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Effectiveness of innovation policies: biotechnology in The Netherlands (1994-2001)

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Contents

1 Introduction

The EPOHITE project explores the effectiveness of biotechnology innovation policies in the EU Member States. EPOHITE applies an actor-based approach for studying the policy impact on the performance of important components in the innovation system. A selected group of different actor types, which are relevant for a successful innovation system and which are therefor the subjects of innovation policy in most countries, are analysed in detail using a mix of quantitative and qualitative indicators.

In the EPOHITE project, we distinguish between 4 types of actors: large firms, successful small and medium sized enterprises (SMEs), high performing start-ups, and public sector research organisations. Large firms are both national firms and multinationals, which are not dedicated to biotechnology, but have biotechnology research activities in the country. They are present in the biopharmaceutical and/or agro-food sector. Successful SMEs have left the start-ups stage and have the main goal to manage consolidation and growth. They usually have been established before 1996 and have already received a third tranche of investment. High performing start-ups are new biotech firms that are mainly dealing with managing the start-up stage, but are also planning or have already experienced growth. Public sector research organisations include university research groups, academic hospitals, public research institutes and charity research organisation that receive at least 25% of their budget from public funding and that carry out a considerable part of their basic and/or applied research in biotechnology.

In order to assess the performance and success of the four actor groups, national case studies in 14 EU Member States are conducted. Based on the national case studies, clusters of countries performing at the same level will be defined and analysed for their policy effectiveness. The website http://www.epohite.fhg.de gives more information about the methodological aspects of the EPOHITE project.

In this national report, the Dutch case study is presented. First of all, in chapter 2 an overview of the Dutch policies affecting the innovation system in the Netherlands is provided. In chapter 3, the performance of the Dutch biotechnology innovation system is discussed, based on the results of the analysis using quantitative performance indicators like publications and patents. Based on the interviews with the Dutch respondents, the respondents' perspectives on the policy effectiveness are summarised in chapter 4. Finally, chapter 5 presents the main conclusions on the policy effectiveness in the Netherlands.

2 The Dutch biotechnology policy profile: 1994-2001

2.1 Introduction

In this chapter we present an overview of the public policies affecting the biotechnology innovation system in the Netherlands in 2001 and its changes since 1994. We distinguish between so-called vertical policies, with instruments and programmes that aim at directly influencing the biotechnology system and horizontal policies, with instruments and programmes that mostly have an indirect influence.

With approximately 16 million inhabitants the Netherlands belongs to the category of small countries within the European Union. In 2001, the Dutch gross domestic product (GDP) amounted to € 429 billion. Moreover, in 2001 The Netherlands showed a positive trade balance with exports amounting to € 280 billion and imports to € 257 billion. Main industrial sector is the agricultural and food sector with the (petro)chemical sector as second best.

The gross domestic expenditures on R&D (GERD) have shown an increase since the early 1990s to € 7.6 billion in 1999 (CBS, 2002). This means a growth of 33.5% since 1994. Business expenditures on R&D amounted to € 3.8 billion in 1999 and government expenditures to € 2.7 billion. However the Dutch R&D intensity, in terms of GERD as percentage of GDP, has been fluctuating over the recent years: 2.04% in 1997, 1.94% in 1998 and 2.02% in 1999. This is below the OECD average (2.21%) but above the EU-average (1.85%) (CBS, 2002).

In 2001, the Dutch government spent approximately € 3 billion on research and development of which the Ministry of Education, Culture and Sciences (63.9%) and the Ministry of Economic Affairs (16.5%) are the most relevant contributors (NWO website). The main administering agencies responsible for executing the different programmes and instruments are the Netherlands Organisation for Scientific Research (NWO) and Senter.

NWO promotes basic and applied scientific research at Dutch universities and other public research organisations with funds mostly coming from the Ministry of Education, Culture and Sciences. NWO's subsidy policy can be summarised as:

1. maintaining a substantial financial volume for open competition,
2. introducing transdisciplinary scientific themes, involving several Research Councils,
3. strengthening the person-based individual support for pioneering research by highly talented researchers, and
4. increasing the financial resources for major investments in large scientific research equipment (incl. databases etc) (NWO website).

One of the main tasks of Senter is the management of technology and R&D support schemes. Most of the R&D funds come from the Ministry of Economic Affairs and is channelled through Senter to companies and research organisations.

During the 1980s, the Dutch government stimulated biotechnology through several specific programmes of which the innovation-oriented research programme (IOP) and the industrial biotechnology stimulation programme (PBTS) were the most prominent. In the period 1981-1993, the Dutch government invested more than € 178.6 million in biotechnology over the period, mainly through biotechnology specific instruments (Enzing et al, 1999). This resulted in a strong public and private research base. However, in the early 1990s, the Dutch government shifted towards a more generic or horizontal S&T policy. Over the period 1994-1998, total public spending on biotechnology amounted to € 155 million of which € 11 million through specific biotechnology programmes and funding mechanisms and € 144 through general funding mechanisms (Enzing et al, 1999).

In the following, as programmes and instruments often serve several policy goals they can be found under several policy types. Annex 1 shows how the programmes and instruments match with the various policy types.

2.2 Vertical policies in the Dutch biotechnology innovation system in 2001

2.2.1 Policies for knowledge base support

2.2.1.1 Instruments for the support of basic research

The instruments for the support of basic research in the field of biotechnology are a number of research programmes managed by NWO. These programmes mostly deal with genomics or genomics related areas:

- Research programme *Genomics* (2001-2006, € 13.7 million)
- Research programme *Biomolecular Informatics* (2001-2007, € 18.5 million)
- Research Programme *Structural/functional relation biomolecules* (1995-2003, approx. € 2 million)

In addition, basic biotechnology research is stimulated through the '*Centre for Biomedical Genetics*' which is a so-called Top Research School. The Ministry of Education, Culture and Sciences initiated these Top Research Schools through a bonus incentive scheme in 1997 in order to upgrade the existing academic research schools in the Netherlands.

2.2.1.2 Instruments for the support of industry oriented (and applied) research

Instruments to support industry oriented and applied research in biotechnology by public research organisations are managed by both NWO and Senter. The programmes, and in particular the IOP scheme, are mainly focused on performing industry relevant and oriented research. The IOP scheme as such could be regarded as a horizontal instrument as it is organised into several technological areas. However, we consider the specific IOP *Genomics* scheme as a vertical policy instrument as it is especially initiated for the stimulation of industry-oriented research in genomics.
The BioPartner support for shared research facilities is managed by Mibiton, which started as a revolving fund in 1994 for running high grade biotechnology facilities that are located and serviced by Dutch scientific groups at universities and institutes.
Most of the programmes deal with genomics, genomics related areas and research in diagnostics and therapeutics.

Another instrument aiming at the industry oriented research is the Leading Technological Institute ‘Wageningen Centre for Food Sciences’ (WCFS). WCFS is one of the four Leading Technological Institutes established in 1997 at the initiative of and with support from the Dutch Government. WCFS is an alliance of research organisations and industry to carry out strategic, non-competitive and industry-oriented fundamental research that will increase the understanding of the mechanisms involved in food functionality.

- Innovation-focused Research Programme Genomics - *IOP-Genomics* (2000-2008, € 20.4 million for the period 2000-2004)
- *BioPartner Facilities Support* (€ 1.8 million annually)
- Support Programme for Innovative Medicine Research and Entrepreneurship in the Netherlands – *STIGON* (2000-2004, € 8.8 million)
- Research Programme *Computational Chemistry of Biosystems*, together with Unilever (1996-2002, € 1.34 million)
- Leading Technological Institute ‘Wageningen Centre for Food Sciences’ (€ 12.3 million annually)

2.2.1.3 Instruments for the support of academic co-operation
Instruments actively supporting academic co-operation in biotechnology among public research organisations and disciplines are not present as such. Some of the instruments that aim at stimulating basic and applied research, e.g. the IOP Genomics and the NWO research programme ‘Biomolecular Informatics’, address implicitly the realisation of sustainable research networks.
However, the Ministry of Education, Culture and Sciences started in the early ‘90s graduate research schools – combining high quality research with PhD and graduate education – in order to upgrade the quality of Dutch science and education. Mostly, several university research departments are united in these graduate research schools. In 2001, 8 graduate research schools were dedicated to biotechnology research (Kern et al, 2002). In this context, the Top Research School ‘*Centre for Biomedical Genetics*’ also contributes to the stimulation of academic co-operation.

2.2.2 Policies for commercialisation support

2.2.2.1 Instruments for building technological capabilities for industry
The main instrument supporting the creation of industry oriented biotechnology research is the *IOP Genomics* scheme, managed and administered by Senter. However, the research itself is mostly carried out by PhD students at university research departments and financed by industry. The Wageningen Centre for Food Sciences can also be considered as an instrument in improving the technological capabilities of industry through biotechnology research.

- Innovation-focused Research Programme Genomics - *IOP-Genomics* (2000-2008, € 20.4 million for the period 2000-2004)
- Leading Technological Institute ‘Wageningen Centre for Food Sciences’ (€ 12.3 million annually)

2.2.2.2 Instruments for the commercialisation of scientific results from PSROs
Instruments to support the commercialisation of scientific results are mainly provided by the Ministry of Economic Affairs through BioPartner, which acts as administering

agency. In addition, some programmes of NWO explicitly aim to support the commercialisation of scientific results in the (bio)medical field.

- Support Programme for Innovative Medicine Research and Entrepreneurship in the Netherlands – *STIGON* (2000-2004, € 8.8 million)
- *BioPartner First Stage Grant* (€ 11.34 million)
- *BioPartner Centres* (€ 2.3 million)
- *BioPartner Network*
- *BioPartner Start-up Ventures* (€ 10 million)

2.2.2.3 Instruments for the stimulation of public-private collaboration
The main programme to support public-private collaboration in biotechnology is the IOP Genomics scheme. Moreover, public-private collaboration is promoted through the Leading Technological Institute 'Wageningen Centre for Food Sciences' (WCFS).

- Innovation-focused Research Programme Genomics - *IOP-Genomics* (2000-2008, € 20.4 million for the period 2000-2004)
- Leading Technological Institute '*Wageningen Centre for Food Sciences'* (€ 12,3 million annually)

2.2.3 Policies with a socio-economic and/or ethical dimension
As part of the Netherlands Genomics Initiative, the Netherlands Organisation for Scientific Research (NWO) administers a special programme that is focused on the socio-economic and ethical issues of genomics research:
- Research Programme *Societal Issues in Genomics Research* (2001- , € 2.3 million)

2.3 Horizontal policies in the Dutch biotechnology innovation system in 2001

2.3.1 Support of the knowledge base, including mobility of researchers
Horizontal programmes to support the knowledge base are mainly managed by the Netherlands Organisation for Scientific Research (NWO). In 2000, NWO introduced the new-style *Innovational Research Incentive Scheme* which provides support through three different subsidy schemes (Veni, Vidi, Vici) to outstanding scientific researchers in several phases of their careers.

The most relevant NWO programmes with expected connections to biotechnology research are:
- Research programme *Food and Chronical Diseases* (1997-2002, € 5.22 million)
- Research programme *Nutritious Food* (2000-2006, € 8.17 million)
- Research programme *Combinatorial Chemistry* (2001-2008, € 3.4 million)
- *Innovational Research Incentive Scheme* (2000-2007) with the following subsidy schemes:
    - VENI (€ 0.2 million for a period of 3 years for approx. 120 awards)
    - VIDI (€ 0.6 million for a period of 5 years for approx. 75 awards)
    - VICI (€ 1.25 million for a period of 5 years for approx. 25 awards)

2.3.2 Support of commercialisation of technologies
There are several horizontal instruments that support the commercialisation of technologies. They are all administered by Senter. Several of these programmes aim at

research collaboration between industry and public research organisations, e.g. the IOP schemes. Some programmes specifically focus at small and medium sized enterprises in order to stimulate knowledge and technology transfer.

- Innovation-focused Research Programme Precision technology – *IOP Precision Technology* (€ 4.54 million)
- Innovation-focused Research Programme Industrial Proteins – *IOP Industrial Proteins* (1992-2001, € 7.3 million)
- Technological Development Projects – *TOP* (€ 24 million annually)
- Directive Stimulation of R&D – *WBSO* (€ 368 million annually)
- Economy, Ecology, Technology – *EET* (€ 54.2 million annually)
- Subsidy Knowledge Transfer Branch Organisations SMEs – *SKB*
- Subsidy Knowledge Transfer Entrepreneurs SMEs – *SKO*
- Technological Co-operation – *TS*

2.3.3 Firm creation
Horizontal instruments to support the creation of start-ups is provided by the Ministry of Economic Affairs:

- Subsidy *Infrastructure Technostarters* (€ 45 million)
- *Dreamstart*

2.3.4 Regulation matters for the biotechnology industry
Specific biotechnology regulation in the Netherlands is mostly based on EU directives, in particular 90/219/EC on the contained use of GMOs and 90/220/EC on the deliberate release of GMOs. Three ministries have regulatory responsibilities in the field of biotechnology:
- The Ministry of Agriculture, Nature Management and Fisheries is responsible for all regulations concerning biotechnology with animals based on the Animal Experiences Act and the Animal Health and Welfare Act;
- The Ministry of Public Health, Welfare and Sports is mainly responsible for regulations concerning the introduction into the market of (novel) food products and genetically modified plants;
- The Ministry of Public Housing, Spatial Planning and Environment is responsible for all regulations concerning the contained use and deliberate release of genetically modified organisms mainly based on the EU directives 90/219 and 90/220.

The Dutch regulatory framework concerning biotechnology used to be ahead of other countries. During the 1990s however, most national regulations have been harmonised with the European directives and regulations. In 2002, a preliminary evaluation of biotechnology regulation has been performed on behalf of the Dutch Government (BioCollectief, 2002). The firms and research organisations that were interviewed experienced several general obstacles in the execution of the regulations: procedures take too long, the managerial and administrative burdens are heavy and the transparency of procedures can be improved. These obstacles were experienced in almost every area of regulation as mentioned above.

Specific problems concern the regulation on deliberate release, in particular field trials, by the Ministry of Environment. During the previous governmental period, the Ministry of Environment introduced a new and very tight framework for examination of the applications for licenses to release GMOs in the environment. Not only the new applications have been subject to this new framework, but also the earlier applications that were written according to the old examination criteria. Therefore, many ‘old-style’ applications have been refused. Moreover, the time needed by the Ministry of Environment to examine the field trial applications increased from 18 weeks on average in 1996 to 94 weeks on average in 1999 (the legal term for examination is maximally 26 weeks!). Not only has the number of applications for field trials dropped significantly since 1996, but firms also have suffered serious financial losses and some have decided to move their research outside the Netherlands (BioCollectief, 2002).

Other important and more general regulations that are relevant to the biotechnology innovation system concern the working conditions (not only in laboratories), employment (including attracting foreign employees), quality control (e.g. ISO and Good Manufacturing Practices)

2.3.5 Legislation on IPR

Recently, IPR legislation and in specific biotechnology patents became a hot topic in Dutch politics. Since their introduction by the European Commission, the Dutch government attempted to delay and even refuse the implementation of the European directives on biotechnology patents. Main objection is that parts of the human body can be patented if they form part of an invention and therefore can be isolated or produced for industrial applications. According to the Dutch government this would mean an ‘instrumentalisation’ of human material and is therefore to be rejected. Moreover, the Dutch government believed that the directives would lead to conflicts between the regulations on patents and on plant breeders’ rights. In October 2001, the European Court of Justice rejected all Dutch objections to the EU directives, which compelled the Dutch government to implement the directives immediately. However, the Dutch government agreed in April 2002 on several amendments that are in conflict with the original directives and what will lead to their partial implementation. At the verge of fall 2002, the directives still have not completely been implemented and the Netherlands is probably facing a lawsuit by the EU.

Also of current interest are the IPR policies by Dutch universities. During the past, universities could decide individually how they handled IPRs. However, recent research showed that only a few universities are able to grasp the opportunities of the IPR system, as researchers are not stimulated enough to protect their research outcomes and as universities are not able to fully exploit the patented knowledge. Therefore, the ‘National Platform Patent Policies Universities’ has been initiated in 2001 by the Ministry of Economic Affairs and the Netherlands Industrial Property Office. The goal of this platform, with representatives from industry, universities and other public research organisations, is in particular to investigate the possibilities of nationally co-ordinated IPR policies for universities.

2.3.6 Availability of financial capital in high growth sectors

The Ministry of Economic Affairs has a special programme to stimulate financial organisations to give credit to SMEs. The SMEs Credit Guearantee Decree (BBMKB) provides extra security for the credit. Another incentive is the ‘Aunt Agaath Decree’, which is a fiscal incentive for business angles to invest in start-ups.

2.4 Changes since 1994

During the 1980s, the Dutch government introduced several biotechnology specific support programmes and schemes. These were aiming at strengthening both the public and the private biotechnology knowledge base. However, an important shift by the Dutch government from specific to generic S&T policies characterised the first half of the 1990s and as a consequence specific programmes for biotechnology were no longer provided in the period 1994-1998 (Enzing et al., 1999). There were mainly generic R&D programmes and biotechnology had to compete with other technologies. The commercialisation of research results and industry-university research were the most prominent themes in the S&T policies in this period. In 1999, the Dutch government again developed plans for reinforcement of the Dutch biotechnology research and industry through biotechnology specific policies.

In 1999, the Ministry of Economic Affairs introduced a new programme to stimulate start-ups in the life sciences, the *Life Sciences Action Plan*. It aims at establishing 75 new life sciences companies in the period 2000-2005 and has a total budget of € 45.3 million. BioPartner is the public organisation that co-ordinates the various instruments of the programme and supports biotech start-ups by acting as an intermediate organisation and by providing incubator facilities, risk capital, first stage grants and facilities support.

In 2000, the Dutch industry and public sector research organisations presented a *Strategic Actionplan Genomics* in which they pleaded for reinforcement of the Dutch research infrastructure in the field of genomics. The 'Temporary Advisory Committee for the Genomics Knowledge Infrastructure' advised the Dutch government to invest € 272 million in the next 5 years (Kern et al., 2001). The Dutch government agreed and initiated a national genomics strategy with a budget of € 188 million for the coming 5 years.

One key part of the strategic plan was the establishment in 2001 of a national organisation that co-ordinates all the initiatives and programmes in the field of genomics, i.e. the *Netherlands Genomics Initiave*. The Netherlands Genomics Initiative is a taskforce within NWO, and aims at making the Netherlands the leading player in the field of genomics within five years. The Netherlands Genomics Initiative has been allocated a budget of € 188 million. It not only started new genomics programmes but also got existing genomics programmes like the *IOP Genomics* and the NWO research programmes '*BioMolecular Informatics*', '*Genomics*' and '*Societal Issues of Genomics*' under its direction. Other relevant NWO programmes that have been initiated in 2002 are:

- Research Programme *From Molecule to Cell* (2002-2008, € 8.6 million)
- Research Programme *ACTS IBOS* (2002-approx. 2012, € 13.6 million)
- Research programme *Tissue Engineering* (2002-2007, € 3 million)

Policy types	**Importance (1-5)**	
	2001	**Trend 1994-2001**
Vertical Policies in the biotechnology ASI		
A. Policies for knowledge base support		
1. Instruments to encourage basic research	5	++
2. Instruments to encourage industry oriented (and applied) research	5	+
3. Instruments for strengthening academic co-operation among PSROs and disciplines	5	+
B. Policies for commercialisation support		
1. Instruments to build up technological capabilities for the industry	5	+
2. Instruments to encourage the commercialisation of scientific results from PSROs	5	++
3. Instruments to encourage the collaboration between public and industrial research	3	0
C. Policies with a socio-economic and ethical dimension	3	+
Horizontal Policies in the biotechnology ASI		
D. Science and technology policies		
1. Instruments to support the knowledge base, including mobility of researchers	5	0
2. Instruments to support the commercialisation of technologies	5	0
3. Instruments to support firm creation	3	+
E. Regulation matters for the biotechnology industry	4	0
F. Legislation on intellectual property rights (IPR)	3	+
G. Measures to assure the availability of financial capital in high-growth sectors	3	+

Table 2-1 Overview of biotechnology policy profile in the Netherlands

The policy measures are evaluated with an ascending scale from 1 to 5 based on the emphasis given by the policy system to the specific instruments and programmes. To evaluate the changes since 1994 a “0” is awarded to those instruments and programmes that have not experienced significant change in the emphasis received since 1994, “+” and “–“ indicate increasing or decreasing significance.

3 The performance of the Dutch biotechnology innovation system

In this chapter we discuss the performance of the Dutch biotechnology system, in specific the Dutch biotechnology knowledge base and the commercialisation of biotechnology in the Netherlands. We do this by using data concerning scientific publications, patents, venture capital, IPOs and firm creation. Moreover, a comparison is made between these indicators for the Netherlands and the EU average. The graphs in this chapter only consider growth rate and the Dutch share in European context, both expressed in %. Annex 2 and annex 3 include the overview of the absolute figures for the various indicators and rankings.

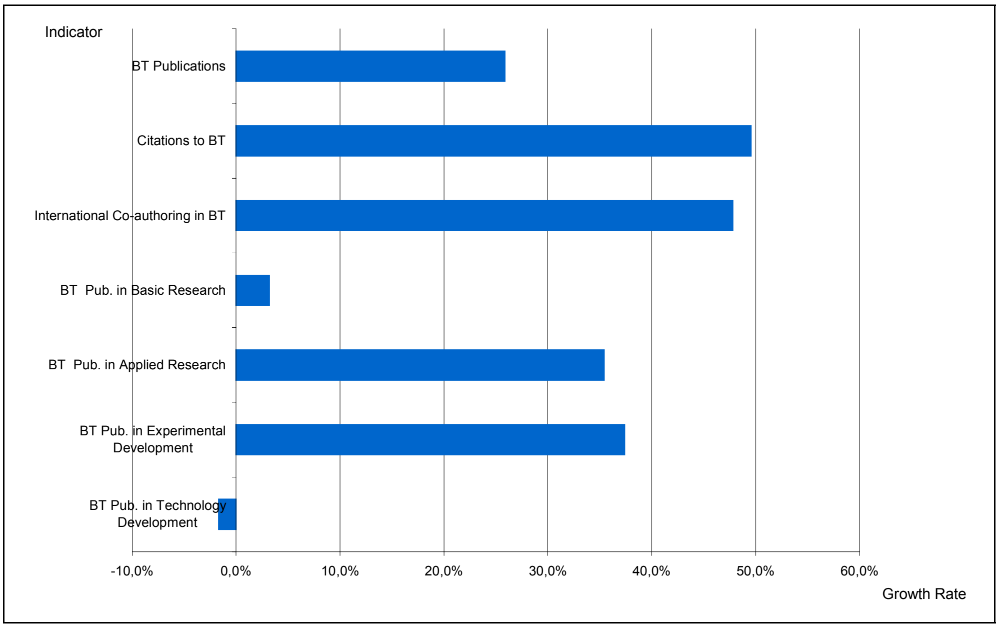
3.1 The performance of the Dutch knowledge base in biotechnology

The total number of Dutch scientific publications in biotechnology has increased with almost 26% from 2632 publications in 1995/1996 to 3306 publications in 1999/2000 (figure 3-1). This is far below the EU growth rate in publications of +45.4%. Therefore, the share of Dutch biotechnology publications in the total number of EU biotechnology publications decreased from 7.77% in 1995/1996 to 6.71% in 1999/2000 (figure 3-2). In 1995/1996, the Netherlands ranked fifth in Europe as regards the total number of publications, behind the UK, Germany, France and Italy (Annex 3). In 1999/2000, the Netherlands has been caught up by Spain and dropped to the sixth place in Europe (Annex 3). When considering the biotechnology publications per capita units, the Netherlands ranked second in Europe in 1995/1996 with 169 publications per capita, behind Sweden (209 publications per capita). In 1999/2000, the Netherlands (209 publications per capita) dropped to the fourth place behind Sweden, Denmark and Finland (Annex 3).

The number of international co-publications in the field of biotechnology with at least one Dutch author showed an increase with approximately 50% (figure 3-1): 1048 co-publications in 1995/1996 to 1549 co-publications in 1999/2000. This is below the EU growth rate of +66% and therefore the Dutch share in the total number of co-publications in the EU dropped from 8.64% in 1995/1996 to 7.67% in 1999/2000 (figure 3-2). The Netherlands ranked fifth in Europe in 1995/1996 and in 1999/2000, both in absolute numbers and corrected for the total number of biotechnology publications (Annex 3).

In 1995/1996, Dutch biotechnology publications were cited 10,708 times. This increased with almost 50% in 1999/2000 to 16,014 citations (figure 3-1). This growth is below the EU growth rate of +68%. Therefore, the share of Dutch citations in the total number of biotechnology citations in the EU decreased from 7.96% in 1995/1996 to 7.1% in 1999/2000. In both periods, the Netherlands ranked fifth in Europe in terms of number of citations, behind the UK, Germany, France and Italy (Annex 3). If we correct the number of citations to Dutch biotechnology publications for the total Dutch publication output in biotechnology then the Netherlands ranked fifth in Europe in 1995/1996 behind the UK, Belgium, Finland and Sweden. In 1999/2000, the Netherlands moved up to the fourth place behind the UK, Denmark and Austria (Annex 2).

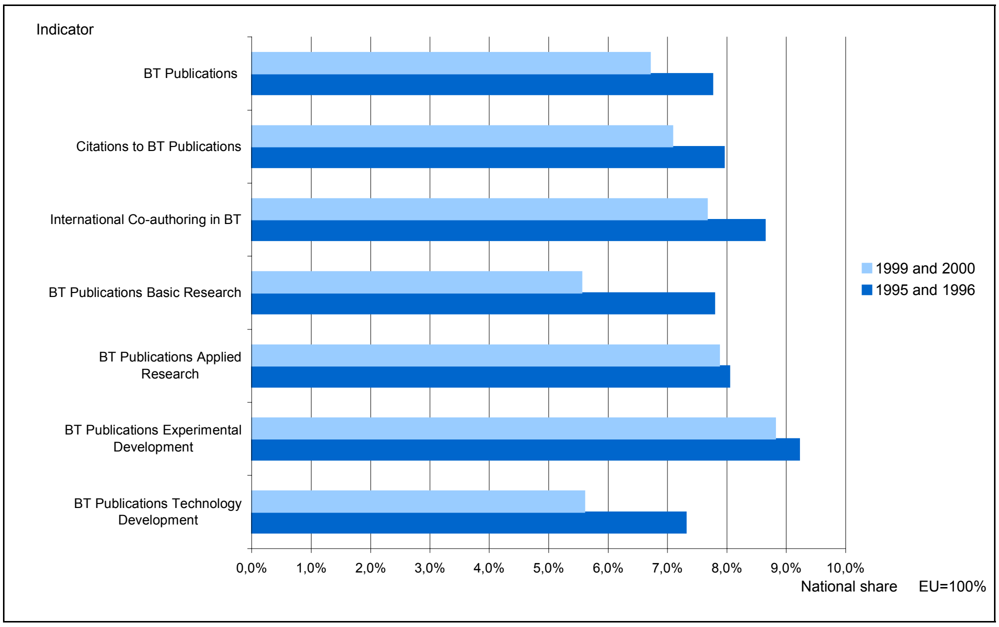
Most Dutch biotechnology publications concern the first stages of the innovation process, i.e. basic and applied research. Figure 3-1 shows that in the period from 1995/1996 to 1999/2000, the strongest increase can be found in the number of publications in the field of applied research (35%) and experimental development (37%). These are just below the European growth rates. However, although the majority of Dutch biotechnology publications concern basic research, only a very limited increase of +3.5% in this kind of publications can be observed for the period from 1995/1996 to 1999/2000. The increase in biotechnology publications in basic research over the same period in Europe has been almost 45%. Therefore, the share of Dutch biotechnology publications in basic research in Europe sharply decreased from 7.8% to 5.6% (figure 3-2).



Source: EPOHITE Research

Data: Science Citation Index

Figure 3-1 Biotechnology (BT) knowledge base indicators for The Netherlands, Growth rates between 1995/1996 and 1999/2000.

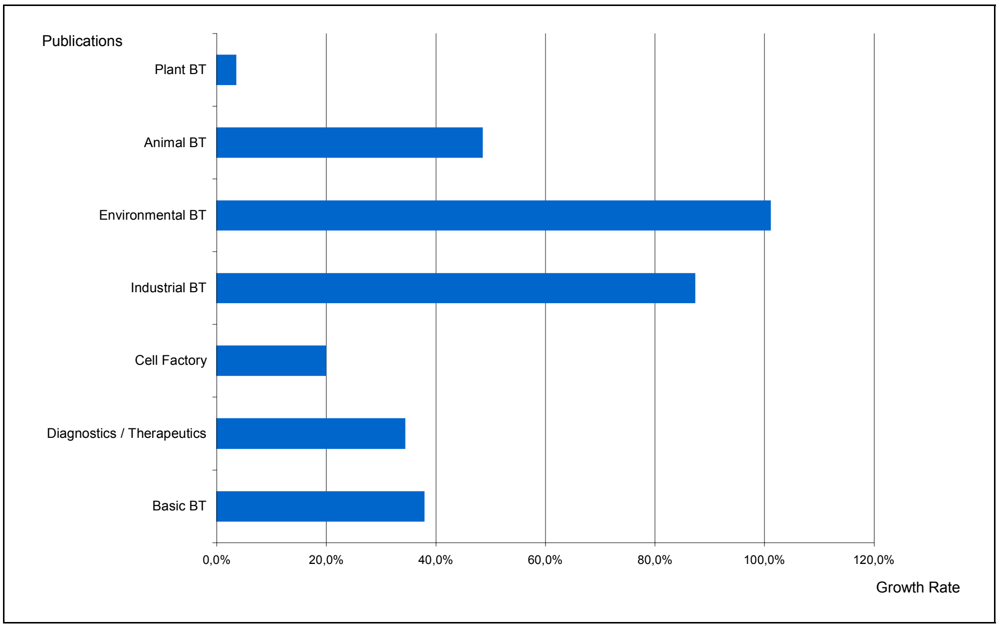


Source: EPOHITE Research

Data: Science Citation Index

Figure 3-2 Biotechnology (BT) knowledge base indicators for The Netherlands, National share in the European Union, a two period comparison.

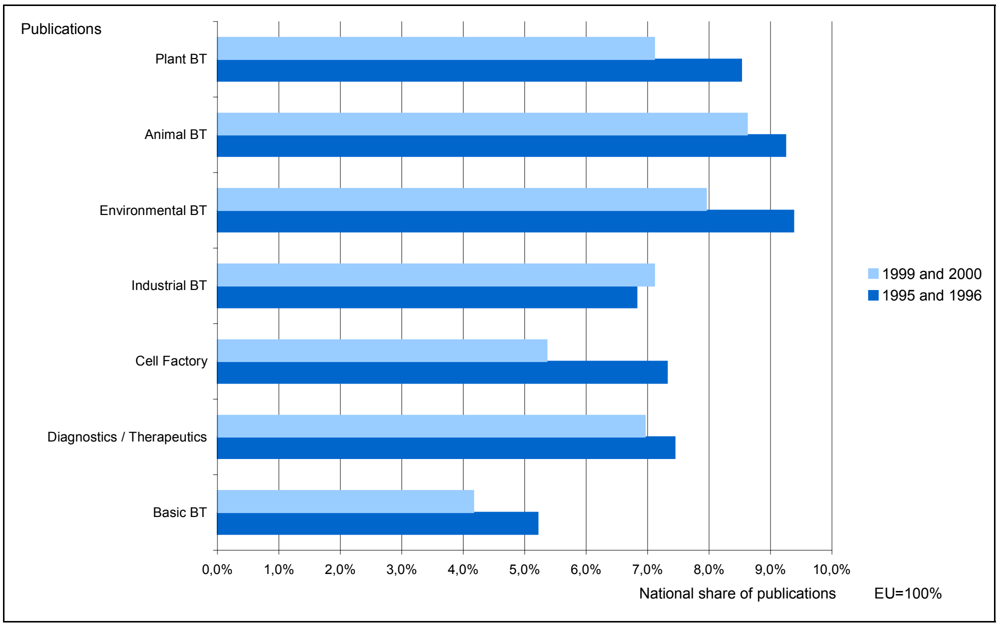
Over the period 1995/1996-1999/2000, the number of Dutch biotechnology publications has increased in all subfields, especially in the fields of environmental and industrial biotechnology (figure 3-3). Although the number of Dutch scientific publications has increased since 1995/1996, the Dutch share in the total number of biotechnology publications in the EU decreased in all sub-fields except for industrial biotechnology (figure 3-4). A decrease of the Dutch share was especially to be found in the fields of cell factory, environmental biotechnology and plant biotechnology.



Source: EPOHITE Research

Data: Science Citation Index

Figure 3-3 Biotechnology subfields, growth rates of Dutch publications between 1995/1996 and 1999/2000.



Source: EPOHITE Research

Data: Science Citation Index

Figure 3-4 Biotechnology sub-fields, Dutch share of publications in the European Union, a two period comparison.

3.2 The performance of the Netherlands in commercialising biotechnology

The results regarding the commercialisation of biotechnology are similar to those for the Dutch biotechnology knowledge base. We can often observe important growth at the national level but the growth rates are below the EU growth rates, resulting in a decrease of the Dutch share in the EU totals (Annex 2).

In 1996, 50 biotechnology companies existed in the Netherlands[1]. In 2000, the number of companies had increased to 85, meaning a growth of 70% (figure 3-5). Because of a higher increase of the total number of biotechnology companies at the European level (+102%) the share of the Netherlands in this European total decreased from 7.5% in 1996 to 6.3% in 2000 (figure 3-6). Both in 1996 and 2000, the Netherlands ranked fifth in Europe as regards the number of biotechnology companies (Annex 3). When corrected for the size of the country, the Netherlands ranked sixth in both 1996 and 2000 with respectively 3.2 and 5.4 biotechnology companies per million capita (Annex 3).

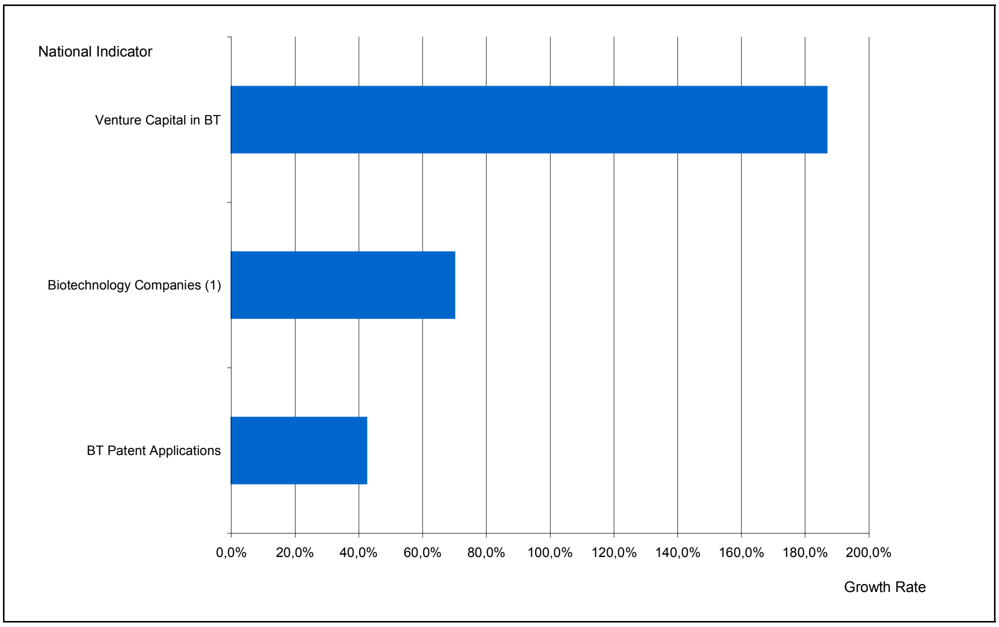
Since 1998, 4 Dutch biotechnology companies performed initial public offerings (IPO): Pharming (Nasdaq in 1998, EuroNext in 1999), Fornix BioSciences (Euronext in 1999[2]) Crucell (Nasdaq and EuroNext in 2000) and Isotis (Euronext in 2000). IPOs performed by Dutch biotechnology companies represent 8.7% of all IPOs by biotechnology companies in Europe in the period 1998/2000 (figure 3-5). Only Germany and the UK show higher shares in the EU (both 32.6%).

The number of Dutch biotechnology patent applications at the EPO increased with 42.6% from 249 applications in 1995/1996 to 355 applications in 1999/2000 (figure 3-5). However, the total number of EU biotechnology patent applications at the EPO increased with over 69% from 2,723 applications in 1995/1996 to 4,609 applications in 1999/2000. Therefore, the Dutch share in all EU biotechnology applications at the EPO decreased from 9.1% in 1995/1996 to 7.7% in 1999/2000 (figure 3-6).
The Netherlands ranked fourth in Europe in both 1995/1996 and 1999/2000, behind Germany, the UK and France (Annex 3). When taking into account the size of the country, the Netherlands holds a third position in Europe in 1999/2000 with 22.5 applications per million capita, behind Denmark and Belgium (Annex 3). In 1995/1996, the Netherlands ranked second behind Denmark with 16 applications per million capita (Annex 3).

As regards the amount of venture capital invested in biotechnology, the Netherlands belongs to the top five in Europe, behind Germany, the UK, France and Belgium. In 1995/1996 the amount of venture capital invested in biotechnology exceeded € 19.8 million. In 1999/2000 this amount exceeded € 56.8 million, meaning an increase of more than 186% since 1995/1996 (figure 3-5). However, the EU growth rate over the same period has been much higher (+337,7%). This means that despite a strong growth at the national level, the Dutch share in the total amount of venture capital invested in

[1] These numbers are based on the information in the Ernst&Young Annual Life Sciences Reports. However, research by TNO-STB showed 46 companies in 1996 and 100 in 2000, meaning an increase of 117.4%. The E&Y numbers are used for the sake of comparability as they are also used for the other countries within the EPOHITE project.
[2] Fornix BioSciences originated from a 'reversed takeover' of Dr. Fisher Farma by Artu Biologicals in 1999. The name Artu Biologicals was changed into Fornix BioSciences.

biotechnology in the EU decreased sharply from 7.4% in 1995/1996 to 4.9% in 1999/2000 (figure 3-6).

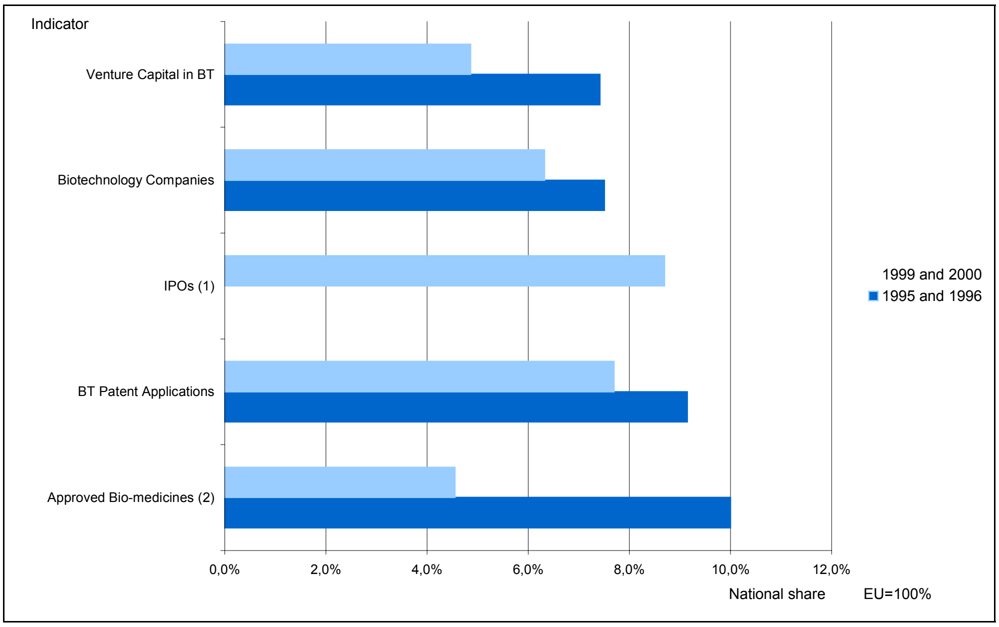


Source: EPOHITE Research

Data: European Venture Capital Association (EVCA), Ernst&Young Annual European Life Sciences Reports, Nasdaq, Neuer Markt, London Stock Exchange and Euronext's websites, European Agency for the Evaluation of Medicinal Products (EMEA), Database of International Patent Applications (PCTPAT), Database of European Patents (EPAT).

Note 1: Figures for the number of biotechnology companies correspond with the years 1996 and 2000

Figure 3-5 Indicators for the commercialisation of biotechnology in The Netherlands. Growth rates between 1995/1996 and 1999/2000.



Source: EPOHITE Research

Data: European Venture Capital Association (EVCA), Ernst&Young Annual European Life Sciences Reports, Nasdaq, Neuer Markt, London Stock Exchange and Euronext's websites, European Agency for the Evaluation of Medicinal Products (EMEA), Database of International Patent Applications (PCTPAT), Database of European Patents (EPAT).

Notes: The figures for each period result from adding up the figures of the given years. Note 1: due to low absolute numbers the two periods correspond to 1995-1997 and 1998-2000. Note 2: Due to low absolute numbers the two periods correspond to 1995-1997 and 1998-2001.

Figure 3-6 Indicators for the commercialisation of biotechnology in The Netherlands. National share in the European Union, a two period comparison.

3.3 Conclusions

When only taking into account the absolute numbers of the indicators, the position of the Netherlands in Europe can be seen as being the 'best of the rest', behind the big three Germany, United Kingdom and France. This is true for both 1995/1996 and 1999/2000. Moreover, the Dutch growth rates in both knowledge base and commercialisation indicators show significant increases at the national level.

However, considered in terms of growth rates we can conclude that the European position of the Netherlands is in decline. The EU as a whole has performed much better concerning most of the indicators. This means that at EU level the contribution of the Netherlands to the development of the knowledge base and the commercialisation of biotechnology knowledge is decreasing. This can not only be explained by the fact that European countries, which were only involved into biotechnology to a very limited extent, are quickly intensifying their biotechnology research and commercialisation. Most striking is the fact that the Dutch growth rates for many indicators belong to the lowest for all EU countries. The Dutch growth rate in biotechnology publications was with 26% the lowest one in the EU and the gap with the next EU country, i.e. France, is 13 percentage points (Annex 3). The Dutch growth rate for the number of biotechnology publications in the field of basic research was also the lowest one in the EU with 3.5%. The gap with the next EU country, i.e. the United Kingdom, is almost 33 percentage points (Annex 3). This not only means that other countries are catching up fast with the Netherlands, but also that the gap with the leading European countries is growing.

4 Policy effectiveness: An assessment from the Dutch actors' perspective

In this chapter, we present the main findings from the interviews with a selection of actors in the Dutch biotechnology innovation system. Main purposes of the interviews were to find out about the actors' experiences within the Dutch biotechnology system and the effects of Dutch public biotechnology policies on their activities.

Interviews have been performed with interviewees from 12 organisations of which 3 public sector research organisations, 2 start-ups, 4 successful small and medium sized enterprises and 3 large firms. The organisations have been selected based on their activities in the field of biotechnology. A list with the interviewees is given in annex 4. The main findings are presented according to the different policy types.

4.1 Policies to support the knowledge base in biotechnology

4.1.1 Instruments to encourage basic research

The interviewees have applied for most of the national public support programmes mentioned in Chapter 2 of this report. For the interviewed academic research groups these programmes are especially the ones managed by the Netherlands Organisation for Scientific Research (NWO). Many research groups are highly dependent on the NWO-funding. One academic research group is receiving additional funding as being a member of the Top Research School 'Centre for Biomedical Genetics'. Next to these national programmes or instruments the EU and charities are important sources for research funding. All these programmes are used for funding both basic and applied research activities.

The public sector research organisations argue that the amount of funding available is far too small for continuously performing high-quality research, especially for basic research. Moreover, one research group argues that the biotechnology funding is allocated over too many research themes and research groups; funding should only go to a select group of high-quality research groups that are active in a limited number of research areas. All public sector research organisations observe a shift in funding from basic towards more application-oriented research, with the danger of losing the strengths in fundamental research. Therefore they agree on the necessity of large programmes earmarked only for basic research. Another important point of concern is the increasing demand for extensive applications, mid-term evaluations, final reports, etc (i.e. too much bureaucracy) that is already resulting in serious problems.

For firms the most relevant national public programmes are the horizontal/generic programmes '*Bedrijfsgerichte Technologische Samenwerking*' (BTS, now changed into '*Technologische Samenwerking*' TS), the '*Technologische Ontwikkelingskrediet*' (TOK, now TOP) and the '*Wet Bevordering Speur en Ontwikkelingswerk*' (WBSO, which is in fact a tax facility for R&D activities). As can be expected, funding is especially used for applied research.

The experiences with these programmes vary strongly according to the type of interviewee.

Large firms are quite satisfied with the opportunities provided by the national public programmes. These programmes mainly serve as an additional source for funding to the corporate R&D budget. Although aspects like bureaucracy are identified they are not judged as very problematic as these firms often have a long history in dealing with the programmes, their terminology, the responsible governmental organisations, etc. The latter is also true for the SMEs that are interviewed. This is quite different for the biotechnology start-ups, as they are strongly limited in their financial and human resources. They judge applying for public funding as very time consuming and therefore are more critical towards the public programmes. However, many start-ups are highly dependent on public programmes, as they are an important source for R&D funding.

4.1.2 Recruitment of researchers

Only one interviewee (of an academic research group) has problems in recruiting research staff with relevant biotechnology expertise. The other academic research groups and companies rely successfully on their own networks for recruitment of new staff. The close relations with universities make it for companies quite easy to get access to academic human resources.

However, for the academic research groups it is getting harder to attract research staff as they have to be offered outstanding career perspectives. Universities have only very limited resources for this compared to firms. Moreover, attracting foreign researchers, especially from outside the EU, is very difficult due to time consuming and very strict procedures.

4.1.3 Collaboration

All interviewees collaborate in R&D. Two of the three academic research groups perform at least 80% of their research activities in collaboration. This is only 20% in the case of the third research group. The two research groups having intense research collaboration co-operate with both university groups and industrial partners. The third research group only co-operates with other, mainly foreign, academic research groups. The main reason for co-operating with other research groups is to get access to specific expertise and knowledge and for sharing research facilities. Obtaining additional funding for research is not a reason for the interviewees to co-operate with other academic research groups.

The majority of the companies interviewed perform approximately 1/3 of their R&D activities in collaboration. Research partners are both university research groups and industrial partners. Main reason for co-operating with academic research groups is their expertise in fundamental research complementary to the firms' knowledge. Other reasons mentioned are the use of this fundamental knowledge to underpin the scientific basis of the firms' products and the (international) reputation of the research groups and their scientists. This reputation can be very supportive e.g. to fund raising, product launches and realising strategic alliances.

Main reason for co-operating with other companies is the development and marketing of in-house technologies. This is especially the case for the successful sme's and the high performance start-ups. Moreover, joint research is performed in the form of tight user-supplier relationships in which the partners are the 'lead users' of the firms' research results or as suppliers of very specific knowledge or resources like bio-active components or research equipment.

Only three interviewees, i.e. one academic research group and two start-ups, report that they are not using national public programmes to support their research collaborations.

The main reason for the two start-ups is that applying for public support asks for too large expenditures in time and human effort, especially in comparison to the very limited resources available within these companies. The academic research group states that public programmes can only marginally stimulate research collaboration as most of the co-operations are based on existing relationships and networks. The funds available through these programmes only serve as additional research budgets.
Those research groups and companies that use public programmes for their joint research activities are positive about the programmes. Especially the experiences with ‘Bedrijfsgerichte Technologische Samenwerking – BTS’ are very positive. In addition to the fact that the programmes provide additional funding for research, they also lower the financial risks of firms that wish to engage into new partnerships or elaborate their research networks. Another important advantage of the programmes is that the ownership of the research results only belongs to the organisations involved in the projects. Last but not least, bureaucracy is rather limited and experienced as being acceptable.

None of the interviewees seems to experience difficulties in finding research partners: they all make use of their own networks. Therefore external support in this matter is irrelevant to their opinion. Moreover, the interviewees that have made use of external support in the past in finding research partners judge the results from this support as inadequate and insufficient.

4.2 Policies to support the commercialisation of biotechnology

Two of the three academic research groups actively pursue the commercialisation of their research outcomes. This is realised by selling research outcomes to industry, patenting and licensing activities and university spin-offs. Some universities try to stimulate their scientists in patenting their research outcomes by providing some financial incentives. Nevertheless, the support provided by the universities is experienced as being very limited: the university transfer and IPR support units operate too slowly and do not possess enough biotechnology knowledge. Excellent biotechnology IPR expertise is also very hard to find outside the universities: most of this expertise is to be found within the industry.

A lack of stimulating public policies was felt concerning the creation of biotechnology start-ups and academic spin-offs. A lack of understanding by e.g. venture capitalists and public agencies what biotechnology is about was the main reason for the former. The latter has mainly to do with the non-entrepreneurial climate within universities and the disability to properly estimate commercial opportunities. It is expected that the BioPartner initiatives will be an important improvement as they aim at stimulating (academic) entrepreneurship in life sciences.

It was reported earlier that all interviewees collaborate in R&D with both public and private partners. Each firm in the sample is satisfied concerning the knowledge transfer through joint projects with public research organisations. The interviewees from the firms all judge the public research organisations they are co-operating with as being capable of providing the requested knowledge and expertise. However, there is still a ‘language-barrier’ between the academic research groups and the firms: the academic knowledge still needs to be ‘translated’ into really useable (applicable) knowledge. This is seen as a natural consequence of the differences in playing fields of each partner, i.e.

science and industry. The firms experience it as their task of realising this translation. All firms in the sample are very positive about the possibilities offered by the public programmes aimed at stimulating joint research efforts between industry and academics, although not every firm uses these programmes due to limited internal resources (see before).

Knowledge transfer through patents and licensing agreements between public sector research organisations and firms also takes place. A problem however is the disability of universities in correctly estimating the commercial value of knowledge. Universities tend to overestimate the value of knowledge and therefore have too high financial demands according to the firms. They feel that universities, i.e. research departments, transfer bureaus and individual scientists, forget that still major efforts have to be made by industry in making the patented knowledge applicable into products and processes.

Firms experience that the possibilities for commercialisation have improved since 1994, also for biotechnology. Firms are in particular positive about the availability of public R&D stimulation programmes and incentives like WBSO, TOK (now TOP) and BTS/BIT (now TS). The programmes provide them with important additional R&D funding, possibilities to get involved into (new) co-operations, scientific peer reviews of the firms' research efforts, etc. Moreover, high-tech firm creation has gained importance in the policy area since mid 1990s resulting in increased opportunities for attracting venture capital, in the Technostarters incentives and in the BioPartner programmes and incubator facilities.
However, the aspect of intellectual property rights as a major framework condition for commercialisation is still underexposed in Dutch public policies. IPRs are especially important to biotechnology start-ups and small and medium sized enterprises as they often form the core of these firms and influence their commercial possibilities. Having IPRs or IPR portfolios not only provides important knowledge protection, but is also essential for building a trustworthy image towards venture capitalists, potential research partners, clients etc. Nevertheless, the interviewees regard the availability of support in biotechnology IPR matters as largely insufficient. Especially the financial consequences of applying for and maintaining the patents put a heavy load on the smaller firms. This aspect of biotechnology IPRs is less relevant to large firms as they often have their own legal departments and patent attorneys; although, they complain about the costs and time necessary for IPR trajectories.

4.3 Policies with a socio-economic and ethical dimension

All interviewees take into account socio-economic and/or ethical aspects of their biotechnology activities. This can be related to all kinds of aspects like food safety, sustainability, the use and spreading of GMOs, working conditions, human health, animal testing and experiments, etc. Most important reasons for taking these issues into considerations are the presence of laws and regulations and social acceptability. The necessity to pay attention to socio-economic and ethical issues in subsidy applications seems to be of marginal influence. Although all interviewees take them into account, only one (large) firm is actively communicating with the public and engaged into activities and events dealing with these issues. It is seen as necessary as governmental bodies, non-governmental organisations, the public, etc, are critically watching them. Moreover, this firm is the only one that actually experiences these socio-economic and ethical issues as directly influencing the firm's research and overall activities. Some

firms choose not to engage into these kinds of activities, as they are not active in biotechnology areas with important ethical or socio-economic issues at stake e.g. industrial microbiology, biotechnology equipment and supplies, areas of medical biotechnology, etc. Another important reason for not engaging in these activities is that some firms prefer to operate on a low profile basis, as they fear the consequences of the social acceptability of biotechnology that could damage the firms' reputations and development. Therefore the role of non-governmental organisations has been very limited with respect to the extent into which firms take into account and communicate about socio-economic and ethical issues.
All three academic research groups are actively engaged into activities and events dealing with socio-economic and ethical issues of biotechnology. They do so not only due to the direct ethical issues of their research (human health, experiments with and testing on animals, etc) but also in order to start a debate with and the education of the public. This is achieved by participating in special committees, organising workshops, publishing articles in 'popular' magazines, attending conferences, inviting interest groups for lectures etc. Nevertheless, none of the research groups actually experiences their research activities to be directly affected by socio-economic or ethical issues.

The majority of the interviewees qualify the overall attention for social acceptability of biotechnology by public policies as not supportive. It is argued that organising public debates on different biotechnology issues is not a sufficient means for raising social acceptability. Moreover, the fact that the Ministry of Economic Affairs is strongly promoting biotechnology and at the same time the Ministry of Environment is hindering biotechnology development by rejecting most of the field trial applications creates a rather negative image. Moreover, some interviewees feel that the government should reward those organisations that seek to communicate with the public or at least should stimulate organisations to communicate.

4.4 Regulation matters for the biotechnology industry

The major regulations that influence the interviewed firms' and academic groups' research and overall activities mainly concern: i) working with and introducing GMOs, ii) experiments with and testing on animals, iii) (novel) foods and feed, iv) general working conditions and v) quality control e.g. Good Manufacturing Practices and ISO.

The majority of the interviewees see these regulations as absolutely necessary. Some regulations have important advantages e.g. the improvement of quality, a possible shake out of organisations that can not comply to the regulations, becoming conscious about possible dangers and risks, and even attracting new customers. However, especially the regulations on GMOs, on novel foods and feed and on working with animals are experienced as having considerable negative impacts on the organisations' research activities. The heavy burden of very strict administrative procedures and the complexity of the regulations, especially in international context, are the most important reasons. Research activities get slowed down and the organisations feel very limited in the scope of their research.
According to the interviewees European harmonisation of regulations is especially necessary in the fields of animal testing and experimenting and of novel foods and feed. Public support in legal matters concerning biotechnology is rarely used by the interviewees that mostly rely on commercial support or on internal resources.

4.5 Legislation on intellectual property rights

The main problems with biotechnology IPRs encountered by all interviewees are the bureaucracy and complexity of the filing, registration and maintenance of patents. Although the change of the Dutch Patent Act in 1995 resulted in a simplification of procedures[3], the interviewees all believe that the procedures are still too costly and time-consuming. They feel the same about the rules and procedures of the European Patent Office (EPO). Moreover, the complexity of biotechnology research means that the translations of research outcomes into patent applications is very difficult and demands in-depth knowledge of biotechnology and legal matters, especially in the case of biotechnological processes. The larger firms often have this knowledge in-house, while public research organisations and in particular small and young biotechnology firms need to rely on expensive external support provided by e.g. patent attorneys and consultants.

Although the majority of the interviewees' patent applications are filed at the EPO, many of them favour the United States Patent and Trademark Office (USPTO) system as it is experienced as more professional, less bureaucratic, cheaper and having a broader scope. In addition, one of the research groups favours the USPTO system as scientists can publish their research outcomes even before they file an application.

Although seen as necessary, harmonisation of European IPR legislation and systems is not expected to change the interviewees' activities a lot. The major advantages they foresee in harmonisation of European legislation with national legislation are reduction of bureaucracy and a decrease of costs for application. Most interviewees argue that it should not only be about harmonisation of the EU regulation but also with the US patenting system. Most important however is the necessary implementation by the Dutch government of the EU directives on patenting biotechnology research outcomes. A further refusal or delay of the implementation of these directives is expected to lead to a political isolation in Europe and result in a serious stagnation of the development of the biotechnology industry in the Netherlands.

4.6 Measures to assure the availability of financial capital in high growth sectors

In general the availability of financial capital for innovation and firm creation is judged positively. The choice for a specific financial strategy is highly influenced by the type and size of organisation and their ambitions. The start-ups and small and medium sized enterprises all used a combination of public programmes, venture capitalists/informal investors and private capital as financial sources. Large firms rather rely on their corporate incomes in setting the R&D budgets in combination with R&D subsidies.

The focus of public policies and their influence on the availability of financial capital is mostly to be found in the area of R&D subsidies and the availability of public venture capital, i.e. BioPartner, Stigon, Technostarter and Dreamstart[4]. Especially the R&D subsidies are well evaluated by the interviewees. Nevertheless most interviewees are convinced that the overall budgets of the public programmes are far too small to really speed up the biotechnology developments in the Netherlands. Although initiated rather late, the BioPartner programme is seen as a very important initiative for the stimulation

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[3] The most important change since 1995 is that patents are granted without being examined. Moreover, novelty searches are only necessary for the 20-year patents.

[4] The interviewees argue that the increased availability of risk capital by venture capitalists and informal investors has not really been influenced by public policies. They rather see the increase as a consequence of the economic prosperity in the second half of the 1990s.

of a Dutch biotechnology industry. However, a number of interviewees addressed the need for financial support to young biotechnology firms after the first and second rounds of financing.

5 Policy effectiveness: conclusions and recommendations

The beginning of the 1990s showed a shift in Dutch S&T policies from more specific towards generic support of science and technology. The specific biotechnology oriented instruments were integrated with other technology support schemes or were extended to other technologies. Where biotechnology was stimulated intensively during the 1980s, resulting in an outstanding position of the Dutch knowledge base in biotechnology, during the 1990s biotechnology had to compete with many other technologies. Areas of S&T policies that gained importance during the second half of the 1990s were in particular the commercialisation of scientific knowledge and technology and firm creation. However, at the end of the 1990s new emphasis on specific biotechnology support emerged, as the Dutch government acknowledged the opportunities offered by genomics. Over the past three years several specific instruments aiming at the support of biotechnology have been initiated, e.g. new NWO research programmes, the IOP Genomics, BioPartner and recently the Netherlands Genomics Initiative. Major efforts are made by the Netherlands in order to become leading in the field of genomics in the next four years. Overall, it seems that most parts of the innovation system are being taken into account and addressed by the instruments and programmes.

The performance indicators as presented in chapter 3 indicate that the Netherlands does not rise above the second rank in European biotechnology. Although the Netherlands shows positive growth rates for the knowledge base and commercialisation indicators over the period 1995/1996-1999/2000, they often belong to the lowest growth rates in the EU. Moreover, the gap with growth rates realised by other EU countries is in some cases extremely large, in particular for the total number of scientific biotechnology publications and the number of publications in the area of basic research. This means that the Netherlands has been losing ground in biotechnology in Europe over the period 1995/1996-1999/2000. Other second rank EU countries like Spain, Italy and Belgium are closing the gap with the Netherlands in many areas, while the leading countries in Europe are even expanding their lead.
Of course it is very hard to draw conclusions on the possible relationship between the stagnation of the Dutch biotechnology position in Europe and the public policies since 1994 that affected the Dutch biotechnology innovation system. However, the period for which we analysed the national performance corresponds exactly with the period in which specific biotechnology support was missing in the Netherlands. Therefore, a possible conclusion could be that the Dutch biotechnology innovation system has not been able to further expand its outstanding position in biotechnology mainly because of the abolishment of specific biotechnology instruments and programmes in the Netherlands.

If we take a closer look at the different policy goals it can be concluded that public policies only have been effective in stimulating applied research in biotechnology. The number of publications in applied research and the later stages in the biotechnology innovation process has been growing in line with the rest of the European Union. Moreover, public sector research organisations are increasingly performing applied research and most biotechnology firms make use of the available public support for industrial research. In general, the firms are quite satisfied with the opportunities provided by this support.

Public policies have only been partly effective concerning the stimulation of basic research, networking/collaboration and commercialisation in terms of start-ups and patents.

The successful stimulation of applied research seems to take place at the cost of basic research. The growth in the number of publications in basic research has been marginal and the lowest of all EU countries. Moreover, the (academic) interviewees all point at this shift from basic towards applied research and warn for a growing misbalance between the two.

Most of the organisations interviewed, both public and private, make use of public support for collaborative R&D activities or networking. However, the interviewees argue that this public support has major effects on the collaboration patterns of the organisations. Most of the time they co-operate with their existing partners. The financial public support is only used as additional means for the already planned R&D activities. Moreover, both firms and public sector research organisations are absolutely not in need of any public support for finding new partners as they successfully use their own networks. Only one firm perceived the public support for collaboration as useful for engaging into new collaborations and for diminishing the risks of failure.

The effects of public policies on the commercialisation of biotechnology have been limited, although commercialisation of scientific knowledge has been a priority area in Dutch S&T policies during the 1990s. The growth rate in the number of biotechnology firms in the Netherlands over the period 1996-2000 is far below the EU growth rate and below the growth rates of countries like Germany, France, Belgium and Sweden. Moreover, start-ups and young SMEs can often not bear the costs in terms of financial and human resources that are necessary when applying for public support schemes. Especially the administrative burden puts a heavy load on the development possibilities of these firms. The patenting of biotechnology research results is an important activity for commercialisation. However, there seems to be general lack of IPR support in the field of biotechnology. Especially the combination of expertise in biotechnology and IP legislation is hard to find and very expensive. This is especially a problem for public sector research organisations and young/small biotechnology firms. Moreover, public sector researchers experience the support provided by the public sector research organisations as highly unsatisfactory and obscure.

The goal of this report was to investigate the effectiveness of public biotechnology policies in the Netherlands. We have tried to relate the presence of public biotechnology policies in the Netherlands to the performance of the Dutch biotechnology innovation system by using quantitative indicators, interviews and extensive desk-research. Perhaps we succeeded only to a limited extent in making this relation, we have nevertheless signalled several rather negative developments in the Dutch biotechnology system. It would be too easy to blame the policy makers or to believe that these developments are the consequences of missing or failing public biotechnology policies. Innovation systems always have been and always will be characterised by an interplay of many actors and determinants, including government but also industry, science and consumers. However, the negative developments point at the need for a sense of urgency if the Netherlands wishes to maintain its position in European biotechnology. The recent initiatives in genomics, in which most of the biotechnology stakeholders participate, could mean a major step in the right direction.

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Annex 1: Overview of programmes and instruments

	Vertical policies			Horizontal policies				
				Generic Science & Technology policies				
Policy types and goals	**Policies for knowledge base support**	**Policies for commercialisation**	**Policies with a socio-economic and ethical dimension**	**Knowledge base**	**Commercialisation & firm creation**	**Regulation matters for the biotechnology industry**	**Legislation on intellectual property rights**	**Measures to assure the availability of financial capital in high-growth sectors**
Instruments and programmes								
• NWO Research programme Genomics	✔							
• NWO Research programme Biomolecular informatics	✔							
• NWO Research programme Structure/function relation biomolecules	✔							
• NWO Research programme Computational chemistry of biosystems	✔							
• NWO Research programme Societal Issues in genomics research	✔		✔					
• NWO Research programme Nutritious food				✔				
• NWO Research programme Combinatorial chemistry				✔				
• NWO Research programme Food and chronical diseases				✔				
• NWO Innovational Research Incentive Scheme – Veni, Vidi, Vici				✔				
• NWO STIGON	✔	✔						
• BioPartner – Facilities Support	✔	✔						
• BioPartner – First Stage Grant		✔						
• BioPartner – Centres		✔						
• BioPartner – Network		✔						
• BioPartner – Start-up Ventures		✔						
• Top Research School – Centre for Biomedical Genetics	✔							
• Senter – IOP Genomics	✔	✔						
• Senter – IOP Precision Technology				✔	✔			
• Senter – IOP Industrial Proteins				✔	✔			

	Vertical policies			Horizontal policies				
				Generic Science & Technology policies				
Policy types and goals	**Policies for knowledge base support**	**Policies for commercialisation**	**Policies with a socio-economic and ethical dimension**	**Knowledge base**	**Commercialisation & firm creation**	**Regulation matters for the biotechnology industry**	**Legislation on intellectual property rights**	**Measures to assure the availability of financial capital in high-growth sectors**
Instruments and programmes (continued)								
• Senter – TOP					✔			
• Senter – WBSO					✔			
• Senter – EET					✔			
• Senter – TS					✔			
• Senter – SKB					✔			
• Senter – SKO					✔			
• Senter – BBMKB								✔
• Senter – Tante Agaath								✔
• Technostarters					✔			
• Dreamstart					✔			
• Technological Top Institute – WCFS	✔	✔						

Annex 2: Overview of Dutch and EU performance indicators

		Netherlands			EU		
		1995/1996	1999/2000	growth in %	1995/1996	1999/2000	growth in %
BT publications	Total	2632	3306	25.6%	33856	49214	45.4%
	per million capita	169	209	23.6%	90.98	130.89	43.9%
Citations to BT publications	Total	10708	16014	49.6%	134600	225988	67.9%
	per total BT publications	4.07	4.83	18.7%	3.98	4.59	15.5%
Internationally co-authored papers	Total	1048	1549	47.8%	12126	20202	66.6%
	per total BT publications	0.40	0.47	17.4%	0.36	0.41	14.6%
BT publications basic research	Number	846	873	3.2%	10858	15713	44.7%
BT publications applied research	Number	545	738	35.4%	6773	9379	38.5%
BT publications experimental development	Number	313	430	37.4%	3394	4878	43.7%
BT publications technology development	Number	59	58	-1.7%	807	1035	28.3%
Publications Plant BT	Number	519	537	3.5%	6085	7454	22.5%
Publications animal BT	Number	293	435	48.5%	3168	4910	55.0%
Publications environmental BT	Number	99	199	101%	1052	2496	137.3%
Publications industrial BT	Number	94	176	87.2%	1375	2466	79.3%
Publications cell factory	Number	493	591	19.9%	6507	9214	41.6%
Publications diagnostics/therapeutics	Number	1199	1610	34.3%	16090	23541	46.3%
Publications basic BT	number	74	102	37.8%	1419	2443	72.2%
Venture Capital BT	PPP in 1000	19821	56834	186.7%	267238	1169612	337.7%
Biotech companies (1)	total	50	85	70%	666	1346	102.1%
	per million capita	3.22	5.36	66.5%	1.79	3.57	99.2%
IPOs (2)	number	0	4	400%	31	46	48.4%
BT patent applications	total	249	355	42.6%	2723	4609	69.3%
	per million capita	16	22.5	40.6%	7.32	12.26	67.5%
Approved biomedicines (3)	number	1	1	0%	10	22	120.0%

(1) The amount of Biotech companies and the per capita numbers refer to the years 1996 and 2000; (2) Due to low numbers the two periods correspond to 1995-1997 and 1998-2000;

(3) Due to low numbers the two periods correspond to 1995-1997 and 1998-2001

Annex 3: Overview of performance indicators in EU member states

Countries	BT publications total			Citations to BT publications total			BT co-publications total			Venture Capital BT PPP in 1000			Biotech companies total (1)			BT patent applications total		
	1995/ 1996	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*
Austria	797	1216	52.57%	3233	6323	95.58%	335	607	81.19%	-	-	-	-	-	-	69	109	57.97%
Belgium	1176	1848	57.14%	5291	8402	58.80%	546	972	78.02%	21454	60441	181.72%	35	65	85.71%	140	265	89.29%
Denmark	893	1336	49.61%	3238	6747	108.37%	429	672	56.64%	3166	43202	1264.56%	29	64	128.57%	153	217	41.83%
Finland	862	1220	41.53%	3730	5709	53,06%	328	576	75.61%	2646	19183	625.10%	30	77	156.67%	60	71	18.33%
France	5413	7548	39.44%	19059	33957	78.17%	1712	2919	70.50%	41188	176752	329.13%	101	177	75.25%	407	717	76.17%
Germany	6778	10174	50.10%	26859	47475	76.76%	2294	3887	69.44%	58945	581118	885.87%	104	330	217.31%	790	1535	94.30%
Greece	294	545	85.37%	870	1536	76.55%	108	227	110.19%	-	-	-	-	-	-	2	7	250.00%
Ireland	269	422	59.88%	845	1965	132.54%	118	189	60.17%	3540	276.24	-92.20%	26	31	19.23%	18	38	111.11%
Italy	3375	4978	47.50%	12380	19747	59.51%	1141	1805	58.19%	2217	25537	1051.84%	32	52	62.5%	103	149	44.66%
Netherlands	2632	3306	25.61%	10708	16014	49.55%	1048	1549	47.81%	19821	56834	186.74%	50	85	70.00%	249	355	42.57%
Portugal	192	396	106.25%	560	1272	127.14%	92	227	149.45%	2412	963	-60.05%	-	-	-	1	10	900.00%
Spain	2032	3390	66.83%	5027	11592	130.59%	606	1108	82.84%	49	12444	25473.72%	15	25	66.67	46	79	71.74%
Sweden	1848	2622	41.88%	7770	11603	49.33%	753	1297	72.24%	298	15386	5059.42%	65	165	153.85%	107	184	71.96%
United Kingdom	7342	10351	40.98%	34993	53571	53.09%	2587	4144	60.19%	111503	176747	58.51%	180	275	52.78%	578	876	51.56%

	BT publications per million capita			Citations to BT publications per total BT publications			BT co-publications per total BT publications			Biotech companies per million capita (1)			BT patent applications per million capita		
	1995/ 1996	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*	*1995/ 1996*	*1999/ 2000*	*Growth in %*
Austria	99	150	51.07%	4.06	5.20	28.08%	0.42	0.50	18.76%	-	-	-	8.5	13.4	57.65%
Belgium	116	180	56.00%	4.5	4.55	1.11%	0.46	0.53	13.30%	3.45	6.34	83.80%	13.8	25.9	87.70%
Denmark	168	252	49.92%	3.63	5.05	39.12%	0.48	0.50	4.70%	5.32	12.03	126.13%	29.1	40.8	40.21%
Finland	168	236	40.48%	4.33	4.68	8.08%	0.38	0.47	24.08%	5.85	14.87	154.19%	11.8	13.6	15.25%
France	93	128	38.10%	3.52	4.50	27.84%	0.32	0.39	22.27%	1.73	2.99	72.83%	7.0	12.1	72.86%
Germany	83	123	48.30%	3.96	4.67	17.93%	0.34	0.38	12.88%	1.27	3.97	212.60%	9.7	18.5	90.72%
Greece	28	51	82.64%	2.96	2.81	-5.07%	0.37	0.41	12.97%	-	-	-	0.2	0.7	250.00%
Ireland	74	117	57.90%	3.14	4.66	48.41%	0.44	0.45	2.10%	7.17	8.55	19.25%	5.0	10.4	108.00%
Italy	59	87	47.55%	3.67	3.97	8.17%	0.34	0.36	7.25%	0.56	0.91	62.50%	1.8	2.6	44.44%
Netherlands	169	209	23.63%	4.07	4.83	18.67%	0.40	0.47	17.42%	3.22	5.36	66.46%	16	22.5	40.63%
Portugal	19	40	105.00%	2.92	3.21	9.93%	0.47	0.57	20.95%	-	-	-	0.1	1.0	900.00%
Spain	52	86	65.96%	2.47	3.42	38.46%	0.30	0.33	9.60%	0.38	0.63	65.79%	1.1	2.0	81.82%
Sweden	209	294	40.68%	4.20	4.43	5.48%	0.41	0.49	21.40%	7.35	18.47	151.29%	12.1	20.6	70.25%
United Kingdom	125	175	40.02%	4.77	5.18	8.60%	0.35	0.40	13.62%	3.07	4.64	51.14%	9.9	14.8	49.49%

(1) The number of biotech companies and the number of biotech companies per million capita refer to the years 1996 and 2000

Annex 4: List of organisations and respondents

- *AVEBE*: Dr. P.M. Bruinenberg and Dr. J. van der Meer
- *Catholic University Nijmegen / Nijmegen Centre for Molecular Life Sciences / Department of Cell Physiology*: Prof. Dr. C. van Os
- *Cosun Food Technology Centre*: Dr. P.D. Meyer
- *Crucell Holland NV*: Prof. Dr. T. Logtenberg
- *Delft University of Technology / Faculty of Applied Sciences / Department of Biotechnology*: Prof. Dr. J.G. Kuenen and Drs. P. Osseweijer
- *Erasmus University Rotterdam / Medical Genetics Centre*: Prof. Dr. F.G. Grosveld
- *Halotec Delft BV*: Mr. F.E.D. Halsema
- *IsoTis NV*: Mr. E. van den Berg
- *Kreatech Biotechnology BV*: Dr. H.J. Houthoff
- *MucoVax BV*: Dr. L. Thörig
- *Numico Research*: Dr. P. Tassignon and Mrs. L. Kusters
- *OctoPlus International BV*: Dr. L.G.J. de Leede