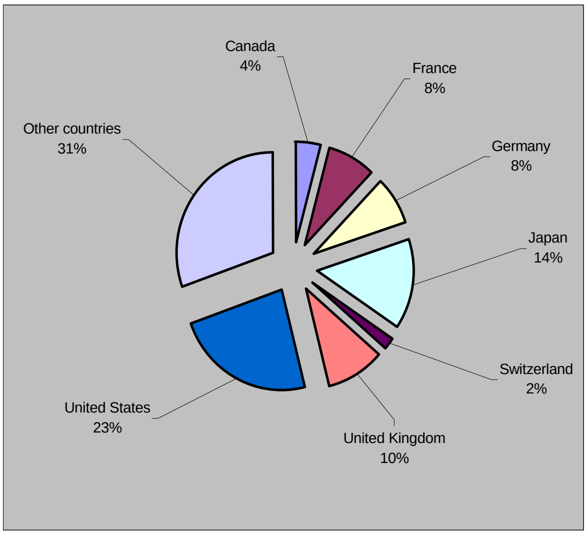
[87] EPO biotechnology patents consist of five IPC codes: C12M (apparatus for enzymology or microbiology), C12N (micro-organisms or enzymes, compositions thereof), C12P (fermentation or enzyme-using processes to synthesize a desired chemical compound), C12Q (measuring or testing processes involving enzymes or micro-organisms), C12S (processes using enzymes or micro-organisms to liberate, separate or purify a pre-existing compound or composition). See OECD (2001c, p. 32).

[88] Swiss Federal Institute of Intellectual Property.

The relative impact of a particular paper is based on the number of citations by other published work. Thus, if a paper has more citations than the average for its field, i.e. biotechnology and applied microbiology, it has an above average impact. Over the 1986-1998 period, Switzerland, Finland, the Netherlands, Sweden, the United States and Germany had above average impact rates, ranging from 1.8 for Switzerland to 1.3 for Germany, while Spain, Japan, France and Italy had below average impacts.[89] (See figure 5-11.)

National profiles of relative scientific specialization can be obtained from the distribution of published articles by field and comparing this to the average (van Beuzekom, 2001, pp. 17-18). Based on publications in 1998, the results show that each country analyzed[90] has an above average strength in at least one health/bio-medical area. The United Kingdom was the strongest across all the health/bio-medical fields, followed by Italy and to a lesser extent the United States. Japan was well below average in just a few of the fields. In the case of biomedical engineering, the field with some of the strongest links to biotechnology, the United States, Germany, and Canada were above average, while Japan, France, and Australia were below.

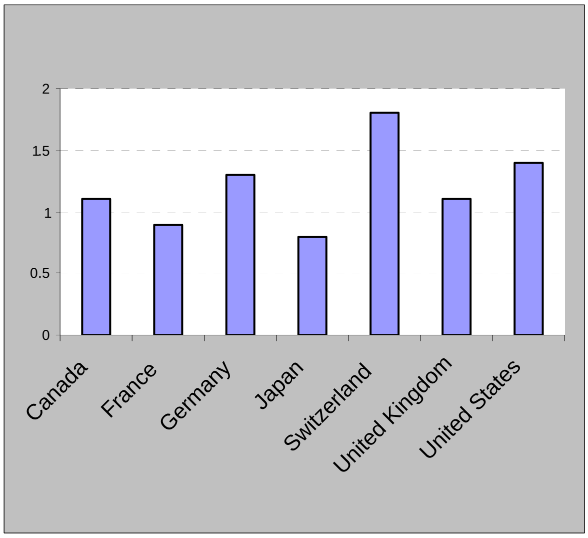
Figure 5-10: National shares of the total number of publications in the biotechnology and applied microbiology NSIOD journal category (1998)



Source: data from Sandström *et al.* (2000).

Figure 5-11: Relative impact by country of publications in the biotechnology and applied microbiology NSIOD journal category (1986-1998)

Rate above or below the mean number of citations.



Source: data from Sandström *et al.* (2000).

5.4.3 *Biotechnology and trade*

There is no existing trade data that is specifically limited to biotechnology products. Nevertheless, an important database is offered by the US Census Bureau, which defines "biotechnology products" as a group that is almost completely based on biologics. However,

[89] For example, a Swiss paper published over the 1986-1998 period received 80% above the average number of citations, while a Japanese paper (0.8) received 20% under the average number.
[90] Countries analyzed include Australia, Canada, France, Germany, Italy, Japan, the UK, and the US.

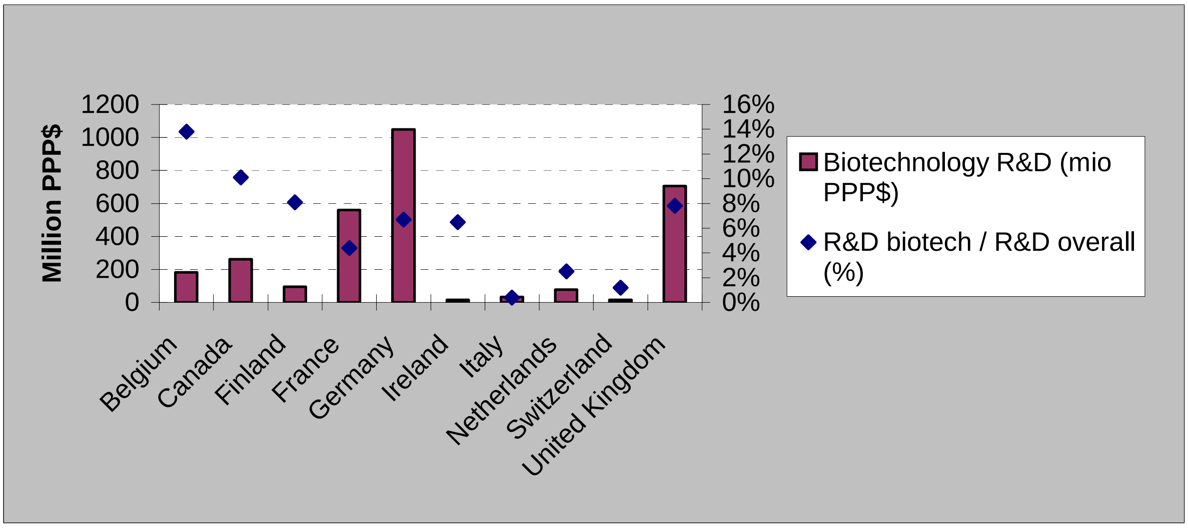
this definition includes many products that are not part of advanced biotechnology, and excludes other important biotechnologies.

Referring to the US Census Bureau, US biotechnology exports to OECD countries amounted in 1999 to more than USD 1.34 billion as compared to imports of USD 970 million from OECD countries. At the same time, more than 80% of US biotechnology exports and imports went to, respectively came from, seven OECD countries. Belgium (24% of exports and 26% of imports), and to some extent the United Kingdom, are more or less equally represented in the US export and import balance sheet. The other three leading destinations for US biotechnology products in 1999 were Japan (20%), Germany (9.1%) and Canada (15.2%), but both Japan and Germany were not among the major providers of US imports and Canada's share amounted to only 7.2%. Switzerland (11.7%), Ireland (6.9%) and, in a less important way, France (13.1%) and the Netherlands (10.6%) are among the major exporters of biotechnology to the United States but are less significant importers. National specializations and weak intra-industry trade might be an explanation for this (van Beuzekom, 2001, p. 22).

5.4.4 Biotechnology and government funding

Data on government appropriations can provide an indication of the relative importance of public biotechnology funding. The median contribution of government budgets in OECD countries devoted to biotechnology is 3.5% in 1997. But the spread between different countries is large, ranging between 0.4% (Italy) to 13.8% (Belgium). In absolute PPP$ terms, Germany spends the most on biotechnology followed by the United Kingdom and France. (See figure 5-12.)

Figure 5-12: Public funding of research and development (1997)



Source: based on data from the European Commission (2000), Eurostat, Statistics Canada, and national sources.

Concerning publicly funded biotechnology R&D as a percentage of publicly funded R&D, more recent data (2000 or nearest available year) shows New Zealand, Canada and Denmark at the top with shares above 10% (Devlin, 2003).[91]

[91] For a recent and complete overview on biotechnology statistics in selected countries, see Devlin (2003).

6 Swiss Biotechnology: A Case Study

This chapter summarizes the results from 14 interviews we have conducted with key actors in the field of biopharmaceuticals in Switzerland, mainly in its three major clusters, i.e. the Basle region, the greater Zurich area, and the Geneva-Lausanne area. In the case of a private company, we were first interested in the creation of the company itself, its origin and motivation. Second, we were looking at the knowledge network the company or institution is involved in, specifically the links existing between universities and private companies, but also between private companies themselves (strategic alliances). Third, we were interested in institutional factors (availability of capital, intellectual property, public opinion) influencing the biopharmaceutical landscape in Switzerland. And finally, we sought to understand the impact of public support of biotechnology via research programs, with a special focus on the SPP Biotechnology, and the formation of clusters in biotechnology. (See appendix 1a and 1b.)

The order in which the interviews are presented refers to the three Swiss clusters in biopharmaceuticals we were analyzing: First, the Basle region; second, the greater Zurich area; and third, the Geneva-Lausanne area. Finally, two companies located outside the clusters are interviewed.

6.1 The Basle region

6.1.1 Actelion Pharmaceuticals, Ltd.

Interview with Dr. Walter Fischli, Senior Vice President, Head of Drug Discovery, and Co-Founder, on November 27, 2002.

Actelion, founded in late 1997, is a biopharmaceutical company with its headquarters in the Innovation Center in Allschwil/Basle – counting more than 400 employees in March 2003. The company is focusing on the discovery and development of innovative synthetic small molecular weight drugs. The focus of research is the endothelium, which is the innermost fibrosis layer of blood vessels and plays a role in cardiovascular diseases, inflammation, fibrosis, and many types of cancer. For its research activities, Actelion combines technologies from molecular biology and medicinal chemistry to clinical development, and also benefits from a worldwide international collaboration.
Tracleer, an orally available dual endothelin receptor antagonist, has been approved as a therapy for pulmonary arterial hypertension. Actelion markets Tracleer through its own subsidiaries worldwide.[92]

Actelion was founded by four researchers active in drug discovery working for Hoffmann-La Roche (Roche) in Basle. Successful work of the respective research groups and a certain lack of recognition by Roche finally led to a breakaway. As the proposal of a spin-off made to Roche was rebuked, the company was entirely created with the researchers' own private savings without receiving any financial support from Roche. With exception of one bank guarantee, the company did not receive public support either: no agreement could be achieved with the CTI, and the cantonal government of Basle-Land was reluctant as the company – logically – did not make any profits at the time.

[92] See www.actelion.com.

The first financing round of the company comprised five investors, and the second round was followed by an IPO. Therefore, new shares were issued to secure funding for the company. In general, it is difficult in the beginning of a company's life to find investors without overly stringent requirements. Networking and contacts are therefore very important. Access to qualified personnel is considered as non-problematic, especially as the company was able to benefit from an extensive already-existing network. Indeed, Actelion started with four people, and now there are more than 500 employees worldwide (including Hesperion, Ltd.). The Basle region was the only site that was taken into consideration by Actelion. Reasons for this decision are the unique pharmaceutical environment, access to specialists and skills, and its firmly implanted industry.

Various links exist between Actelion and academia or public research institutes. There are collaborations with a Paris hospital, the Bangkok University, and several research institutes in Japan and other countries. One product has been developed together with the Swiss Tropical Institute, and the company approached the World Health Organization (WHO) for a collaboration on malaria vaccines. In addition, many students from Switzerland, Germany and France are working at Actelion while doing their diploma works or post-doctoral studies in chemistry, biology and other fields. There are also many active links with industry including small companies and Big Pharma. Usually, Actelion tries to get into collaborations when there is a general need for them.

The quality of education in Switzerland is qualified as very good as it is more pragmatic than in the US. Moreover, according to Dr. Fischli, there is a huge advantage in Switzerland compared to the US in fields like chemistry, structural development, and drug development; on the other hand, the US has an advantage in basic research. However, Basle is "still considered number one" in biopharmaceuticals.

IP is of extreme importance for every biopharmaceutical company. During only four operational years, Actelion applied for over 30 patents which are all drug-discovery related, mostly covering compounds. The strategy of Actelion is to patent as much as possible, except for processes. As tremendous expertise is necessary in this field, a former patent division director of Roche has been appointed to do this job.

Public opinion has a big influence on the biopharmaceutical industry. The acceptance of the national referenda on animal protection (1985, 1992, 1993) could have meant – quoting Dr. Fischli – "the end of the Swiss pharmaceutical industry". In his opinion, Switzerland already has a very good system of animal protection. The biotechnology industry is certainly dependent on the public opinion but should not bend to it as it has to maintain its independence.

Actelion was not an active participant of the SPP Biotechnology, but several collaborations resulted from this program. There is an active collaboration with the NCCR Neuro (Neural Plasticity and Repair) on brain research. Furthermore, Actelion applied for a European grant and got involved in the Medicines for Malaria Venture (MMV) at the World Health Organization (WHO), but was soon confronted with stifling bureaucracy. To improve the collaboration between academia and industry, much more financial support is needed than often realized by universities. Also universities cannot be involved in all steps of, for example, drug discovery: they are competent in research, but – according to Dr. Fischli – the final product is out of their reach.

In general, there should be more concrete action and less talk from local authorities in supporting clustering as they could help a lot. The Innovation Center in Allschwil/Basle (like the Biotech Center Zurich-Schlieren) is a private venture with no support from the two local governments (Basle-Land and Basle-City). The BioValley initiative is good for companies that lack networks and contacts but is for this reason less interesting to Actelion.[93] According to Dr. Fischli, this network should be more engaged in pro-active support and clustering as start-ups need immediate access to adequate working facilities.

6.1.2 F. Hoffmann-La Roche AG

Interview with Prof. Dr. Klaus Müller, Head of Science & Technology Relations and Secretary-General of Roche Research Foundation, on November 27, 2002.

Roche is a leading, worldwide active research-oriented healthcare company with core businesses in pharmaceuticals, diagnostics, vitamins and fine chemicals. The company, headquartered in Basle, was founded in 1896 and employs today approximately 70,000 people in 170 countries. The innovative achievements of Roche are mainly due to long-standing investment in R&D, particularly in modern biotechnology. In 2002, the Roche Group achieved sales of CHF 29.7 billion and invested more than 4 billion in R&D. For the same year, the core pharmaceuticals business achieved sales of CHF 19.1 billion.[94]

Roche is involved in a huge array of alliances with multinationals and SMEs around the world. In 2001, Roche and Chugai announced that they would enter into an alliance to create a leading research-driven Japanese pharmaceutical company. To broaden its range and fortify its position, Roche has also made some key acquisitions. A majority share in Genentech, a worldwide leading biotechnology company, reinforces the position of Roche in the promising new field of pharmaceuticals produced by means of biotechnology.

For Prof. Müller, academia represent an “important partner for new ideas”. Exchanging ideas, learning together, and being in contact with academia are key elements for technology-driven companies such as Roche. For example, several research groups with international scope inside Roche collaborate with groups outside the company. While working together on feasibility issues, they may develop a prototype, and later on an entirely new product. In this context it is worth mentioning the fundamental importance of IP issues, especially related to diagnostics.

But there are also sabbaticals for Roche collaborators or PhD students working for the company. All this is part of a process of mutual learning, e.g. learning about other technologies. The interaction with other people and the in-house validation of worldwide technologies will then allow the transfer of technology. As a result, Roche is permanently moving between basic and applied research. By the way, the Roche Symposium for leading bioscientists and chemists is constantly on the look for new talents.

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[93] The BioValley initiative (“The Life Sciences Network”) is a tri-national network which enables and coordinates the exchange of know-how and technology among research institutions, organizations, industry, and the public in Germany (Freiburg), France (Alsace) and Switzerland (Basle). See www.biovalley.com.
[94] See www.roche.com.

According to Prof. Müller, the government is able to influence clustering, mainly by increasing its research spending. Even though Roche influenced in a positive way the creation of the NCCRs, Prof. Müller is not fully convinced about investing substantial amounts of public money in "networks". The important thing is to focus on particular issues and to foster certain issues. In general, a multinational like Roche is not in the need to join a national research program, as the company is open to any development worldwide.

The public opinion plays an extremely important role in the field of life sciences. But this doesn't mean that campaigns influencing the public opinion have to be aggressive. Though it was very important for Swiss biopharmaceutical companies that the Gen-Lex initiative was accepted (thus refusing the Gene Protection initiative), companies, unlike universities or hospitals, always have the possibility to move out of a country. For Prof. Müller, it is important to bring life sciences into schools and colleges, thus influencing the public opinion from the early beginning. But this also means that more partners are needed, for example from academia or via the creation of a Swiss organization for life sciences.

6.1.3 Ecovac GmbH

Interview by telephone with Dr. Helmut Eckert, Founder of Ecovac and Co-Founder of igeneon AG, on December 2, 2002.

Founded in 1996, Ecovac GmbH is located in the Canton of Basle-Land (Oberwil). Manufacturer of vaccines for tumor therapy, Ecovac patents are exploited by igeneon AG, Vienna, Austria.[95]

With 30 years of experience in senior R&D positions at Sandoz, Dr. Eckert left the company after its merger with Ciba-Geigy in 1996. As a result of his pharmaceutical research and project work in the field of cancer research, Dr. Eckert created Ecovac with modest resources as a limited liability company (LLC), essentially for responsibility reasons. Locating the company in proximity to Basle was mainly due to private reasons but also because Basle is an important place for services.

Combining university and proper resources, a first product was then developed on self-initiative in view of a contract allocation. In 1999, Dr. Eckert co-founded igeneon with a colleague from Vienna, Austria, thus bringing the product into the new company. Today, igeneon employs more than 60 people.

For Dr. Eckert, networking was the essential ingredient for over 30 years of work within Sandoz and continues to be a key feature, especially in the case of technology transfer into a newly created company like igeneon. For example, due to the network in place, two products have been in-licensed to igeneon from Novartis and Protein Design Labs (PDL).

Networking with academia is entirely based on personal contacts. According to Dr. Eckert, the assistance provided by the CTI was not very constructive as "direct" assistance is generally needed. In fact, together with the chamber of commerce, the CTI proposed different

[95] See www.igeneon.com.

laboratories which were not very helpful in the end. Hence the real infrastructure that is needed is the university itself.

In 1999, igeneon was founded with venture capital mainly (30%) from the Novartis Venture Fund. Further investors were Bank Austria TFV (now 3i Austria) and Technologieholding (now 3i). Other financing resources included the Vienna Business Agency (VBA) contributing, together with another public institution, 50% to the research activities of the company. According to Dr. Eckert, the same favorable conditions could be found for example in Munich, Germany. In contrast, "the Swiss can only dream about it": as there is no big venture capital firm, the first hurdle to clear for an emerging company in Switzerland is very difficult.

Concerning regulatory and institutional factors in the biopharmaceutical field in Switzerland, they can be considered as quite neutral and similar in comparison to other European countries. Bearing in mind the strategic importance of IP, related issues are particularly well organized in Switzerland.

Even though Dr. Eckert was never directly concerned by public research programs, he assisted people involved in such programs. For example, in the eyes of Dr. Eckert, Unitectra Technology Transfer and the SPP BioTech Program Direction have fulfilled a very useful function. Dr. Eckert also helped as a consultant in the framework of the BioTechPark Freiburg/Germany and the Innovation Center Allschwil/Basle. To entirely appreciate the success of those institutions, input-output analysis are necessary. Nevertheless, they provide a basis for useful interactions and synergies between involved companies, and are able to offer infrastructure for biopharmaceutical companies.

6.1.4 Speedel Pharma AG

Interview with Mr. Konrad Wirz, CFO, on December 3, 2002.

Speedel Pharma was launched at the end of 1998 in Basle by a group of pharmaceutical industry managers and scientific experts who decided to create a new kind of drug development company, explicitly focused on the fast-track development of innovative cardiovascular and metabolic drugs.
The Speedel Group, that works today with a team of 40 pharmaceutical scientists and managers, is a privately held company which has secured until this date more than CHF 44 million in equity and derived development and license revenues in the aggregate amount of about CHF 55 million. Speedel in-licenses drug candidates at the end of the discovery phase from fully integrated pharmaceutical companies as well as from research and biotechnology companies. It also identifies – by Speedel Experimenta AG – own development candidates. The ex-front-runner of Speedel's development portfolio has been Aliskiren (SPP 100), an orally active rennin inhibitor, licensed from Novartis Pharma AG in 1999. In summer 2002, Novartis has exercised its call-back option for Aliskiren with the goal to further develop this compound in order to gain regulatory approval and commercialization in hypertension.[96]

[96] See www.speedelgroup.com.

The only public support Speedel had for its foundation was a favorable agreement with the local tax authorities. Because of its rich history in chemistry and pharmaceuticals and the possibility to access the best people in the world in the field, Mr. Wirz considers Basle as a very good place to be for a company like Speedel. Even though the quality of education in biopharmaceuticals in Switzerland is more than adequate, the real problem resides in the quantity of trained people. Hence, it is not surprising that the 40 employees of Speedel, who practically all worked for one of the big pharmaceutical companies (Novartis or Hoffmann-La Roche) in Basle, come from almost 20 different nations.

Concerning links with academia, Speedel is not involved in any research agreement at this point as research activities are still very young. However, there are some university professors on the Scientific and Technical Advisory Board of the company. Likewise, there are no strategic alliances between Speedel and other companies, apart from the license agreements with Big Pharma.

In the field of intellectual property, Mr. Wirz sees no real handicap or substantial differences with regard to the US. Though Speedel has no specific IP strategy and while having a legal entity in the US, the company tries to keep its IP in Switzerland. There is one Speedel employee working full-time on patents and IP. The amount of capital available to business is considered to be very high in Switzerland. Moreover, technical expertise on biotechnology and pharmaceuticals is very good. The reverse is that Swiss investors are generally quite risk-averse in comparison to the US which makes it often difficult to get VC funding.

Public opinion has a great influence on the biopharmaceutical industry but, according to Mr. Wirz, not directly on Speedel. This is especially the case for Switzerland. With regards to GMOs, for example, there is a big philosophical difference between the Old and the New World, where Switzerland and Europe as a whole, stand to lose out to the US.

Concerning national or European research programs, Speedel has not participated in any programs until now. Even though measures supporting clusters in biotechnology are not easy to define, Mr. Wirz is sure that regional authorities could influence them in a positive way. As the Basle region, with its traditional links to France and Germany, already represents a unique place for biopharmaceuticals, it should be the ideal place to promote. On the other hand, it is still difficult to see the fruits of, for example, the BioValley initiative.

6.1.5 Novartis Pharma AG

Interview with Prof. Dr. Oreste Ghisalba, Former Program Director of SPP Biotechnology, on February 7, 2003.

Novartis is a world leader in health-care with core businesses in pharmaceuticals, consumer health, generics, eye-care, and animal health. The company was created in 1996 from the merger of the Swiss companies, Ciba and Sandoz.
In 2002, the Group’s businesses achieved sales of CHF 32.4 billion (USD 20.9 billion) and invested approximately 4.3 billion (USD 2.8 billion) in R&D. During the same year, the core pharmaceuticals business achieved sales of CHF 21.0 billion (USD 13.6 billion), with the cardiovascular and oncology businesses being the main drivers. Headquartered in Basle,

Novartis Group companies employ more than 70,000 people and operate in over 140 countries around the world.[97]

Besides his activities at Novartis Pharma AG and his function as a lecturer at the University of Basle and the EPF Zurich, Prof. Ghisalba is in charge of the organization of governmental research programs, like it was the case for the SPP Biotechnology (1992-2001).[98] The definition of "biotechnology" used for defining the field of research of this program was based on the definition given by the European Federation of Biotechnology which says that biotechnology is the combination of natural sciences and engineering sciences.[99] Referring to Prof. Ghisalba, the SPP Biotechnology was clearly an application-oriented program, also including social aspects such as biosafety, IP issues, technology transfer aspects, etc. Even if the program was terminated at the end of 2001, there are still some activities which continue today.

The task of the program directorate, backed by a group of experts in charge of giving input and discussing incoming projects, was to control the realization of the program's goals which is particularly important in a new network. These goals were initially set by an international and national group of people designing topics that were interesting to Switzerland, either to be strengthened or to be newly created. Finally, goals were set in collaboration with the researchers in Switzerland, hence also admitting bottom-up definitions.

The outcome of the program was many-fold. Besides the new operating networks which were established, 18 start-up companies have been created. In addition to the global program budget of CHF 100 million allocated by the Swiss Federation, some CHF 40 million have been attracted from industry, as well as more than CHF 60 million of venture capital throughout the duration of the program. Beyond its lifetime, the VC invested in the new companies amounted to more than CHF 100 million. Moreover, more than 70 licenses and patents have been created.[100]

The start-up companies created through the SPP Biotechnology generated some 300 new jobs, a number which is still increasing. Thanks to the program, services have also been provided to people and companies outside the program. For example, Unitectra, today's technology transfer organization of the Universities of Bern and Zurich, assisted in the establishment of companies which were not funded by the SPP Biotechnology. National research institutions and the public sector have been involved in biosafety research. In addition, a periodical (BioTeCH forum) which detailed the results gained from all the projects of the program was published throughout the SPP.

The BICS (Biotechnology Information and Communication Switzerland) office was opened in Basle in order to inform the public on issues of concern. The importance of the public opinion is shown for example in the field of agrobiotechnology where the development in Switzerland is blocked for the moment. For Prof. Ghisalba the current attitude is not scientifically but rather ideologically motivated. Of the three agencies created under the SPP Biotechnology, two are still existing: the already mentioned Unitectra (former Biotectra) and

[97] See www.novartis.com/pharma.
[98] Or the recently (2003) launched campaign CTI Biotech headed by Prof. Ghisalba (see section 4.3).
[99] See chapter IV, 4.1 (definitions).
[100] For more detailed information see: SNSF, *Prisma Spectrum 1992-2001*, Bern, SNSF, pp. 28-30.

the Center for Biosafety and Sustainability (BATS), which gets support from the Basle government. (See section 3.4.)

Unquestionably, ethical aspects have to be taken into consideration in certain fields such as stem cells, and there are admittedly other open questions that exist. That's why the SPP Biotechnology tried to foster a transdisciplinary approach, for example by involving people also from the social sciences in publications and technology assessments. Likewise, Prof. Ghisalba suggests defining research programs in case of the existence of safety issues. In this context, a new research program on bio-safety issues has been proposed to the SNSF which might be established by the end of 2003.

For Prof. Ghisalba, the SPP Biotechnology has given a "huge boost" to Swiss research in biotechnology. Additionally, the "in-house" evaluation of the situation of Swiss biotechnology allowed to change the public perception of biotechnology in Switzerland and encouraged finally new people to create new companies. It was shown that there were much more biotechnology companies in Switzerland than reported by other previous studies. Since the publication of the first Swiss Biotechnology Industry Guide, co-edited by the SPP Biotechnology Program Direction, an additional 70 companies have been reported, totaling today more than 250 companies (including provider and service companies).[101]

Even though a research program has to contain a predefined strategy and clear plans, flexibility is another important element as unplanned and unexpected results have to be taken into consideration. For instance, Prionics AG, one of the largest companies created through the SPP biotechnology was initially never planned to be set up. That's why for Prof. Ghisalba it is definitely possible to create a favorable environment, e.g. for the creation of a new company, but it is not possible or wise to plan too far ahead: "If you control too much and if you plan too much, you kill innovation!" Finally, trust among people involved in a research program is essential. The program direction just intervened when help, support or advice were needed.

According to Prof. Ghisalba, the SPP Biotechnology can be probably considered as the first instrument which allowed an effective collaboration in the field of biotechnology between industrial and academic partners in Switzerland. In total, more than 100 companies have been associated with the program, with a main focus on SMEs. But collaboration took also place between companies. For example, the research results of a collaboration between a big company and university were transferred to a smaller company where they were finally put into practical application. In fact, big companies are often interested in using certain products but without producing them in-house. Therefore, the program led to real networks involving several partners creating a technological solution, which constitutes a viable basis for the business of a small company.

In addition, the SPP Biotechnology initiated the Association of Swiss Biotechnology Companies (ASBC). This step was particularly important to increase the visibility of the Swiss biotechnology industry, allowing networking not only on a political level but also on an industrial level.

Having been scheduled for ten years, the SPP came to the end of its term in 2001. For Prof. Ghisalba, the end of the program was not a finality as such because there is certain continuity

[101] See chapter IV, 4.1.

of the program albeit "on other levels". For example, the program has been replaced to a certain extent by the creation of the NCCRs in Life Sciences. This new program contains research and educational aspects, but it also has the duty to do knowledge and technology transfer. This means that research results continue to be made publicly available to industry, but in a different set-up of programs with smaller and more focused entities. Specially focused on application-oriented research, the CTI offers another alternative to the program. Therefore, when the program came to an end, Prof. Ghisalba, former member of the CTI, tried to ensure a certain transition from the SPP to the CTI for individuals who were involved in the program.[102] Finally, the Universities of Applied Sciences are more recent players in the field. Their task, fostered by the CTI, is to conduct application-oriented research. In the case of biotechnology, the network – SwissBioteCHnet – has been created, linking several Universities of Applied Sciences.

6.2 The greater Zurich area

6.2.1 GLYCART Biotechnology AG

Interview with Dr. Joel Jean-Mairet, CEO, on November 27, 2002.

GLYCART Biotechnology AG is a company involved in the research, development and commercialization of a new generation of antibody-based products for the treatment of cancer and other life threatening and debilitating diseases. GLYCART's core platform technology is "GlycoMAb" which enhances the power of monoclonal antibodies.
Founded in 2000 as a spin-off from the Swiss Federal Institute of Technology in Zurich (ETHZ), GLYCART is currently located within the Institute of Biotechnology at the ETHZ in Zurich, but on the way to move to Schlieren in the greater Zurich area.[103]

After validating the results of research, followed by the decision to formulate a business plan, GLYCART was founded as a R&D spin-off from the ETHZ. Support for patent writing and technology transfer issues, together with a loan from the Novartis Venture Fund, allowed the company to start operations in January 2001. The powerful technology of antibodies, which represents today about 25% of all bio-pharmaceutical products that are in development, was a sufficient motivation for the creation of the company.

Concerning public support, GLYCART received assistance from Unitectra, the technology transfer organization from the Universities of Bern and Zurich, for IP issues. The ETHZ allocated a CHF 50,000 credit for the starting of the company which also won an important prize for innovation. Moreover, support and advice were principally obtained through networking with various actors involved in biotechnology.

As already mentioned in the company's introduction, GLYCART is preparing to move from the ETHZ to the new Biotech Center in Zurich-Schlieren. Reasons for moving to the Biotech Center are mainly a greater space availability, the existence of top class laboratories, and the creation of networks. Other advantages are synergies which can be derived from companies already located there, for example through the exchange of personnel and facility sharing. It has to be underlined here that the ETHZ is nevertheless considered as an ideal place for start-

[102] This transition definitely succeeded in the creation of CTI Biotech in 2003 (see section 4.3).
[103] See www.glycart.com.

ups, especially considering its reasonable rents. Quoting Dr. Jean-Mairet: “I can recommend to any biotech start-up to stay as long as possible at the University, because you have a lot of resources, access to equipment, libraries, networks, computers, etc.”

GLYCART has several ongoing collaborations with public and private institutions. Among academic institutions, research links exist with the Centre Hospitalier Universitaire Vaudois (CHUV), the Paul Scherrer Institute (PSI), and the Institute of Biotechnology of the ETHZ. Relating to industry, a sound network exists with several companies, even if there is no concrete collaboration or technology transfer for the moment. Regarding big pharmaceuticals, GLYCART is close to signing agreements with companies whose names cannot be disclosed yet. Two research and license option agreements have already been signed which allow a royalty percentage on products with GLYCART technology. Indeed, substantial information flow is expected in near future.

The quality of education in life sciences at the ETHZ is considered to be very high. Nevertheless, a certain stimulus for entrepreneurship is lacking. The lack of experienced technology transfer officers in Switzerland constitutes another handicap. In fact, GLYCART is currently dealing with a technology transfer office in the US (California). Moreover, the University should do more to secure financing, especially in the seed phase of a start-up. In this context, a lot of progress still has to be made.

Like any other high-tech company, GLYCART relies on IP, and thus has a very well-defined IP strategy. As the company went directly US and international, it is not too much concerned about the Swiss IP regulation. However, IP harmonization at the European level is a key issue. Concerning capital access, Switzerland is considered a good place to be. In general, the availability of capital is high, but the degree of access thereto varies according to the quality of one's business plan. Depending on the density of a company’s network, there might be direct access to quality investors.

Public opinion definitely influences the biotechnology sector. To create a mutual trust between the public and industry, more communication is necessary. Sensitive issues have to be well explained to the public, in particular in Switzerland.

Concerning research programs, GLYCART participated in the SPP Biotechnology which contributed directly to the success of the foundation of the company. Moreover, referring to Dr. Jean-Mairet, this program clearly helped to bridge the gap between university and industry, as shown for example by Cytos Biotechnology AG. GLYCART is not involved in a CTI project, but the company is currently applying for the CTI Start-up label so as to be entitled to government grants in the future. Although the company is in a rather advanced stage for applying for this label, the critical mass it has reached should be a helpful criterion.

There is no public financial support from the local (Zurich) or federal governments for clustering in biotechnology in the Zurich area, even though Dr. Jean-Mairet is certain about the influence regional authorities could take on the creation of clusters. Until now, the only support provided from the City of Zurich were useful contacts and addresses.

6.2.2 The Genetics Company, Inc.

Interview with Prof. Ernst Hafen, Co-Founder and Scientific Director, on January 27, 2003.

The Genetics Company (TGC) was established in May 1998, as a joint spin-off between the University of Zurich and the Swiss Institute of Experimental Cancer Research (ISREC) in Epalinges/Lausanne. TGC, located in the Biotech Center Zurich-Schlieren, is a drug discovery and development company active in the areas of cancer and neurodegenerative diseases. Up to now, TGC has generated a set of small molecules that are able to improve the therapies of (colorectal) cancer and Alzheimer's disease.
In December 2002, TGC acquired key assets from CallistoGen AG, Berlin, including small molecule lead candidates against Alzheimer's disease and proprietary in silico small compound screening, and De Novo design technologies in order to substantially strengthen its in-house chemistry capabilities and to expand its product line.[104]

TGC, which currently has 26 employees, was created by professors of the University of Zurich and ISREC in 1998 with the aim of using knowledge from basic research to define drug targets in human disease. The company participated in the Venture 1998 business plan competition, jointly organized by the ETHZ and McKinsey Switzerland, and received distinctions which led to many contacts, especially with investors and lawyers. Moreover, a CEO with Big Pharma experience was hired. After having been located initially at the University of Zurich, TGC decided to locate in the Biotech Center Zurich-Schlieren mainly due to reasons of space and facilities availability while staying close to the University of Zurich.

To receive financing, the company contacted major VC companies outside Switzerland, and profited from networking opened up by the Venture 1998 competition. TGC received financing through the Novartis Venture Fund and Nextech Venture. A second round of financing will soon be initiated. The company received a public loan of CHF 100,000 from the "Eidgenössische Stiftung zur Förderung schweizerischer Volkswirtschaft durch wissenschaftliche Forschung" that was especially helpful for the foundation of the company. In addition to this public support, TGC was awarded the CTI Start-up label, and the company received two CTI grants for two different projects.

Recruiting technical assistants working in specialized fields was quite difficult in the beginning of the expansion of the company in February 2002, especially as Cytos Biotechnology AG was going through a considerable expansion process at the same time thus drying up the market for qualified personnel. On the other hand, it was easier to find academic scientists and researchers because of the already existing links with academia, but also because of Swiss researchers coming back from abroad and preferring to work for a private company. Moreover, Germany and France represent another important source of researchers. The quality of education is considered to be very high in Switzerland. But, according to Prof. Hafen, it is not the responsibility of universities to produce tailor-made graduates for the industry.

Many projects at TGC started as university projects with patents filed with the help from the technology transfer office (Unitectra) of the University of Zurich. This was the basis for

[104] See www.the-genetics.com.

further collaborative research among research groups at the university on a contractual basis, with an IP share regulated individually for each project. In fact, regulations are in place for university-industry collaborations, but the awareness of how to handle them are missing. That's why more experience and knowledge of “what industry wants” is needed. Besides some informal contacts, there are no formal collaborations between TGC and other companies at the moment.

The importance of IP is very high as it represents the “start-up company’s currency”. However, according to Prof. Hafen, there is some lack of experience and support in this domain in Switzerland which necessitates a certain degree of self-learning. Access to capital is difficult for “early-stage companies” as many VC companies are only interested in companies which are close to a product. Therefore, TGC had to look for companies specialized in seed financing.

The public opinion plays a very important role for biotechnology. In this context, the Geneprotection Initiative (1998) was a major blow with a fortunate result. In case of approval, it would have meant a severe setback to the industry. Considerable time has been spent informing the public on the topic, hence reducing anxiety largely promoted by the media.

TGC did not participate in the SPP Biotechnology. In fact, Prof. Hafen considers a bottom-up approach more appropriate than top-down research funding like in the case of the SPP Biotechnology. TGC participated in two CTI projects and received the CTI Start-up label (*supra*). In general, public funding is fundamental as every young company needs support. Concerning the formation of clusters, they are a prerequisite for interaction between companies. The Technopark Zurich or the Biotech Center Zurich-Schlieren are two good examples.

6.2.3 ESBATech AG

Interview with Dr. Alcide Barberis, CSO, on February 4, 2003.

ESBATech AG, located at the Biotech Center Zurich-Schlieren, is a spin-off company from the Institute of Molecular Biology of the University of Zurich. Founded in September 1998 and currently employing more than 30 people, the company focuses on medical applied research using yeast as a genetic tool. ESBATech has developed several selection processes which are used for the identification of new drug targets (functional genomics) as well as the discovery and optimization of lead compounds for further drug development.[105]

The research results of the laboratory of the University of Zurich presented the basis for applications in drug discovery, and thus the creation of the company. An effective “launch pad” to the ideas was then given by the Venture 1998 business plan competition which provided support through a coach and a business angel. The first financing round of the company took place in 2000 with the Novartis Venture Fund. A second financing round started in 2001 and included Innoventure Capital AG (Credit Suisse), Venture Incubator AG, Lombard Odier Darier Hentsch & Cie, Immunology Fund as the lead investor, Novartis Venture Fund, HBM BioVentures, BSI New Biomedical Frontier, Difasa Holding, and Peter

[105] See www.esbatech.com.

Ohnemus. It has to be mentioned here that the collaboration with Hoffmann-La Roche AG was an essential element for the starting of the company.

Access to qualified personnel is not considered as an obstacle, and the quality of education in Switzerland is excellent. However, Dr. Barberis regrets the lack of involvement of business students in the creation of spin-offs. The location of the company is due to a spontaneous move to the Biotech Center Zurich-Schlieren even before it was created. The main reasons for this were the availability of top-quality laboratories and the proximity to Cytos Biotechnology AG.

At present, there are no links with universities. There have been some superficial contacts with the University of Geneva for a European project which did not materialize finally. But in general, there are no real obstacles in collaborating with academia. Creating links with industry has become difficult over the last years as industry is becoming more and more risk-averse. In fact, it is almost impossible to get financial support unless there is a product. Nonetheless, ESBATech is continuously on the look-out for new partnerships.

The first patent filed by ESBATech is owned by the University of Zurich as this was the result of research done at the University. In this case, filing was done by the technology transfer office of the University of Zurich (Unitectra). Later patents belong to the company and are filed by a patent lawyer located in Zurich. Concerning access to capital, until the creation of ESBATech, there was no real lack of capital in Switzerland. However, the recent economic downturn is drying up money and access to it gets difficult for new biotech start-ups. Even if ESBATech does not yet feel any influence of the public opinion on the company’s work, it remains a very important issue. If, for example, laws become too restrictive, biotechnology venture funds would move elsewhere.

In March 2000, ESBATech obtained the CTI Start-up label qualifying the company for venture capital investments, and initiating a collaboration with the University of Zurich. The CTI grant that followed still during the start-up phase (normally used for salaries in university-industry collaborations) was part of an agreement with the University of Zurich who became shareholder of the company. Regarding public support to clusters in biotechnology, Dr. Barberis is in favor of the US approach: the government should facilitate clustering, without intervening actively and spending money on the creation of new commissions and institutions. Therefore, according to Dr. Barberis, the government should provide good general conditions to companies, e.g. access to already existing clusters, working permits, etc. For information, the Biotech Center Zurich-Schlieren was created spontaneously, whereas recent discussions on the potential of creating a Biotech Park in Zurich were rapidly abandoned.

6.3 The Geneva-Lausanne area

6.3.1 NovImmune SA

Interview with Prof. Dr. Bernard Mach, Chairman and CSO, and Mr. Jack Barbut, CEO, on December 4, 2002.

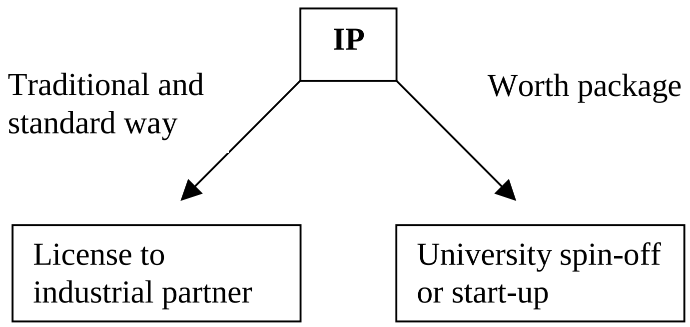
NovImmune SA is a start-up company, founded in 1998 and located in Geneva, which is dedicated to new therapies for the treatment of autoimmune system diseases and immuno-

suppression for organ transplantation. Initially funded in the seed phase by "friend and family financing", the company completed its first round of venture financing in July 2000 for CHF 15 million, with five investors participating. Combining leading scientific discoveries from the University of Geneva with a strong business plan, NovImmune has also entered into a unique agreement with the University of Geneva, which has agreed to participate as a shareholder in the firm.

In 1977, Professor Mach's interest in translational research and the potential links between academic research and industry materialized by the creation of Biogen in Geneva. In addition to all the experience acquired through the creation of this company, Prof. Mach became convinced that a job as a university professor and, at the same time, as a private business man were fully compatible, hence creating a win-win situation for both the university and the private sector. This practice was in fact already fairly common to professors in the US at the time.

When intellectual property is created from a university laboratory, there are generally two outcomes: the "traditional and standard way" of dealing with it is to valorize the discovery by licensing it to an industrial partner, which is the role of technology transfer offices. Or, if the "package" is considered worth it, a new company or spin-off from university research is created. Note that for creating a new company, it is absolutely necessary to have a business model that can transfer the know-how into a sustainable business. (See figure 6-1.)

Figure 6-1: IP transfer from university



The package of discoveries and IP related to it, the experience with venture capital and the practice of starting biotechnology companies, the network in place, and the fact that Prof. Mach was about to retire as a professor, led to the decision to set up the company at the end of 1998. Among all the decisional aspects, networking takes an outstanding place. According to Prof. Mach, "networking means being able to pick up the phone and call any CEO of any pharma or biotech company, trying to establish bridges, links and synergies". On the other side, networking also establishes links to the financial community. Among the first difficulties while setting up the company was the problem of settling the IP issues with the university, mainly because there was still no technology transfer office at this time.

Today, this is probably different as a lot of progress has been made in Switzerland in this sense over the last four years. However, this still does not mean that the academic and political environments are encouraging the creation of new companies. For Prof. Mach the goal would be that the Swiss government encourage the role of universities as a “stepping stone” to the creation of new enterprises. According to Prof. Mach, the difficulties that NovImmune was confronted with in the beginning cover all the cases of bottlenecks an entrepreneur encounters in Switzerland or Europe when wanting to start a company.

The first bottleneck is the lack of entrepreneurship within universities. Second, there is a lack of encouragement from the authorities, i.e. universities and political institutions. In fact, the person who stays at the university and has simultaneously a non-managerial advisory function within a company will often experience pressure and difficulties within his faculty as he is “flirting with business”. What is important here is to have a well-defined transfer policy for each institution which can only be achieved with professionalism. But besides some exceptions, most technology transfer offices in Switzerland are run by professors who have only little business expertise. Moreover, the role of technology transfer offices remains ambiguous: some offices consider it their duty to get the maximum financial benefit possible for their university, while others make it their objective to catalyze and facilitate the creation of spin-offs.

Another important bottleneck is the lack of “coaching structures”, that is the lack of incubators and other structures facilitating the foundation of a new biotechnology company.[106] While the reservoir of good projects and innovation, and the absolute amount of money available in Switzerland do not constitute bottlenecks, one obstacle is the insufficiency of structures that facilitate access to seed financing. For example, in this context, the Swiss government should allow business angels to write off losses that could be incurred from their investments.[107] But in general, fiscal conditions should be counted as a bottleneck on their own. In Switzerland, fiscal conditions could be improved to facilitate and encourage partners at different echelons, e.g. investors or companies in terms of stock-option plans, etc.

A further major and specific bottleneck for biotechnology companies is space. Biotechnology spin-offs are extremely dependent on a very heavy infrastructure, involving expensive laboratories and equipments. This is also why the co-existing or sharing with the university is extremely valid. Accessing the technology without compromising the company’s IP rights is crucial as IP is one of the key ingredients of a successful start-up company. By the way, according to Prof. Mach, the two main differences between the IT and the biotech world are the time frame and risk-assessment. As a consequence, the words “product” and “profitability” are completely foreign to a biotech start-up.

An additional bottleneck is the diversity of competences and backgrounds among people which are required in the field of biotechnology. This is partly why one of the aspects of the strategy of new biotechnology companies is outsourcing. In fact, one of the rules which were set up during the creation of NovImmune stipulates that whenever a problem can be better solved elsewhere, the company will outsource, with all its implications. This means the company constantly has to re-assess, and has to be flexible in shifting its priorities.

The prior bottleneck directly leads to another one, which some people consider as the most important one: there is a key time during the maturing of a new biotechnology company during which it should be run by a professional manager, and not by a scientist. But there is an objective lack of professional managers with sufficient knowledge in the field of

[106] See appendix 7 for an overview on technology parks and business incubators in Switzerland.
[107] For a deeper discussion on this topic, see seco (2003, p. 53 ff).

biotechnology in Switzerland, and the culture of the pharmaceutical business is totally different from that of the biotech business.

The final bottleneck is the Swiss and European culture of intolerance towards failure. Without a fiscal and legal environment that allows an entrepreneur to start over again without penalty, besides psychological and financial punishment, there is no incentive to entrepreneurship. But “it is through failure that you learn, not through success”. (See table 6-1.)

Table 6-1: Seven major bottlenecks in creating a biotech company in Switzerland

1st bottleneck	Lack of entrepreneurship within universities
2nd bottleneck	Lack of encouragement from public authorities
3rd bottleneck	Lack of coaching structures (incubators, etc.)
4th bottleneck	Lack of space (infrastructure)
5th bottleneck	Diversity of competences among people required
6th bottleneck	Lack of professional managers with sufficient knowledge in biotech
7th bottleneck	Swiss and European culture of intolerance towards failure

There is a sufficient pool of good scientists within Switzerland and outside that perfectly correspond to the needs of the industry. Swiss universities provide excellent training in the life sciences. Thus, Prof. Mach does not anticipate any difficulty in recruiting. Additionally, there are some very good Swiss scientists abroad that could be repatriated. Overall, medical research, biology, and life science research in Switzerland rank very high compared to the rest of the world.

Concerning the SPP Biotechnology, Prof. Mach considers that the interpretation of the field of biotechnology was given too broad a definition for this program, including for example agriculture, fermentation, and machines, and not covering for example life sciences and drug development. Moreover, with one exception at the EPFL, only Swiss-German universities received funding through this program. But Prof. Mach is convinced that if there were another national research program in this field today, it would be oriented in a different way.

6.3.2 Apotech Corporation

Interview with Prof. Jürg Tschopp, Co-Founder, on December 6, 2002.

Apotech Corporation, located in Epalinges/Lausanne, was founded in 2000 in Geneva. The company is an operating life sciences reagents company discovering, developing and producing new products in the field of apoptosis and inflammation research. Product offering, combined with technical information supports researchers in science advancement. The company’s technology base lies in molecular biology, cell biology, protein biochemistry and monoclonal antibody production.[108]

[108] See www.apotech.com.

In 1996, Apotech Biochemicals SA was co-founded by Profs. Lars French (University of Geneva) and Jürg Tschopp (University of Lausanne). The principal motivation was to find extra resources for their research laboratories. Apotech started selling its products through Alexis, a company based in the Basle region. In 1999, Apotech's activities, i.e. product sale and drug development, were split, thus creating a spin-off, named Apoxis. Today, Apotech Corporation continues to focus on research, and Apoxis, which took over all patents for drug development, sells products. In 2002, Apotech had 25 employees, with offices in the US and in Japan.

Because of the existence of an already extensive IP portfolio, the choice of top-quality international investors and VC (preferred to Swiss VC) was abundant, contrary to the current state of industry. A dense network and useful contacts also facilitated financing. Public support was (and will be) provided by CTI projects which contributed funds via Apoxis to finance researchers at Apotech.

As the laboratories at the Institute of Biochemistry of the University of Lausanne (UNIL) started to become too small quite early, the company moved to the Biopole Lausanne Region which was created in 2000. Precisely, it was the Canton of Vaud that assisted in finding and financing land. As for access to qualified personnel, the company has faced no difficulties in recruiting until now.

Apotech holds a contract with the University of Lausanne giving a 20% discount to the University on all Apotech products. At the same time, the company's researchers get all existing reactives at the University for free. Another important aspect: Apotech has the first right of refusal with regard to anything that comes out of Prof. Tschopp's laboratory. In addition to this contract, negotiations are undergoing between the University of Lausanne and Apoxis to become shareholders in the company. The basic principle is that investors invest in Apoxis, and Apoxis delegates basic research to the University.

On the level of industry links, in addition to contracts with Hoffmann-La Roche and Novartis, Apotech has a contract with US-based Biogen whose leading product uses at present Apotech patented technology. To note that the contract between Biogen and Apotech was concluded before the one between Apotech and the University. In fact, according to Prof. Tschopp's experience, industry always appreciates if they can circumvent universities as decisions can be taken more rapidly and efficiently.
Apotech has a well-defined strategy in place for IP. In respect to a contract between Apotech and Apoxis, all research results are forwarded to Apoxis to be patented there. In total, there are 15 patents as of 2002.

Besides its participation in a CTI project, Apotech did not take part in any other public programs, such as the SPP Biotechnology. Though Prof. Tschopp would prefer a team of small units who once a year make a tour of the Swiss biotechnology industry, and thus create and distribute contacts and networks, he welcomes the NCCR initiative and values the results of the earlier SPP Biotechnology.

Prof. Tschopp is convinced that public authorities can have a big influence on the creation and the development of clusters; the Biopole Lausanne Region is proof of that. The problem consists in finding the right people to do this work, as public authorities are often risk-averse and lack confidence in the success of the biotechnology sector.

6.3.3 Laboratory of Cellular Biotechnology, CBUE (EPFL)

Interview with Prof. Dr. Florian Wurm, Co-Founder of ExcellGene, on January 28, 2003.

The Center of Biotechnology UNIL/EPFL (CBUE), which comprises the Laboratory of Cellular Biotechnology (LBTC) of Prof. Wurm, is an academic institution focusing on teaching and fundamental and applied research within the field of molecular and cellular biotechnology. Its research and development work has a principally medical emphasis, applying tools for molecular biotechnology, cellular biotechnology, cell technology, process engineering, analytical biochemistry and downstream-recovery technologies. Several projects within the CBUE aim at the development of novel therapeutic and/or prophylactic products for human use. Due to links to external academic and commercial institutions, know-how has been accumulated in recombinant protein expression and the development of suitable manufacturing processes for clinical applications.[109]

In 1995, Prof. Wurm was nominated professor of biotechnology at the EPFL, while his colleague Nicolas Mermod was nominated professor of molecular genetics at the University of Lausanne. Jointly they founded the Center of Biotechnology which still exists at the EPFL, and which includes the Laboratories of Molecular and Cellular Biotechnology UNIL-EPFL. At that time, people in Switzerland started to realize that the Swiss biotech scene was lacking a certain emphasis, especially concerning the “modern” aspects of biotechnology.

Concerning research in biotechnology, Switzerland – compared to other countries – can definitely offer high-quality science in basic fields, as proven by the Nobel Prize in Chemistry 2002 for Kurt Wüthrich (ETHZ). But, according to Prof. Wurm, by comparing fundamental research from any area which is put into use, Switzerland is far behind other countries. There are countries, like the US, which aggressively support biotechnology because of a clear conviction that this is the only economic sector that is growing. In fact, “we’re just beginning to see what’s possible”, even though Switzerland has not embraced this idea yet.

Prof. Wurm sees insufficient lobbying in biotechnology as one major reason for this unsatisfactory situation in Switzerland, which is not improved by the presence of Big Pharma. Also the SNSF “gave up” the SPP Biotechnology, thus closing down all applied research programs. This program represented an important source of funding and was essential for the survival of Prof. Wurm’s laboratory. Even if the university has its own responsibility, an institute like the EPFL should not have difficulties in supporting applied research. Overall, Prof. Wurm estimates that the SPP Biotechnology was a “very good” program, mainly due to the persons in charge of it.

Prof. Wurm’s laboratory maintains various links with industry, e.g. Pfizer, AstroZenica, Aventis, Merck, and VaxGen, a spin-off from Genentech specialized in HIV vaccines. Those links help for example in a significant way to overcome financial difficulties inside the laboratory. Another important contract has been established with the Ludwig Institute for Cancer Research, a not-for-profit global research organization. As the Institute encounters difficulties to translate its fundamental research into reality, Prof. Wurm’s laboratory supports moving some of its products into the pipeline for clinical evaluation.

[109] See dcwww.epfl.ch/igc4.

Even though the constraints from industry are very high with respect to IP, Prof. Wurm's laboratory produces approximately 30 scientific papers per year. This implies dealing with the restrictions imposed by industry, which is very protective of its IP, on the one side, and the need to publish as a professor on the other. With regard to IP registration, the laboratory usually files for patents if there might be a commercial potential for them. The problem here is that in the field of biotechnology, a patent may not have a real value for several years, due to long patent granting procedures. So although the EPFL supports the idea of filing patents, the office in charge often does not have enough money to sustain those patents. As a consequence, Prof. Wurm is more concerned about running his laboratory and being productive than filing patents.

According to Prof. Wurm, technology transfer is still lacking experience at the EPFL, though it is extremely important to know how to "sell" good ideas. For example, Prof. Wurm is co-founder and scientific advisor of a spin-off from his own laboratory, called ExcellGene. As the costs of taking licenses are high, and since the company did not go for "big money" and VC (as too risky), it was decided to slowly build up the company. At this stage, ExcellGene is planning a move to the Biopole Monthey (Valais) in the near future.

Although the last referendums in Switzerland related to life sciences (e.g., GMOs) turned out positively, the attitude among the public opinion is still tense. In fact, there is not a single politician in Switzerland who publicly supports biotechnology or declares his dissatisfaction with Big Pharma which rarely create new jobs. That's why for Prof. Wurm, political will is still lacking in Switzerland.

6.3.4 Department of Medical Biochemistry, University of Geneva

Interview with Prof. Dr. Robin Offord, Co-Director of the Department of Medical Biochemistry and Former Medical Faculty's President of Pre-Clinical Medicine, on February 26, 2003.

The Department of Medical Biochemistry of the University of Geneva School of Medicine is located in the "Centre Médical Universitaire" (CMU). Part of the section for Basic Medical Science, the department currently counts eleven research groups, among them that of Prof. Offord.[110]

Prof. Offord co-created altogether four biotechnology companies in the US and Switzerland. He was co-founder of the California-based start-up which divided to become Gryphon Sciences (re-branded as Gryphon Therapeutics) and Ciphergen Biosystems. Founded in the "classical Californian way" with insufficient VC, the first difficulty was to get a lead investor. One of the reasons for establishing the company in California was the origin of one of the three scientific founders. Moreover, no institutional discouragement was encountered. On the other hand, Geneva or Zurich were less enthusiastic about welcoming the company. Public help was proposed in Switzerland, but in the end no deal took place.

Prof. Offord was a director of Geneva Bioinformatics SA (GeneBio). The mission in mind at the creation of this company was to assemble world-wide data on proteins in a systematic

[110] See www.unige.ch/medicine.

way. This knowledge base then became SWISS-PROT. After a first failure of applying for funding to the European Union (EU), support was finally granted by the University of Geneva, private industry, and the EU. Today, SWISS-PROT is an equal partnership between the European Molecular Biology Laboratory (EMBL) and the Swiss Institute of Bioinformatics (SIB). One major issue during the foundation of the company concerned the access modalities for private companies and academia to the data base. In fact, the explicit mixing of business and academic issues was a true problem for the University of Geneva at the time. Another important issue was the complexity of the IP – non-existing in the beginning – as it was public domain.

In 2000-2001, before returning to his University position, Prof. Offord was founding President and Executive Vice-Chairman of Geneva Proteomics, Inc. (GeneProt). GeneProt evolved out of decade-long academic research and was created during the bubble of 2000, which facilitated the attraction of important institutional and strategic investors from the US and Europe, including Switzerland. Furthermore, the company received support from the University of Geneva as well as several cantonal and federal authorities, which helped to overcome problems such as working permits and location.

For IP protection, licensing agreements and a cash investment, a 5% equity share was granted to the University of Geneva. Moreover, to fully respect public interests, Prof. Offord's salary as a professor was repaid to the University. Overall, there were very few obstacles that occurred during the foundation of GeneProt. The only exception for Prof. Offord is the existence of the capital tax. As the grant of share options, necessary if recruiting worldwide, constitutes an additional income, individuals are taxed on their annual value. (See box 1.) But even though on the other side there is no capital gains tax, Prof. Offord considers that in general "institutional factors are against entrepreneurship in Switzerland".

Box 1: Employee participation rights

Employee stock-options represent a new way of remuneration with some success in the industrialized world and also in Switzerland. Those options provide to the company's collaborators, mainly its managerial staff, the right but not the obligation to acquire a certain number of shares for a price fixed in advance (strike price) at a fixed date ("European" option) or until a fixed date ("American" option). Obviously, the share price – when exercising the right – is inferior to its market price (Zarin-Nejadan, 2004, p. 101 ff).

Hence, this kind of incentive remuneration has mainly two objectives: on the one hand, it allows the collaborators to participate in the created added value of the company, and on the other hand, it coincides their interests with those of the share holders. In addition, stock-options can facilitate the creation of new companies as they allow to remunerate employees without affecting the losses and profits account.

In our days, the fiscal administration considers non-realized stock-options as an immediately taxable income. This means that the option owner has to pay taxes without having realized an income. This creates a certain number of problems, mainly the one of time limitation as most option plans generally contain a clause fixing a limitation in time. Another problem concerns mainly American companies remunerating largely via options. In doing so, the stock-options' revenue might be higher than the fix salary. In those cases, collaborators might miss liquidities allowing them to pay their income taxes.

Therefore, it seems that taxes should be paid in the moment of exercising such options and not, as currently, when delivering them to the employee. Many countries, principally Germany, France, Japan, the Netherlands and the UK, have recently modified their fiscal legislation in this context, introducing more favorable legal provisions with regard to stock-options. In Switzerland, a reform of the fiscal treatment of stock-options is currently on the way.

While recruiting is generally a difficult task, the Swiss education system is qualified as excellent by Prof. Offord, especially for technicians. On the other hand, it seems that Switzerland as a whole, but also Europe, is "uncomfortable with excellence" in a certain way: therefore, losses like the one of Biogen have to be avoided. And GeneProt is already incorporated in Delaware…

6.4 Other locations

6.4.1 Europroteome AG

Interview with Dr. Silvano Cometta, Project Manager, on November 19, 2003.

EUROPROTEOME AG – the Human Cancer Company – is a product-focused biopharmaceutical firm focusing on R&D and product development in the area of epithelial cancers. Founded and initially located in Geneva, the company is now based in the Biotech-Bogen at Hennigsdorf/Germany (near Berlin). EUROPROTEOME's mission is to provide the oncology market with diagnostic and prognostic products, patient-specific therapies, and immunological tools.
In its research, EUROPROTEOME applies proteome technology to human epithelial cancers in order to identify specific gene expression patterns. Since 1997, the company has set up one of the world's largest human tumor sample banks and cancer networks consisting of clinical and scientific researchers from various research institutes and clinics. Its patented sample preparation method provides a unique source for highly purified human tissue samples.[111]

EUROPROTEOME is the result of research cooperation among different universities in Europe, led by the University of Geneva. Because of IP-related difficulties, the company was set up with the researchers as shareholders and indirectly also IP holders. Accordingly, the IP presented the starting point for setting up the company which was initially done only for legal reasons, i.e. with no offices and no employees.

To receive public and private financing for the effective starting of the company in Switzerland, different attempts have been made. Assistance through the CTI Start-up initiative turned out to be too slow and not responsive enough. A certain familiarity with and an interest in the technology in question were also missing. Moreover, the company was not looking for any collaboration (with academia) at the time, but was basically in search of financing. Contacts in view of local financing with the Cantons of Vaud and Geneva, the University of Lausanne and the EPFL didn't work out either. As a result, EUROPROTEOME looked abroad for public financial support, and moved finally to Hennigsdorf/Germany because of better support from regional authorities in searching for offices, laboratories, personnel, tax breaks, etc. Such a stimulus is missing in Switzerland.

In September 2001 EUROPROTEOME closed its first institutional financing round which provided the company with additional resources of € 9.5 million. Currently, EUROPROTEOME is aiming to raise further equity funding in its second institutional financing round. Overall, Dr. Cometta is not satisfied with the situation in Switzerland concerning access to capital as there is a general aversion to risk-taking, a reluctance to

[111] See www.europroteome.com.

provide financing, and a certain lack of dynamism. As VC companies in Switzerland showed little interest in biotechnology during its first financing round (as they were more interested in IT at the time), EUROPROTEOME decided to move abroad.

In Germany, access to qualified personnel is not considered a problem. The quality of education in Switzerland is adequate but improvements could be done at the post-doc level. In addition, there is a general need for more bioinformaticians. It seems that Switzerland is going the right direction but there is a lack of entrepreneurial spirit among post-doc graduates. Yet the latter is a common phenomenon known also by other countries.

Concerning links with academia, EUROPROTEOME is involved in a large network of researchers who precisely constituted the basis for the foundation of the company. Co-developmental research represents a key element of this network which consists at the moment of a close community of 50 people. By the way, the parties involved in this collaboration are called "clinical cancer network". There is cooperation with different universities on research projects, while sharing technologies, tests, and patient samples. Moreover, regular seminars at EUROPROTEOME with university professors help to discuss future developments and projects. In the case of links with industry, there is technological cooperation with several companies. But EUROPROTEOME is also looking into contacts with Big Pharma (cancer research) for technology co-development and out-licensing.

As already referred to, IP issues are fundamental for a biopharmaceutical company like EUROPROTEOME. If not managed correctly, IP can become a problem. In particular, EUROPROTEOME faced a certain lack of professionalism by Swiss technology transfer offices and university which were not able to provide valuable advice at the time.

Public opinion has a high influence on the whole biotechnology sector. New laws and referendums, for example in the field of GMOs and animal testing, could threaten the livelihood of Swiss companies which may eventually be forced to relocate. In general, there is a need to better inform the public and the media, which is the responsibility of government, industry and universities.

EUROPROTEOME tried to participate in different Swiss and European research programs, but none of them concluded. In Germany, the company was involved in several programs on different projects providing non-repayable funds. These funds then allow to do less applied research, thus focusing more on projects that might in a later stage lead to product development. A suggestion from Dr. Cometta to Swiss institutions managing research programs would be for example to exchange experiences with their counterparts in Germany as they need to become more efficient, i.e. asking for less paperwork, decreasing the time consumption for companies, etc.

The implantation of EUROPROTEOME in Germany did not cause any major difficulties, mainly because public authorities are working with an experienced private investment promotion agency (IIC). Switzerland also needs experienced people with charisma to attract people and companies to the cantons and clusters in biotechnology.

6.4.2 ZLB Bioplasma AG

Interview with Dr. Hanspeter Amstutz, Research and Development, on December 2, 2002.

Founded in 1949 as a department of the Swiss Red Cross (SRC), ZLB Bioplasma AG in Bern is one of the world's leading pharmaceutical companies specializing in the manufacture of plasma products. Employing about 750 people, ZLB develops and produces drugs from human plasma for international markets. Since 2000, ZLB Bioplasma AG is a subsidiary of CSL Limited, a pharmaceutical company which operates worldwide from its headquarters in Melbourne, Australia.[112]

ZLB is involved in numerous networks with academia. The company is collaborating with the University of Bern where a research group was funded by ZLB at the Inselspital Bern (University Hospital). In case of "need for collaboration", research is also done together with the University's Department of chemistry and biochemistry. There is also a scientist from ZLB teaching at the medical faculty of the University of Bern. Another member of ZLB's knowledge network is the Pasteur Institute in Paris with which the company maintains collaborative links.

In the framework of a CTI project, ZLB is collaborating with the ETHZ and Berna Biotech AG in Bern. As a rule, it is extremely important to conclude a general agreement before beginning any kind of collaboration. For example, the Anti-D-project which started around 1995 went through different obstacles. First, the university and professor in question were not interested in creating a commercial product. Second, Unitectra asked to pay royalties to the university but which would have had a deconstructive effect on the whole project. For Dr. Amstutz, Unitectra, being too strongly focused on concrete outputs and products, created a hurdle too high, hence making itself less interesting for the private sector. For ZLB, the large network inside the CSL Group represents unquestionably a big advantage for any kind of commercial collaboration. Public opinion seems to be less of a concern for ZLB as the company's biotechnology research unit is located in Melbourne (Australia).

ZLB participated in the SPP Biotechnology for around four years (1997-2001). The joint research project with the EPFL proved to be very successful. Antibodies have been produced, and the product has been taken to clinical phase which probably couldn't have been realized as fast within the company.

The participation in the program finally came to an end as the technology transfer office of the University of Lausanne (Pactt) raised the charges for laboratory-time provided by the University and the EPFL. Moreover, due to the low productivity in cell culture creation at the University, CSL (Melbourne) is planning to take over this procedure.

Overall, contacts, meetings, reports, but also getting students in contact with practical work, were the main side-products of the participation in the program. Or, to summarize, thanks to the program, academia and industry were brought together. At present, ZLB is developing new research projects to participate in new programs.

[112] See www.zlb.com.

7 Conclusions

The aim of this study is to give a qualitative overview of the Swiss biotechnology scene while focusing on knowledge networks and institutional factors which influence the competitiveness of biopharmaceutical activities in Switzerland. The issues we tried to explore first during our interviews with key actors active in the field of biopharmaceuticals, either from the private sector or academia, were of a general nature: we were studying the general circumstances of the creation of a biotech company (public support, financing, access to qualified personnel, university education and training, company location) or, in case of a public institution, its contribution to the development of biotechnology in Switzerland. Second, we were interested in the knowledge network the company or public institution is involved in, i.e. its existing links with other private companies (e.g., strategic alliances) or research institutions. It was shown that clustering constitutes a natural means of organization among actors in the biopharmaceutical field. In this context we were also interested in the different factors favoring or inhibiting cooperation between Swiss universities and industry. Third, we were looking at the institutional factors affecting biotechnology in Switzerland, i.e. IP related issues, the availability and access to capital, and the influence of the general public opinion on regulatory conditions. Finally, we wanted to know about the benefits of public research promotion programs (e.g., SPP Biotechnology, CTI projects), and how cantonal and/or municipal authorities in Switzerland can be instrumental in the creation of biotechnology clusters on certain sites.

7.1 Starting a company

Normally, the creation of a biotech company goes back to the research results found at the university or inside the R&D unit of a large multinational biopharmaceutical company. Together with existing links with academia and industry, the knowledge accumulated during those research activities often represents the basis for the creation of a new spin-off or start-up company. Even though the high quality of science conducted in Switzerland is clearly recognized by all concerned actors, the effective transfer of technology is generally lacking. Inadequate measures of lobbying by Big Pharma or the SNSF might be one explanation for this situation.

Public support, e.g. looking for offices, laboratories, personnel, tax reductions (breaks) etc., for the creation of new companies generally exists but is less institutionalized in Switzerland, e.g. in form of incubators, than in other countries such as the United States or Germany, for example. Several actors consider the assistance provided by the CTI (CTI Start-up label, CTI projects, etc.) as not reactive and responsive enough. Moreover, its support is not sufficiently constructive and should be more directly oriented. Thus, there is a common understanding that the most appropriate infrastructure for a biotech start-up is the university, though its role as a stepping stone into business is rarely encouraged by the Swiss government. Support through university technology transfer offices, especially in the field of IP issues, is getting more and more professional, but is still behind the US or other European countries.

Networking and broad contacts are the basis for accessing capital. As there is no big venture capital company in Switzerland, financing is more complicated and clearly becomes the first hurdle to clear for any emerging company. In general, the existence of an already extensive IP portfolio or the collaboration with a big biopharmaceutical company facilitates the access to

Swiss and international VC, but it still remains difficult to find investors without excessively stringent requirements. Besides private resources which remain an important source of funding, the Novartis Venture Fund or the Venture business plan competition, for example, represent two major fund suppliers for start-up and spin-off companies in the field of life sciences in Switzerland.

Even though there is a sufficient pool of highly skilled scientists in Switzerland, access to qualified personnel is not always easy. Hence, existing links with university can be extremely helpful in finding academic scientists or Swiss researchers coming back from abroad choosing to work for a private company. The quality of education in the field of life sciences is commonly regarded as excellent. Improvements might be necessary on the post-doctoral level. Although it might not be the responsibility of the university to produce “tailor-made” graduates, a lack of entrepreneurial spirit among post-doc graduates is usually recognized by all actors. But this problem is also well known in other European countries.

Companies are principally located in one of the three major clusters of biotechnology, i.e. in the greater Basle region, the greater Zurich region, and the Lake of Geneva region (Lausanne/Geneva). The reasons advanced for locating in one of these clusters are normally the same: the availability of space, access to top-class laboratories, the creation of networks, establishing links and synergies with already located companies, and accordingly the exchange of personnel and facility sharing. This infrastructure, in close proximity to an academic institution, offers the most favorable conditions to every biotech company. The exclusive pharmaceutical environment of Basle, and hence the easy access to top skills from all over the world, makes Basle particularly attractive for the biotech industry.

7.2 Clusters and knowledge networks

Commonly, clusters are understood as a basis for useful interactions and synergies between companies, offering a favorable environment and infrastructure to biopharmaceutical companies. Even though effects of congestion have to be taken into account, positive aspects generally prevail in clusters, therefore supporting their natural creation. A sound network between industry and academia, emphasized through geographic proximity, constitutes an important asset for every company, and may even present the basis for the creation of a new biotech company as in the case of EUROPROTEOME AG. The various interactions with academia or public research institutes and active links with SMEs or pharmaceutical multinationals can take different forms and are driven by different needs. Technological cooperation, product development, in-licensing from or license agreements with Big Pharma (allowing royalties to be received), diploma works or post-doctoral studies, are just a few examples for networking among a biotech company and its strategic environment. A huge array of alliances with SMEs and multinationals and key acquisitions in the case of Big Pharma are useful instruments to broaden the range and to fortify the position of a company. An already existing network within a group of companies is an additional advantage for commercial collaborations.

While for many companies the academic community represents an important partner for new ideas, universities get access to practical experience through their ties to industry. Moreover, basic research delegated to university by a private company or, for example, moving products of a public research institute into the pipeline for clinical evaluation are two possibilities to obtain external financing for a university laboratory. In general, even though regulations are in place for university-industry collaborations, especially concerning IP issues, it is important to establish a common agreement before any kind of collaboration. Many projects initially started out as university projects constitute a starting point for further collaborative research among a private company and university on a contract basis, with an IP share regulated individually for each project. The ultimate step for the university is then to become shareholder in the company as practiced already by several universities in Switzerland. It seems however that creating links with university, often based on personal contacts, becomes more and more difficult as private companies have become more risk-averse in recent years. Additionally, the industry is unhappy with the slow and inefficient decision-making common in academic institutions. Finally, the awareness of how to handle university-industry collaborations is often missing. More experience and know-how about the needs of industry is required.

7.3 Institutional factors

Like it is the case for any high-tech company, IP related issues are of fundamental and strategic importance for every biopharmaceutical company. Constituting a start-up company's currency, a well-defined IP strategy and the professionalism of IP management become key ingredients for each company. Even though a lot of progress has been made in Switzerland since the end of the nineties there is still a general lack of experience and support in this domain. Indeed, university technology transfer offices still need to acquire more practice in how to sell good ideas. On the other side, academia generally complains about the different views between universities and industry: while industry tries to patent as much as possible, university professors are under permanent pressure to publish. Although university laboratories usually file for patents if there might be a commercial potential in view, university technology transfer offices are most often confronted with limited resources. Thus, it is not surprising that a university professor is more concerned about running his own laboratory than filing patents. Concerning IP regulation, while no major handicap or substantial difference is seen in Switzerland with regard to the US or other countries, IP harmonization on a European level seems to be nevertheless of vital concern for the whole sector.

While capital is generally abundant in Switzerland, access to it is more problematic. The general aversion to risk-taking in Switzerland (and Europe) in comparison to the US, the reluctance to provide financing, and a general lack of dynamism among investors make it particularly difficult for an emerging company to find capital. Additionally, the absence of a big venture capital company in Switzerland and the recent economic downturn make it even more complicated for new biotech start-ups to access capital. Hence, the quality of a business plan and a dense, qualified network become key assets for each company. Venture competitions or the CTI Start-up label may improve this network and qualify a company for VC investment. Finally, technical expertise by Swiss investors in the fields of biotechnology and pharmaceuticals is commonly considered as good, constituting an important criterion of selection for VC.

On the whole, the public opinion plays a very important role in the field of life sciences. This is particularly true for a country with such a high degree of direct democracy like Switzerland. Overly restrictive laws and the ratification of limiting referendums may threaten the business of Swiss biopharmaceutical companies. But unlike universities and hospitals, companies and biotech venture funds have the possibility to leave a country and relocate. For example, concerning GMOs, Switzerland and Europe as a whole stand to lose out to the US as there is a big difference in perception between the Old and the New World. To create mutual trust between the public and industry, and to better inform the public and media about sensitive issues, more communication is necessary. Bringing the life sciences into schools and colleges would allow to inform and help educate a wide audience from early on. In this case, more partners would be needed, involving government, industry and academia. An initiative which already went in this direction was the creation of the BICS office in Basle during the SPP Biotechnology. Its aim is the steady information of the public on biotech issues, including ethical and safety aspects. The creation of a Swiss life sciences organization might be a further step in this direction. Even though the biopharmaceutical industry is dependent on the public opinion, it should be able to keep its independence. Finally, considering the delicate attitude in this domain, a clear political willingness to support biotechnology in Switzerland might help soothe the present situation for all involved actors, the public included.

7.4 Public support

Public funding is fundamental, as every young company needs support. One possibility of receiving public support is the participation in research promotion programs. The most renowned program in Switzerland in the field of life sciences so far, in terms of its impact, was the SPP Biotechnology. This program is considered as having been the first instrument which allowed an effective collaboration in the field of biotechnology between industry and academia in Switzerland. Moreover, the program was able to further advance research in biotechnology and to encourage the creation of new biotech companies, mainly thanks to its in-house evaluation of Swiss biotechnology allowing to positively influence the general public perception.

Besides the companies which were directly created through the SPP Biotechnology, the companies participating directly or indirectly in the program through projects were generally satisfied with its results. All involved actors, either from academia or industry, mainly SMEs, saw a clear improvement in bridging the gap between industry and academia. Networking on an industrial but also political level, the institutionalization of technology transfer (Unitectra) and, for example, familiarizing students with the realities of entrepreneurship were just some of the positive by-products of the program. But also several critics have emerged during the program: First, some actors regretted its character of funding research in a “top-down” way, hence clearly preferring a bottom-up approach. Second, for some actors the interpretation of “biotechnology” was too broad, including many aspects of the “old” biotechnology revolving around fermentations, antibiotic production, baking and brewing. Finally, while some actors complain about the absence of an extension of the program after 2001, its former Program Director sees no abrupt termination as there is a continuation on other levels.

An alternative to the SPP Biotechnology might be the introduction of the NCCRs in Life Sciences. Though this program is not application-oriented at all as it was the case of the SPP, it includes research and educational aspects, but also knowledge and technology transfer issues. But critics regret the investment of important amounts of public money into networks, preferring to focus on particular research issues. Another well-known alternative to the SPP and NCCR initiative, is the CTI. Many companies try to get access to research funding through CTI projects, or try to obtain the CTI Start-up label qualifying a company for VC investment. And the recently launched CTI Biotech promotion campaign represents today another available instrument in the field of life sciences. To underline that all these possibilities can initiate collaboration between private companies and academia. In this context, the Universities of Applied Sciences (HES), fostered by the CTI, offer a real alternative as a valuable partner for application-oriented research. Finally, European research programs may also constitute an alternative on an international level for companies and universities.

There is a general understanding among all actors that clustering in biotechnology can be positively influenced by the public authorities. Thus it is even more surprising that almost all major biotech clusters in Switzerland result mainly from private initiatives (e.g., Biotech Center Zurich-Schlieren). To efficiently support clusters, and to successfully attract people and companies to the cantons and biotech clusters, professional and experienced people are necessary. However, to facilitate clustering and to provide positive general conditions, measures of intervention by the public authorities should be flexible and not too direct. For example, instead of creating additional commissions or institutions, local governments should facilitate the access to already existing clusters and should help in obtaining working permits for high-skilled workers from abroad. With its traditional links to France and Germany, and given its historical dominance in the biopharmaceutical sector, the Basle region could be the ideal place to promote. On the other hand, the success of formal network initiatives is put into question as young companies normally need direct access to adequate working facilities. That’s why those initiatives should be more dynamic in pro-active support and the promotion of clustering. But measuring the real success of already existing initiatives and clusters is another problem.

Overall, biotechnology in Switzerland can be considered a serious competitor to other countries active in biotechnology. Nevertheless, improvements should be made on several levels. Public authorities should stimulate the creation of clusters and support the foundation of new companies more efficiently. Technology transfer is still lacking and access to capital, while abundant, needs to be facilitated. Though institutional factors are generally good, the Swiss tax system could become more favorable for private companies. Moreover, considering the importance of the public opinion in Switzerland, a clear political commitment in favor of biotechnology in Switzerland could give a further boost to this promising industry. Finally, to avoid a delocalisation of Swiss biopharmaceutical companies to the US, Switzerland needs to learn how to embrace excellence – clearly present in this country. Hence, concluding a strategic alliance with a Swiss biotech company or moving to one of the three major clusters in biotechnology could lead to a successful integration in this network of excellence.

ACRONYMS & ABBREVIATIONS

AG	Incorporated company (in German: Aktiengesellschaft)
AF	Federal decree (in French: Arrêté fédéral)
ASBC	Association of Swiss Biotechnology Companies
BATS	Center for Biosafety Assessment, Technology and Sustainability
BFIT	Board of the Swiss Federal Institutes of Technology
BICS	Biotechnology Information and Communication Switzerland
CATI	Cooperative Agreements and Technology Indicators (MERIT)
CBUE	Laboratory of Cellular Biotechnology (EPFL)
CEO	Chief executive officer
CERS	Commission for the Encouragement of Scientific Research
CEST	Centre for Science and Technology Studies
CFO	Chief financial officer
CHF	Swiss francs
CHUV	Centre Hospitalier Universitaire Vaudois (University Hospitals of Lausanne)
CMU	Centre Médical Universitaire (University of Geneva)
CSO	Chief scientific officer
CTI	Commission for Technology and Innovation
DEA	Federal Department of Economic Affairs
DNA	Desoxyribo Nucleic Acid
DTI	Department of Trade and Industry (Great Britain)
EMBL	European Molecular Biology Laboratory
EPO	European Patent Office
ESA	European Space Agency
EPFL	Federal Institute of Technology Lausanne
ETHZ	Federal Institute of Technology Zurich
EU	European Union
EUREKA	European Research and Coordination Agency
Eurostat	Statistical Office of the European Communities
FDA	Food and Drug Administration
FIT	Federal Institute of Technology
FOES	Federal Office for Education and Science
FOPET	Federal Office for Professional Education and Technology
GmbH	Limited liability company (in German: Gesellschaft mit beschränkter Haftung)
GMO	Genetically modified organism
HES	University of Applied Sciences
HIV	Human immunodeficiency virus
ICT	Information and communications technology
IIP	Swiss Federal Institute of Intellectual Property
IMS	Intelligent Manufacturing Systems
IP	Intellectual property
IPC	International Patent Classification
IPO	Initial public offering

IRC	Increasing returns to coalition
IPR	Intellectual property rights
ISREC	Swiss Institute for Experimental Cancer Research
IT	Information technology
LAU	Federal Act of Financial Assistance to Universities
LBTC	Laboratory of Cellular Biotechnology
LLC	Limited liability company
MERIT	Maastricht Economic Research Institute on Innovation and Technology (CATI)
MMV	Medicines for Malaria Venture (WHO)
NCCR	National Centre of Competence in Research
NIH	National Institutes of Health
NIS	National innovation system
NSIOD	National Science Indicators on Diskette
OECD	Organisation for Economic Co-operation and Development
OFIAMT	Office fédéral de l'industrie, des arts et métiers et du travail
PACTT	Partnership and Corporation of Technology Transfer (UNIL and CHUV)
PCR	Polymerase chain reaction
PPP	Purchasing power parity
PSI	Paul Scherer Institute
R&D	Research and development
rDNA	recombinant DNA
SA	Incorporated company (in French: Société actionnaire)
SBA	Swiss Biotech Association
SECA	Swiss Private Equity & Corporate Finance Association
seco	State Secretariat for Economic Affairs
SFOPH	Swiss Federal Office of Public Health
SFSO	Swiss Federal Statistical Office
SIB	Swiss Institute of Bioinformatics
SME	Small and medium-sized enterprise
SNSF	Swiss National Science Foundation
SRP	Strategic research partnership
SPP	Swiss priority program
SRC	Swiss Red Cross
SRI	Industrial Relations Office (EPFL)
SSA	Swiss Science Agency
SSTC	Swiss Science and Technology Council
STI	Science, Technology and Industry (OECD)
S&T	Science and technology
SUC	Swiss University Conference
TLO	Technology licensing office
UNIL	University of Lausanne
USPTO	United States Patent and Trademark Office
USTR	Office of the United States Trade Representative
VC	Venture capital
VSBU	see ASBC
WHO	World Health Organization
WTT	Wissens- und Technologietransfer (University of Basel)

APPENDIX

Appendix 1: Questionnaire (private companies)

- What are the principal activities of your company?
  - Annual turnover
  - Number of employees
  - Importance of R&D activities
- Can you describe your academic and professional accomplishments prior to the foundation of the company?

1 Creation of the company:
- 1.1 How was your company created? (Origin, motivation, etc.)?
- 1.2 Can you discuss the following issues that you dealt with prior to or during the creation of the company?
  - 1.2.1 Support from public institutions
  - 1.2.2 Financing issues (seed capital, venture capital, etc.)
  - 1.2.3 Access to qualified personnel
  - 1.2.4 Strategic choice of company's location
  - 1.2.5 Regulatory constraints

2 Knowledge networking:
- 2.1 Can you describe the existing links, if any, between your company and other research institutes, in particular universities, active in the domain of biotechnology? (Technology transfer through licensing, collaborative research projects, exchange of personnel, exchange of information, etc.)
- 2.2 Can you describe the existing links, if any, between your company and other private companies active in high-tech (strategic alliances, etc.)? Distinguish between Big Pharma companies and other venture businesses.
- 2.3 What are the factors favouring (or inhibiting) the cooperation between Swiss universities and industry, in the field of biotechnology?
- 2.4 In your opinion, does the quality of university education today correspond to the needs of the biotech industry?

3 Institutional factors:
- 3.1 What do you think of the current condition of intellectual property (IP) regulation in the biotechnology sector in Switzerland (opinion, limits, compared to US/EU laws)?
- 3.2 What is your company's strategy with regard to IP? Its strategic importance?
- 3.3 What do you think of the availability of (and access to) capital in Switzerland?
- 3.4 In your opinion, to what extent can the general public in Switzerland influence the economic and regulatory conditions of the biotech industry?

4 Research promotion programs:
- 4.1 Have you participated (or are you currently engaging) in research promotion programs (e.g., SPP Biotechnology, CTI projects, etc.), and/or European programs?
- 4.2 If yes, how did these programs contribute to the success of your business?
- 4.3 In your opinion, did the SPP Biotechnology encourage the rapprochement between Swiss universities and the biotech industry?
- 4.4 According to your experience, to what extent can cantonal and/or municipal authorities in Switzerland be instrumental in the creation of biotechnology "clusters" at certain sites?

Appendix 2: Questionnaire (institutions)

1 Biotechnology:

1.1 What are the defining moments that have marked the emergence and the development of biotechnology in Switzerland?
1.2 What was the contribution of your institution to this emergence?
1.3 What are the respective contributions of universities and private companies?

2 Knowledge network:

2.1 Can you describe the existing links, if any, between your institution and Swiss universities active in the domain of biotechnology?
2.2 Can you describe the existing links, if any, between your institution and private companies active in high-tech?
2.3 What are the factors favouring (or inhibiting) the cooperation between Swiss universities and industry, in the field of biotechnology?

3 Institutional factors:

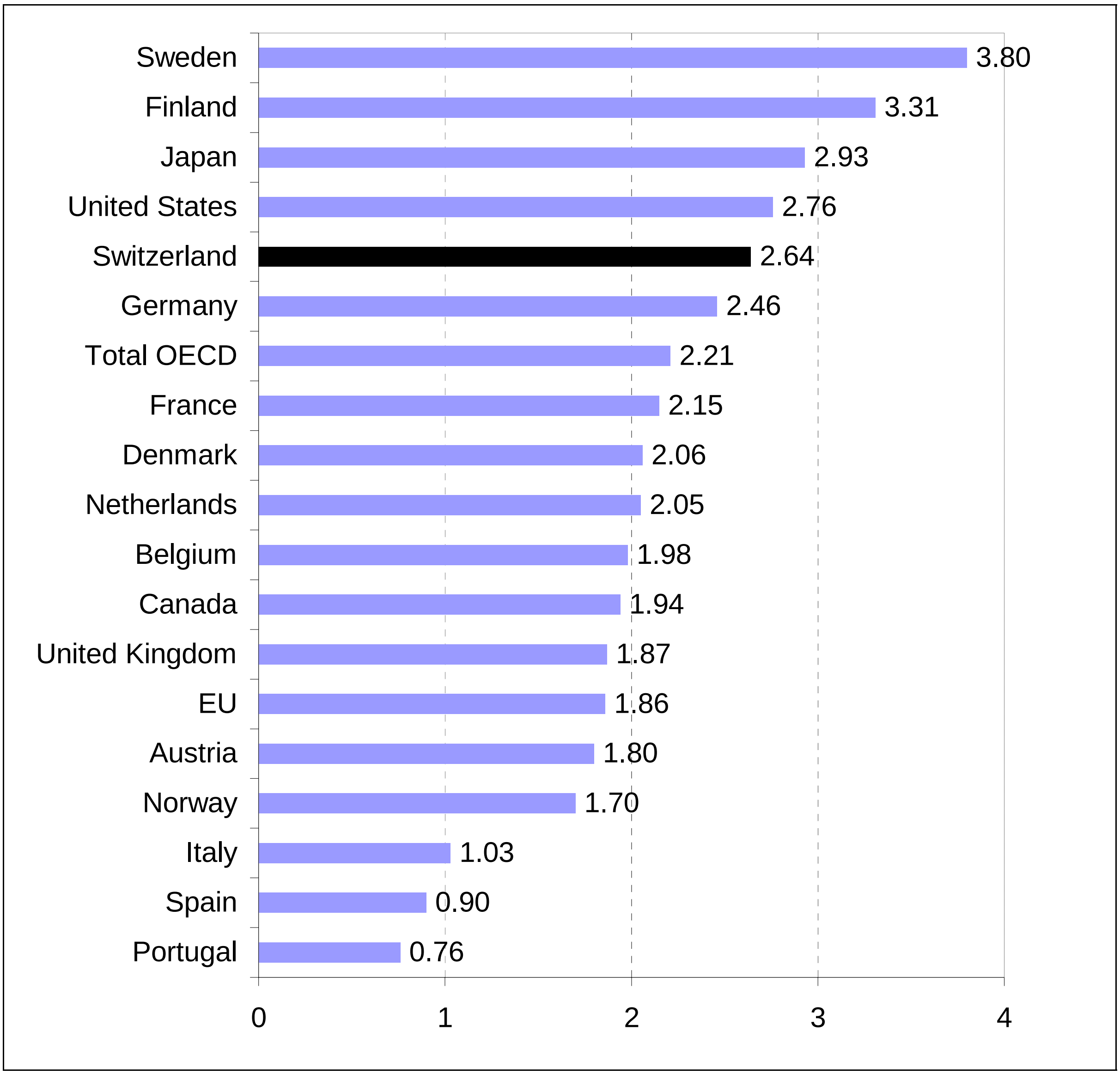
3.1 How do you judge the availability of capital, and the access thereto (seed-capital, venture capital, etc.) in the Swiss financial market?
3.2 How do you see intellectual property (IP) regulation in the biotechnology sector in Switzerland?
3.3 In your opinion, to what extent can the general public in Switzerland influence the economic and regulatory conditions in the biotech field?

4 Research promotion programs:

4.1 Have you participated (or are you currently engaging) in research promotion programs (e.g., SPP Biotechnology, CTI projects, etc.), and/or European programs?
4.2 If yes, what was the responsibility of your institution?
4.3 In your opinion, did the SPP Biotechnology encourage the rapprochement between Swiss universities and the biotech industry?

Appendix 3:

Gross domestic R&D expenditures, international comparison, 2000*.



Source : OECD (2001b) / SFSO (2002).

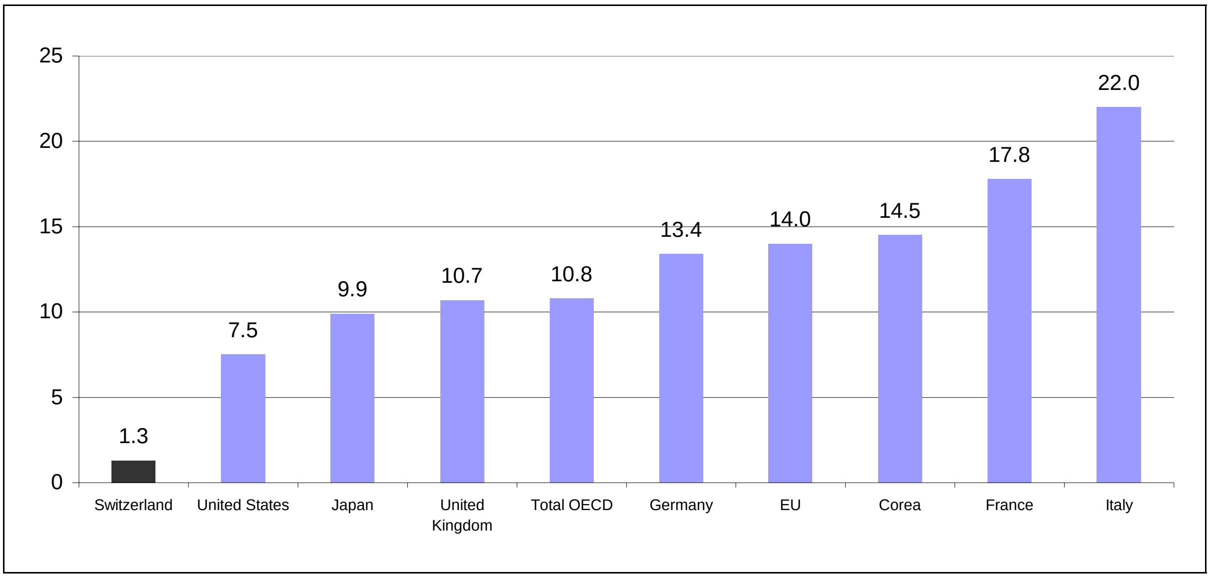
*2000 or most recent year.

Appendix 4:

Execution of R&D by sector of activity, international comparison, 2000*.

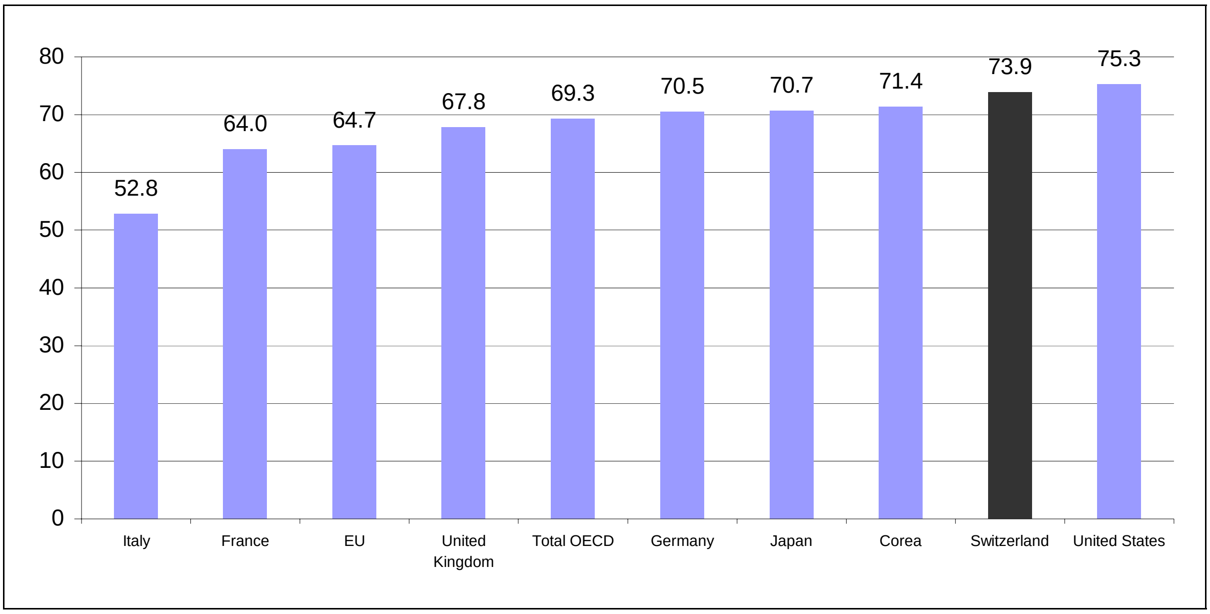
In % (million CHF).

a) State



Source : OECD (2001b) / SFSO (2002).

b) Private companies



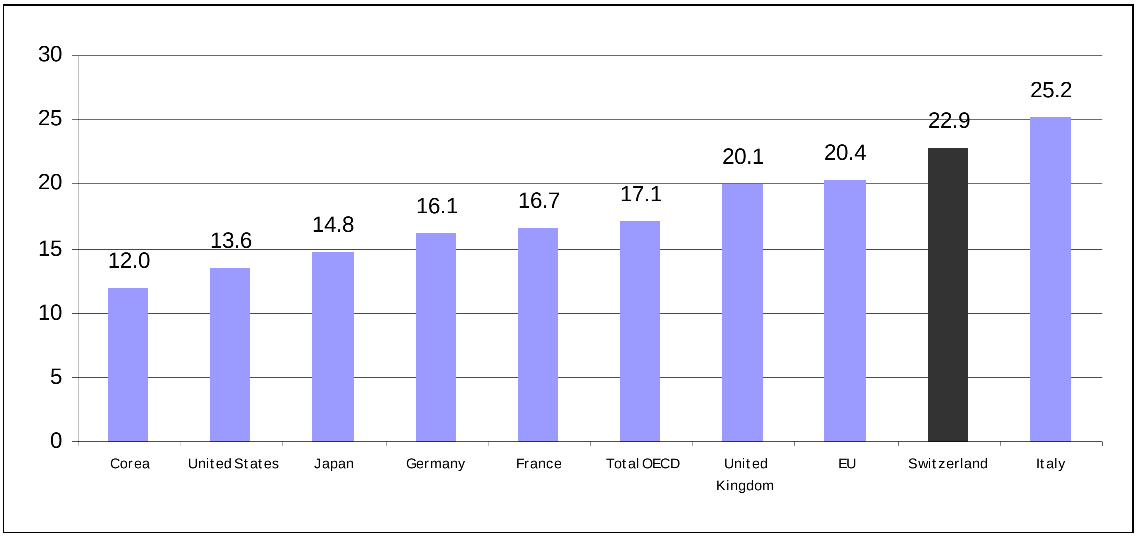
Source : OECD (2001b) / SFSO (2002).

*2000 or most recent year.

Execution of R&D by sector of activity, international comparison, 2000*.

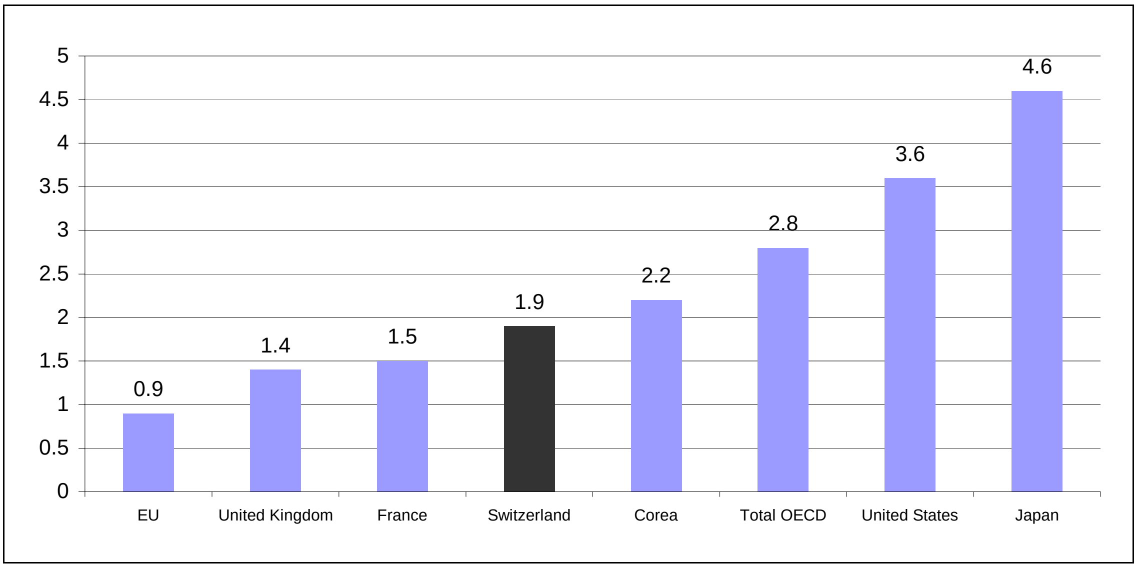
In % (million CHF).

c) Higher education



Source : OECD (2001b) / SFSO (2002).

d) Non profit private institutions



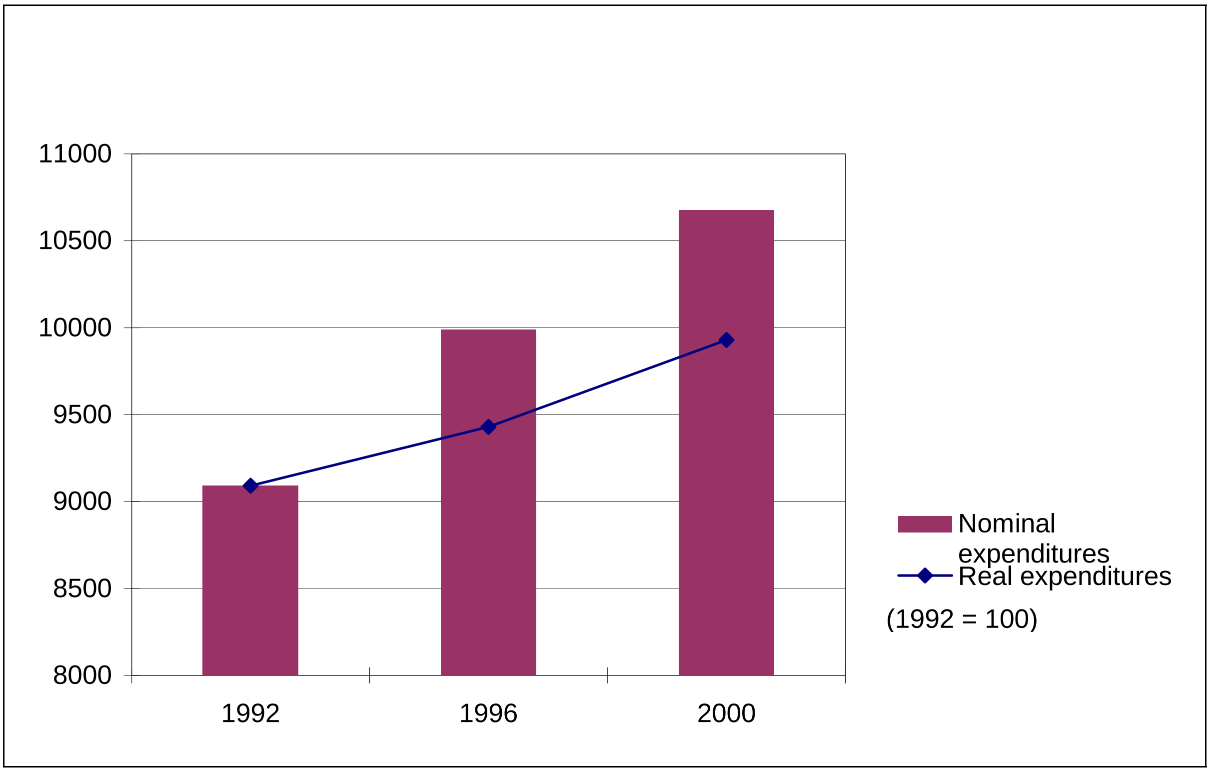
Source : OECD (2001b) / SFSO (2002).

*2000 or most recent year.

Appendix 5:

Intra-muros R&D expenditures in Switzerland, all sectors of activity, evolution 1992 – 2000.

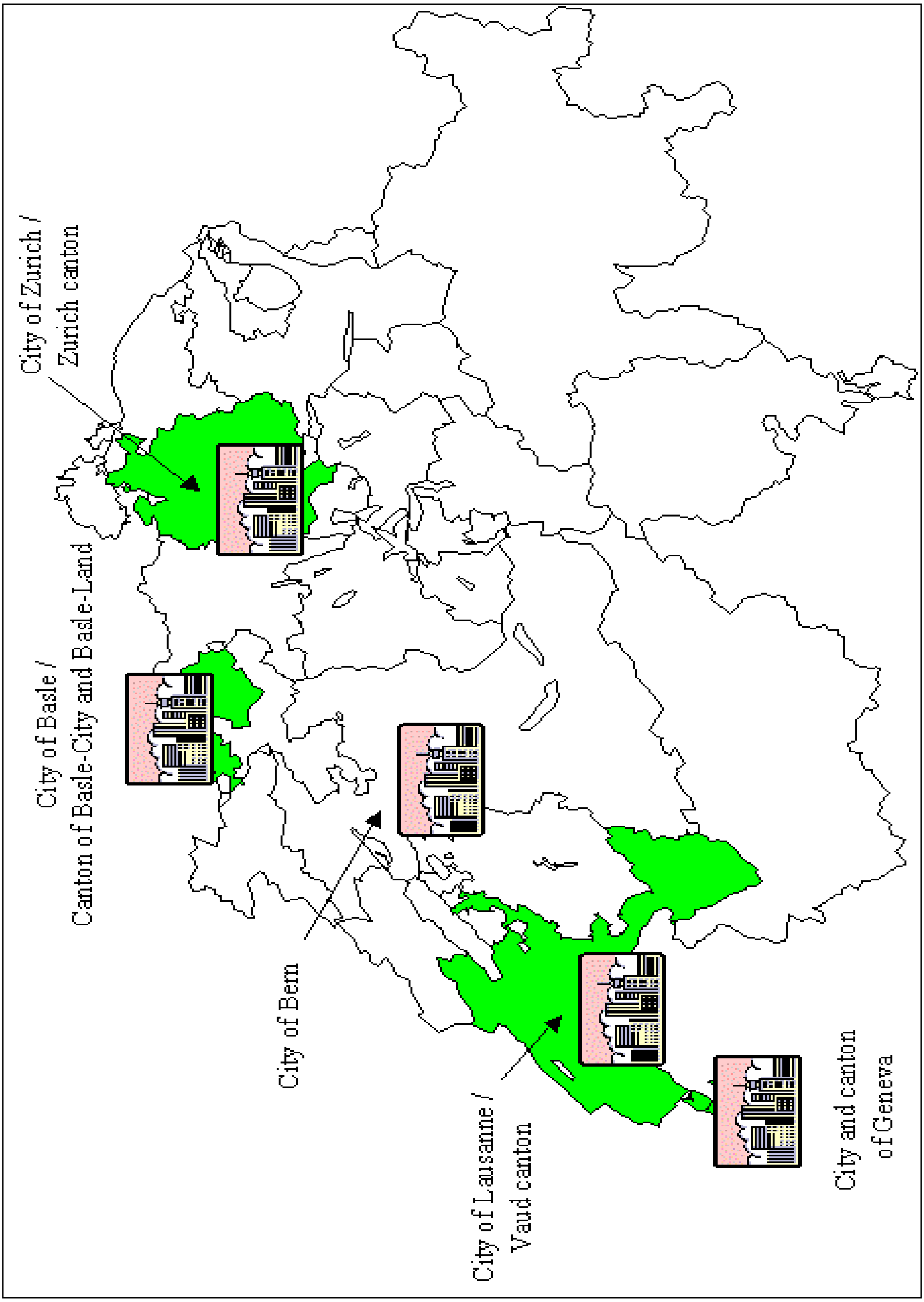
In million CHF, round numbers.



Source : SFSO (2002).

Appendix 6:

Main Swiss areas active in biotechnology



Appendix 7:

Swiss technology parks and business incubators

Areal Gurtenbrauerei www.grueze.ch
Berner Technopark www.bernertechnopark.ch
Biopôle incubateur et parc biotechnologique www.biopole.ch
Business Parc Reinach www.businessparc.ch
Businesspark Zug www.businessparkzug.ch
Centre de Technologies Nouvelles SA (CTN) www.ctn.ch
COFIDEP SA, Porrentruy (Canton of Jura)
e.Tower Thun www.e-towers.org
ESPAS (former Gruefa) www.espas.ch
E-Tower Chur www.fh-htwchur.ch/institute/etower
Galleria High-Tech Center www.galleria.ch
Genossenschaft Technologiezentrum Linth www.tzl.ch
grow Gründerorganisation Wädenswil www.grow-waedenswil.ch
Gründerzentrum Aargau www.agv.ch
GründerZentrum Bern www.grueze.ch
GründerZentrum Berner Oberland www.grueze.ch
GründerZentrum Biel www.grueze.ch
GründerZentrum im MEGA-Zentrum www.grueze.ch
Gründerzentrum Kanton Solothurn www.gzs.ch
GründerZentrum Oberaargau www.grueze.ch
Haus Futur Rapperswil www.hsr.ch
HTC High-Tech-Center AG www.high-tech-center.ch
Initial Innovation and Start-up www.initial-gr.ch
Innovationszentrum Allschwil www.baselarea.org
Innovationszentrum Nordwestschweiz www.innovationszentrum.ch
ITS Industrie- und Technozentrum Schaffhausen www.ist.sh.ch
Kompetenzzentrum toolpoint Hombrechtikon www.toolpoint.ch
mediacampus Zürich www.mediacampus.org
Neode, Parc scientifique et technologique Neuchâtel www.neode.ch
Progetto Parco Technologico www.tinnova.com
PSE Parc Scientifique sur le site EPFL www.epfl.ch/pse
Regiotech Porrentruy Adep www.regioplus.ch
ri.nova impulszentrum www.rinova.ch
START Unternehmenszentrum Zürich www.startzentrum.ch
Start! Gründerzentrum Frauenfeld www.gruendungszentrum.ch
SwissParks.ch, Club of Swiss Technology Parks and Business Incubators www.swissparks.ch
Tebo St. Gallen c/o EMPA St. Gallen www.tebo.ch
Technologie- und Dienstleistungszentrum Flawil www.tedizentrum.ch
Technopark Luzern www.d4center.ch
Technopark Winterthur AG www.tpw.ch
Technopark Zürich www.technopark.ch
Tenum AG, Zentrum für Bau/Energie- und Umwelttechnik www.tenum.ch
TZO Techno-Zentrum Oberwallis www.tzo.ch
TZW Technologiezentrum Witterswil
Vulcain, Pépinière d'entreprises www.theark.ch
Y-Parc SA, Parc Scientifique et Technologique www.y-parc.ch
ZUT Zentrum für Umwelttechnologie/Neuunternehmerzentrum Wirtschaftsraum Thun WRT www.zut.ch

Source: modified and expanded from Swiss Biotech (www.swissbiotech.org).

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