FINAL REPORT

‘Greater yield from R&D investment’

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Contents

Summary

There are some 1,200 organizations active within the Dutch life sciences and medical technology sector. The majority, approximately 700 companies and organizations, are concerned with *biotechnology*, while 157 companies are active in the *pharmaceutical industry*, and approximately 380 in *medical technology.* The sector currently accounts for annual turnover in excess of eight billion euros. During the past two years, it has seen accelerated growth with an average annual growth rate in the order of 12% to 14%.

The knowledge base in the life sciences and medical technology sector may be said to be relatively high. Dutch universities and knowledge institutes are acknowledged to be European leaders in the field. Despite this excellent starting position, however, the degree to which the knowledge is actually applied in practice is not optimal. The Dutch life sciences and medical technology sector must invest more in knowledge application in order to integrate emerging developments in the various technologies. If allowed to remain unresolved, the discrepancy between the development of knowledge and its application in practice could well undermine the long-term success of the Netherlands' biotechnology, pharmaceutical and medical technology industry.

Substantial rise in R&D investments. Recent years have seen marked growth in R&D investments within the Dutch Life sciences and medical technology sector. Following a reduction (in relative terms) during the period 2000-2002, total R&D investments in the biotechnology segment are now estimated to be 95 million euros per annum, while the pharmaceutical industry devotes 550 million euros per annum to R&D and the Medical Technology segment invests approximately 270 million euros. The total R&D investments in the Dutch Life sciences and medical technology sector are therefore in the order of one billion euros per annum and are expected to increase further.

Revenue growth is largely derived from existing products. The biotechnology segment has achieved above-average revenue growth in recent years (34%), as has the medical technology segment (13%). However, with growth of 7%, the Dutch pharmaceutical industry has lagged behind the industry average. Moreover, the life sciences and medical technology sector in general, and the pharmaceutical industry in particular, has failed to keep pace in terms of the proportion of turnover derived from new products, with only 14-15% derived from products which have been developed during the past three years.

Innovative organizations achieve noticeably better results. Innovation pays. The development of new treatments for specific ailments and the creation of cutting-edge medical devices has served to increase the income which can be re-invested in ongoing innovation projects. Statistics reveal that innovative companies enjoy revenue growth of 12% above average, while profitability is 17% higher. Moreover, innovative organizations do better in terms of attracting new clients (+11%) and have seen a higher growth in market share (+14%). In the pharmaceutical industry, innovative ability is a key factor in improved profitability.

The yield of R&D investments is relatively low. The relative contribution of R&D investments to the revenue derived from new products is relatively low. While the average leverage factor within the Dutch private sector as a whole is between 2 and 2.5, biotechnology, the pharmaceutical industry and medical technology achieve a leverage factor of just over 1. Accordingly, R&D investments can be seen to have a far lower yield than in other sectors. This problem seems to be most acute within smaller organizations (with fewer than ten employees) and larger organizations (with over 50 employees).

Social innovation is more important that R&D investments. Within the Dutch life sciences and medical technology sector, approximately 30% of the success of innovation is determined by R&D investments. The remaining 70% is due to 'social innovation', i.e. management, organization and cooperation. This does not detract from the importance of R&D investments and capital acquisition. However, the success of technology development and product innovation relies for the most part on a good organizational design, high management quality and successful external cooperation.

Horizontal cooperation and knowledge sharing are not yet adequate. Horizontal cooperation and knowledge sharing within organizations – although crucial to all innovation – are currently at a low level within the Dutch life sciences and medical technology sector. Only 17% of companies active in biotechnology and pharmaceuticals, and 22% in the medical technology segment, score well in this respect. Good middle management is essential if the horizontal dependencies are to be created and maintained within the organization. The appointment of 'gatekeepers', temporary workgroups or cross-functional teams can do much to facilitate knowledge flows between various departments.

Professionalization of middle management is essential. Many companies within the Dutch life sciences and medical technology sector have a very experienced senior management team but lack professional middle management. Professionalization at this level will facilitate entry to new markets, product development and external cooperation. The creation of a strong middle management structure will also encourage horizontal cooperation and knowledge sharing.

Visionary leadership is important. Greater attention for the long-term, with a clear strategy and a vision for the future, is essential if continued profitability is to be assured. The development of a long-term vision enables management to make important choices and to reserve financial resources for renewal and innovation. Moreover, a clear and challenging vision will promote creativity and enthusiasm among staff. The ability to devise such a vision can be regarded as an extremely important managerial competence, especially within the biotechnology and pharmaceutical segments.

Cooperation with knowledge institutes and universities will be decisive. Despite the growing importance of external cooperation and knowledge sharing, only 38% of companies devote specific attention to these factors. Companies within the biotechnology segment in particular must take greater advantage of the current geographic clustering in order to enhance their innovative ability. Similarly, companies in the biotechnology and pharmaceutical segments could do much to enhance their innovative ability by intensifying their contact and cooperation with universities and knowledge institutes.

Cooperation 'across the boundaries' is essential to radical innovation. Successful cooperative alliances are characterized by a high degree of mutual trust and frequent communication. Cooperation with existing partners is clearly important. However, if successful radical innovation is to be achieved, it is essential to cooperate with *new* partners. Those partners could well be found in other sectors, whereupon they will have few similarities with the organization itself. The successful development of radical innovations will also rely heavily on the involvement and support of senior management.

Further coordination between the top institutes and public-private initiatives is desirable. The existing 'top institutes', public-private initiatives and regional development corporations have an important role to play in encouraging the formation of clusters and facilitating start-ups. Better coordination and cooperation between the various parties will serve to bring together the available

knowledge and experience. Advantages of scale can then be derived at sectoral level in terms of the development and application of that knowledge and experience.

Venture capital is more an injection of funds. The amount of venture capital used by the Dutch life sciences and medical technology sector has more than doubled in recent years, standing at approximately 350 million euros in 2007. The smaller companies within the biotechnology segment are those most likely to call upon external financing. It is not only the availability of funds which makes maintaining good relationships with financiers important; the supervision and monitoring exercised by those financiers does much to enhance the innovative ability of biotechnology companies.

The availability of capital in the early phase of product development has increased but remains low. The availability of venture capital has increased greatly in recent years. However, although 30% of investments relate to the initial phase of product development, the amount concerned is only 3.5% of the total capital invested in the life sciences and medical technology sector. Nevertheless, while the absolute amount of capital investment in the initial development phase remains relatively low, the *proportion* of financing in this stage has more than doubled over the past two years.

1. Introduction

1.1 Background to this study

In recent years, innovation has taken an increasingly important place on the agenda of both the Dutch government and the private sector in the Netherlands. However, the emphasis has generally been placed on increasing R&D investments and promoting *technological* innovation. The organizational aspects of innovation have largely been overlooked, which the authors of this report regard as a grave omission. This situation has given rise to a 'knowledge paradox': although both the private sector and research field are good at developing new knowledge and technologies, that knowledge has not been applied effectively enough in practice. As a result, the yield of R&D investments has fallen dramatically, and the Netherlands' competitive position is likely to be eroded in the long term. If this situation goes unresolved, the Netherlands will be unable to compete effectively against the emerging economies such as China, India and Brazil. The Dutch private sector and research field must therefore devote far greater attention to social innovation.

Research for the Erasmus Competition and Innovation Monitor (www.erasmusinnovatiemonitor.nl) reveals that R&D investments account for only 25% of the success of innovation initiatives. The remaining 75% relies on *social innovation,* with due regard for organization, management and cooperation, which will enable organizations to develop new products and services in a rapid and effective manner. Those organizations which devote greater attention to the organizational aspects therefore achieve noticeably better results: their cost-effectiveness is 25% higher, revenue growth some 20% higher, and profit growth approximately 10% higher than non-innovative organizations.

The Pharmaceutical Affairs and Medical Technology Directorate of the Netherlands Ministry of Health, Welfare and Sport (VWS) wishes to increase the yield of R&D investments within the medical products sector (pharmaceuticals, medical devices and body tissue). To do so would seem to demand greater attention for social innovation. However, firm evidence to support this contention was not available. The directorate therefore commissioned a study of social innovation within the sector. Using a validated measuring instrument, this study examined the main determinants of the success of innovation within: (1) individual organizations and (2) cooperative alliances (partnerships). The output of the study would consist of an overview of the influence and degree of social innovation, together with a set of indicators expressing the innovative ability of the Dutch life sciences and medical technology sector.

1.2 Definitions

This report is concerned with the life sciences and medical technology sector in the Netherlands. The Ministry of Economic Affairs defines 'life sciences' as:

A dynamic area of science and technology which provides a constantly updated 'toolkit' of innovative techniques relating to the use of biological life forms and production processes in many diverse application areas'[1]

[1] Ministry of Economic Affairs, Life Sciences Action Plan (2004); *Kansen Grijpen, Knelpunten Aanpassen*', p.17.

Besides the life sciences (in the sense of the biotechnology and pharmaceutical segments), this report is also applicable to the medical technology sector. Medical technology refers to equipment and devices which are used for the purpose of diagnosis, prevention, treatment, amelioration or compensation of disease and injuries.[2] Examples include equipment for diagnostic imaging, irradiation and anaesthesia, surgical and dental instruments, orthopaedic and prosthetic devices, and revalidation aids.

This report summarizes the current situation within the three segments in terms of (social) innovation, cooperation and productivity. Various topics are discussed in both general terms and in greater detail.

1.3 Research questions

The study of which this document forms the final report was initiated by the Ministry of Health, Welfare and Sport (VWS) and relied on a number of research questions which were derived from the key question:

> *How can the yield of Research & Development activities within the Dutch life sciences and medical technology sector be increased?*

From this key question, the researchers were able to distil the following sub-questions[3]:

- What is the relative importance of R&D and social innovation with regard to a structural renewal of the life sciences and medical technology sector?
- What are the success and failure factors for innovation? What is the importance of organization and management?
- What contribution does external cooperation make to successful innovation? What determines the success of external cooperation?
- What is the significance of venture capital? To what extent does venture capital promote innovation?

1.4 Research methodology and respondents

Further to the findings of the Erasmus Competition and Innovation Monitor, which revealed the importance of social innovation to the innovative ability of organizations, the Directorate of Pharmaceutical Affairs and Medical Technology wished to assess the importance of social innovation within the medical products sector as a whole. A validated measuring instrument was developed for this purpose, able to quantify the various aspects of social innovation (including leadership, management expertise and knowledge-sharing) within (1) individual organizations and (2) cooperative projects intended to develop new products and services (or their intermediate stages) in the pharmaceutical and medical devices segments. Based on the results of this measurement, it becomes possible to offer an overview of the relative importance of R&D on the one hand, and social innovation (organization, management and cooperation) on the other, and to produce a set of indicators which determine the innovative ability of the life sciences and medical technology sector in the Netherlands.

[2] Medical Devices Act, Art. 1, here in translation.
[3] The research questions were formulated in consultation with the Ministry of VWS and discussed with various representatives of the Life Sciences and Medical Technology sector during the start-up meeting held on 6 December 2007.

1.4.1 Research methodology

In order to answer the research questions, it was decided to adopt a two-pronged approach. New insights into the factors determining the success of innovation were gained by means of a large number of interviews with representatives of the life sciences and medical technology sector[4] and with entrepreneurs, government bodies, financiers, researchers and the potential users of new innovative products. These interviews served to create an accurate impression of the main developments and challenges within the sector. New information regarding market developments and relevant topics was raised during the interviews, which could then be further analysed. Similarly, a number of topics which were considered significant to the study were brought up during the start-up meeting held on 6 December 2007. They included the importance of external cooperation, the complexity of the innovation process itself, and the 'capital gap' which currently besets the funding of product development projects. Companies within the life sciences and medical technology sector often experience great difficulty in attracting sufficient capital for the initial stages of technology and product development.

To complement the interviews, a short questionnaire was produced to quantify the degree of (social) innovation within the life sciences and medical technology sector. This 'Erasmus Innovation Monitor for Life Sciences and Medical Technology' enquired into various aspects of management, organization and cooperation, and was distributed to some 650 individual organizations[5] forming a representative sample of the sector as a whole (which has a total of approximately 1200 such organizations).

Table 1.1 Research methodology

Component	Description
Qualitative research based on interviews with diverse representatives of the Dutch life sciences and medical technology sector.	In-depth interviews were conducted with approximately 25 representatives of the biotechnology, pharmaceutical and medical technology segments.
Quantitative research based on the 'Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008' questionnaire.	A questionnaire was submitted to approximately 650 organizations in the Netherlands. Most respondents were the CEO and/or his deputy.
Desk study; document and database analysis.	Various reports, documents and public databases relating to the life sciences and medical technology were examined.

The questionnaire examined various aspects of organization, management and cooperation, including trust and mutual confidence, shared vision, cross-functional integration and the types of partner with which the organizations conduct business. These aspects were then set against the results of innovation processes, such as the speed of development, entrepreneurship, innovative ability and the financial results.

[4] A list of interviewees is given in Appendix B.
[5] Of the 650 organizations approached, 127 took part in the study by returning a completed questionnaire.

1.4.2 The respondents

Various sources were used to generate the respondent sample. First, a list of organizations was compiled using the standard sector identifier codes. Codes BIC 731 ('medical and pharmacological research and development') and BIC 851 ('medical laboratories, blood banks and other organizations engaged in therapy-supportive research') were used to identify biotechnology companies, while Code BIC 244 ('production of pharmaceutical ingredients') was used to select respondents to represent the pharmaceutical industry, and Code BIC 331 ('production of medical equipment, instruments and orthopaedic articles') was used to select companies in the medical technology segment. The resulting list was then supplemented using the membership records of sector representative organizations such as Biofarmind, Faron, FHI, Nefarma, and Niaba. Of the total of some 1,200 companies and organizations active within the Dutch life sciences and medical technology sector, 650 were randomly selected to take part in the study.

Of these 650 organizations, 127 returned a completed questionnaire. The respondent percentage is therefore 19.5% of the sample, and 10.6% of all organizations within the sector. Of the respondent organizations, 36 (28%) are concerned with biotechnology, 34 (27%) with pharmaceutical production and 57 (45%) with medical technology.

The majority of respondents in the Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008 were the CEOs of the companies approached, or another senior management team member. The average age was 48. Interestingly, the average age in the biotechnology segment is somewhat higher (54) than in the pharmaceutical industry (45) or medical technology segment (47).

1.5 Structure of this report

Subsequent chapters of this report present and discuss the results of the study. Chapter 2 offers a general impression of innovation (both technological and social) within the Dutch life sciences and medical technology sector. In Chapter 3, we examine the role of management and organization within the innovation process, while Chapter 4 considers the study results relating to external cooperation. Chapter 5 examines the role of venture capital. The concluding chapter (Chapter 6) presents the authors' main recommendations.

2. (Social) innovation within the Dutch life sciences and medical technology sector

2.1 Introduction

This chapter examines (social) innovation within the Dutch life sciences and medical technology sector. We define the term 'social innovation' based on a brief description of each of the segments, before comparing the 'yield' of R&D investments in the sector to that of other sectors of the Dutch economy. The chapter concludes with a consideration of the relative influence of R&D investments and social innovation (organization, management and cooperation) on the actual success of innovation projects.

2.2 The Dutch life sciences and medical technology sector: an overview

2.2.1 Life sciences and medical technology

Integration of technological disciplines increases the complexity of the innovation process.

Technological developments within the life sciences and medical technology sector have prompted a major process of change. Ongoing integration of technological disciplines such as (medical) biotechnology, informatics, nanotechnology and material technology can only increase the complexity of the innovation process. The development of new solutions will demand greater integration of the existing knowledge domains. Moreover, social developments such as population ageing, the growing number of chronic conditions and the desire to reduce the costs of healthcare, also underline the importance of efficiency and effectiveness within the life sciences and medical technology sector. Alongside the established multinationals we now see the emergence of new, highly specialized companies which have successfully exploited new knowledge in the life sciences domain to create new products for diagnostics and prevention. Doing so relies not only on the ability to develop innovative solutions, but also the ability to shorten the innovation process ('time-to-market') and to increase the yield of R&D investments. New medicines and medical devices must be developed more quickly and at lower costs. This does not entail reducing R&D expenditure, but rather increasing the *yield* of the investments. It calls for better management of the innovation processes and greater cooperation, both within and between organizations, with a view to facilitating the application of new knowledge.

Alongside the development of new and innovation solutions, effectiveness ands speed are becoming increasingly important. The efficiency of the innovation process must be enhanced.

2.2.2. The knowledge base and scientific performance

Previous studies have revealed that the Dutch knowledge base in the life sciences and medical technology is at a high level. Between 1995 and 2004, the Netherlands accounted for some six thousand successful patent applications, and approximately 2.5% of the worldwide patent applications relating to life sciences and medical technology. Recent years have seen above-average growth in the number of patent applications relating to imaging, genetic and biomedical techniques, cell engineering and bio-informatics.[6] Dutch knowledge institutes and universities can also be seen to be remarkably productive. With only 0.25% of the world population, the Netherlands accounts for 2% of all scientific publications, which in turn account for some 3% of all

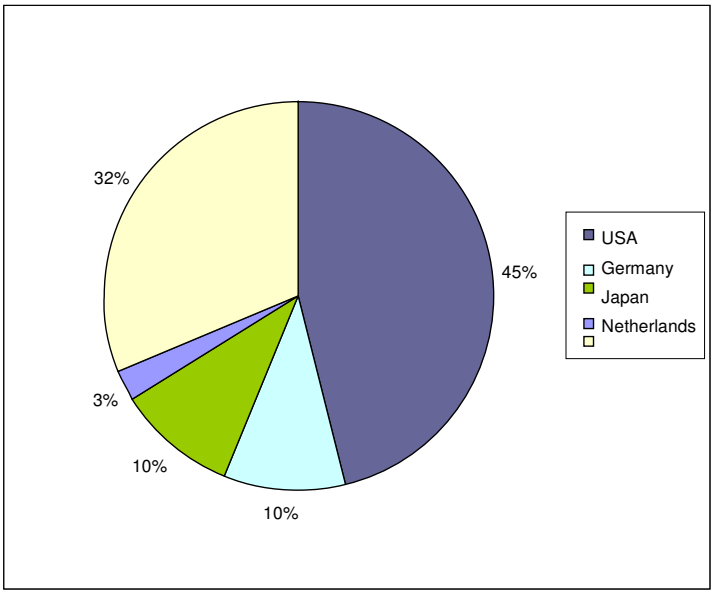
[6] Netherlands Patents Offices (Life Sciences and Health): 'Trends in octrooiaanvragen in medische biowetenschappen', 2006

Dutch universities and knowledge institutes are among the European leaders in terms of productivity and the number of citations.

Apart from the universities, knowledge institutes play a crucial role in knowledge development.

citations in scientific journals and digests. By these standards, the Dutch scientific field is performing exceptionally well[7]. The Netherlands' universities and knowledge institutes are among the European leaders in research, particularly in terms of the number of scientific publications and citations in international literature. The high number of citations can be seen as an indication of the intellectual impact of Dutch publications within the scientific world. The publications which are so frequently cited are usually of extremely high scientific and academic quality. The impact of Dutch university research continues to rise, and is already over thirty per cent above the global average, placing the Netherlands in third place in the world rankings. Countless public knowledge institutes which are not affiliated with a particular university have a very high citation rate and can therefore also claim international prominence.

Figure 2.1 Patents by country of origin



Source: NOWT

Despite the excellent starting position provided by the combination of a high-quality healthcare system and scientific knowledge, the degree to which this knowledge is actually used in practice has now come under pressure. This is not only due to the emergence of comprehensive clinical centres in Eastern Europe, but also to the expansion and relocation of R&D activities to the emerging economies such as China. Moreover, the degree to which enterprise and new start-ups are actively encouraged would appear to be lower than in, say, the USA, although start-ups form an important platform on which to apply the theoretical knowledge developed by universities and knowledge institutes.

The Dutch life sciences and medical technology sector must therefore increase its focus on the practical application of knowledge in order to integrate the diverse developments within the (equally diverse) technological disciplines. By facilitating start-ups and encouraging cooperation between organizations in various segments, it will be possible to create new and innovative combinations which can generate various applications within nanotechnology, biotechnology and the pharmaceutical industry.

[7] NOWT, Science and Technology Indicators, 2008

2.2.3. Convergence of technologies and sectors

One of the most significant developments – and challenges – within the Dutch life sciences and medical technology sector is the convergence of existing and new technologies.

One of the most significant developments – and challenges – within the Dutch life sciences and medical technology sector is the convergence of existing and new technologies. Various study reports suggest that this convergence will lead to a plethora of new applications and projects in the fields of food, health and medicine. The combination and integration of information and communication technology, biotechnology, nanotechnology and materials technology will result in many innovations. Commercial organizations will then find it increasingly necessary to work alongside other companies and their clients, since no one organization will have all the required knowledge at its fingertips.

Future developments are likely to show even greater integration of biotechnology, ICT, nanotechnology and materials technology. The pharmaceutical industry, the food production industry, agriculture and the processing industry will therefore see major changes brought about by promising inventions and developments which derive from the life sciences and medical technology sector.

Within the specific domain of *biotechnology,* there will be many developments in genomics, proteomics, transcriptomics and metabolomics which will bring about dramatic changes in terms of the possibilities for prevention, diagnosis and treatment of a range of medical conditions. It will be possible to detect illness and commence treatment at an ever earlier stage. There will also be greater opportunities for 'personalized medicine'. Examples of the applications of genomics include pharmacogenetics, gene therapy, DNA chips, recombinant DNA drugs and epigenetics.

Developments in *nanotechnology* will render medical technology increasingly 'invisible'. It seems likely that by 2020, applied medical technology will have been fully integrated into the human environment. Minuscule chips will be integrated into clothing, or even implanted into the human body itself. Medical products will use information and communication technology to exchange data, and can be linked to a worldwide wireless communication network. The result is 'remote care', with diagnosis and treatment shifting into the patient's own home.

New advances in *materials technology* will enable the development of intelligent sensors which can be worn on the person, or actually within the body. These sensors will transmit information about the user to healthcare providers, thus facilitating remote diagnostics and treatment. Some microchips will not only monitor the user's health, but could respond proactively to changes by administering the necessary medication, doing so locally to specific parts of the body. The boundary line between 'drug' and 'medical device' will then be less clear cut. Brain implants could create artificial synapses, emulating and assuming the function of faulty natural connections. New techniques in tissue engineering and stem cell research could result in products which repair, regenerate or replace natural tissue and organs.

In the years ahead, developments within biotechnology and the pharmaceutical industry will show further convergence. Greater knowledge about the relationship between genes and certain diseases, together with new techniques, will make it possible to identify the most appropriate medication, and to do so with greater effectiveness and efficiency. Knowledge of the individual variations in the genome will lead to the creation of drugs which are more closely attuned to individual genetic profiles.

Companies will be forced to redefine the boundaries of the possible.

Cooperation is essential if the required knowledge is to be integrated.

The convergence of technologies and the future developments in biotechnology, ICT, nanotechnology and materials technology will force the companies within the life sciences and medical technology sector to re-explore and redefine the boundaries of the technological possibilities. In doing so, cooperation will be essential. The knowledge base of the companies must be broadened, and cooperative alliances with various partners will be required in order to integrate the necessary knowledge. Apart from R&D investments, aspects of management and organization play a crucial part in both internal knowledge development and external cooperation.

2.2.4. International statistics for life sciences and medical technology

The United States is the largest cluster, followed by Europe.

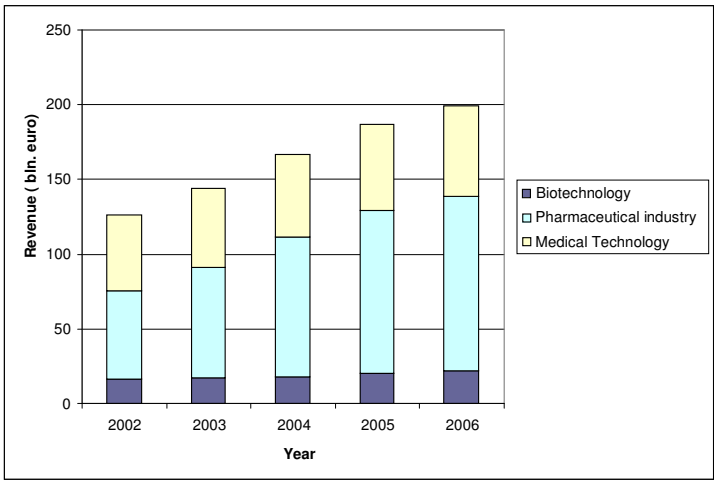
Research into new technologies is not confined to the Netherlands, of course. It is being conducted throughout the world. Despite the emergence of the Asian countries, notably Japan, South Korea and China, the life sciences nevertheless retain a clear centre of gravity in the United States and Europe. The United States accounts for the largest cluster, having a 47% share of the global market (in terms of revenue). Europe, with a market share of approximately 30%, is the second most important cluster in the life sciences and medical technology.[8] The worldwide pharmaceutical market is now on the threshold of a twofold increase in revenue, which is expected to reach USD 1,300 billion by the year 2020[9]. This increase will be due to the rising global demand for drugs and preventive treatments, fuelled by population growth, population ageing and greater prosperity.

Turnover in the European life sciences and medical technology sector increased by more than 50% between 2002 and 2006.

Revenue growth has already been seen in Europe in recent years. Figure 2.2 shows that the turnover of the European life sciences and medical technology sector rose by over fifty per cent between 2002 and 2006. This is almost entirely due to growth within the European pharmaceutical sector. That of the biotechnology and medical technology segments has remained extremely modest by comparison.

[8] EFPIA, 2006
[9] PWC, 2007

Figure 2.2 Revenue of the European life sciences and medical sector, 2002-2006



Source: RSM Erasmus University

Since 2005, the European bio-technology segment has seen average growth of 10%-12%.

Success relies on the ability to shorten the time-to-market.

However, growth in the biotechnology segment showed a significant spurt from 2005 onwards, and European biotechnology companies were able to increase their turnover by an average of 10% to 12%. Given the convergence of technologies and the resultant need for cooperation between the biotechnology segment and the pharmaceutical industry, growth in the biotechnology segment is likely to increase further in the years ahead.[10] The success of the European biotechnology segment relies heavily on the degree to which companies are able shorten the time-to-market of commercially interesting innovative products. This is reflected by the marked increase in the number of products reaching the clinical development phase in recent years.

The Dutch life sciences and medical technology sector has a European market share of 2-3%.

Within Europe, France and Germany are currently the largest market parties in the life sciences and medical technology sector. In biotechnology and the pharmaceutical industry, the Netherlands has an average market share (by revenue) of between 2% and 3%. That of the medical technology segment is somewhat higher, with the Netherlands accounting for approximately 9% of the total European revenue in this segment.

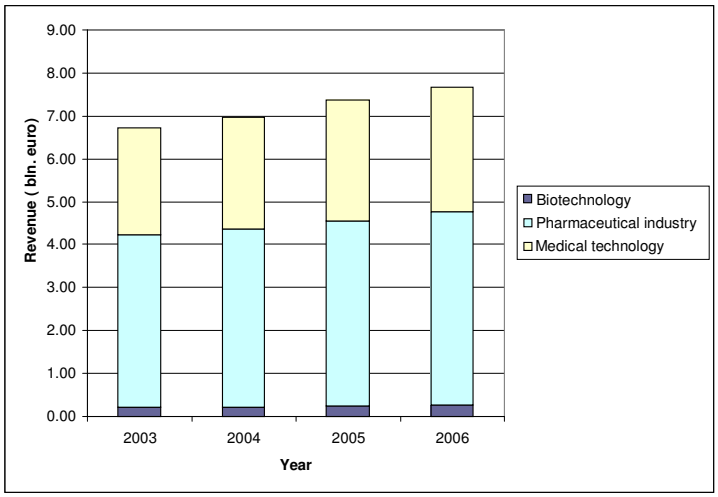
2.2.5. The Dutch life sciences and medical technology sector

Total annual turnover of the Dutch life sciences and medical technology sector exceeds 8 billion euros.

The Dutch life sciences and medical technology sector comprises approximately 1,200 companies which between them achieve annual turnover of approximately eight billion euros. Figure 2.3 illustrates that – as for Europe as a whole – the individual segments have all enjoyed ongoing growth.

[10] Ernst & Young, 2006; 2007

Figure 2.3 Revenue of the Dutch life sciences and medical technology sector, 2003 - 2006

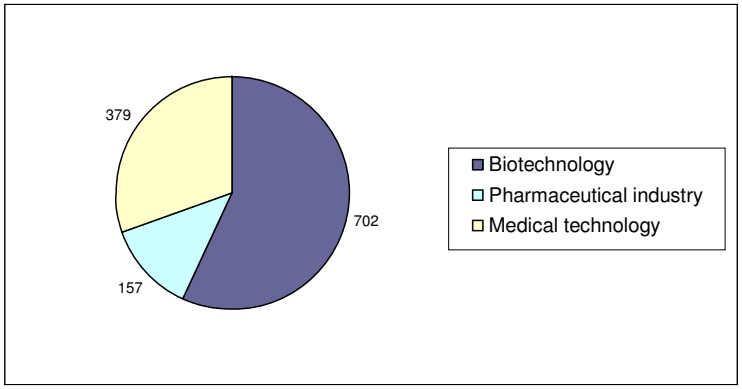


Source: RSM Erasmus University

Recent years have seen accelerated growth in the Dutch life sciences and medical technology sector, with revenue rising by an average of 12-14% per annum.

Growth in the Dutch Life sciences and medical technology sector has averaged approximately 4% per annum, the greatest contribution having been made by the pharmaceutical industry and the medical technology segment. It is noticeable that the biotechnology segment lagged behind in terms of revenue growth during the period 2003 to 2006. In the past two years, the sector as a whole has seen accelerated growth, with revenue rising by an average of 12 to 14% per annum. Various reports conclude that this level of growth will be maintained in the years to come.

Figure 2.4 Number of companies within each segment of the Dutch life sciences and medical technology sector



Source: RSM Erasmus University

Some 1200 organizations are active in the Dutch life Sciences and medical technology sector.

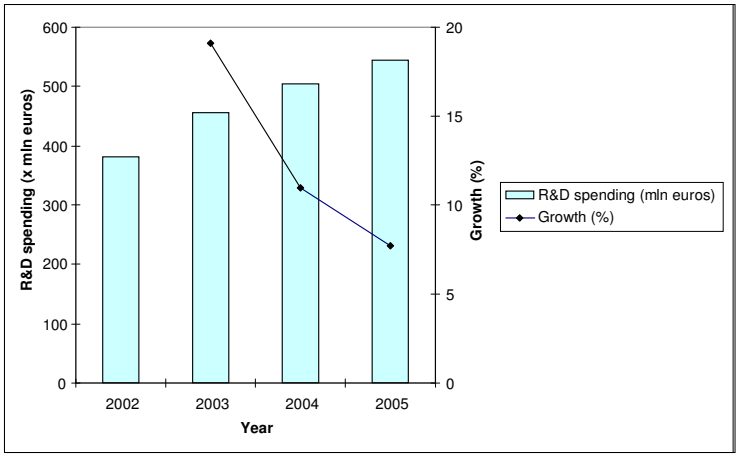
Approximately 1200 companies and organizations are active in the Dutch life sciences and medical technology sector. The majority, some seven hundred, are concerned with biotechnology. For the most part, the biotechnology segment comprises companies engaged in medical and pharmacological R&D (585 organizations) while the remainder (117 organizations) are laboratories, blood banks and other organizations for 'therapy-supportive' research. Some 157 companies are active within the pharmaceutical industry, while the medical technology segment has approximately 380 companies.[11]

[11] This figure excludes dental laboratories (of which there are 702) and those which produce orthopaedic footwear (131).

Recent years have seen a significant increase in R&D investments, in the order of 12% per annum.

Recent years have seen a significant increase in R&D investments within the Dutch life sciences and medical technology sector. Following a relative dip during the period 2000-2002, the absolute investments within the pharmaceutical industry increased from approximately 390 million euros in 2002 to approximately 550 million euros in 2005. This represents average annual growth in the order of 12%. However, it is interesting to note that the average growth in overall R&D expenditure fell from 19% in 2003 to 7.5% in 2005.

Figure 2.5 R&D expenditure by the pharmaceutical industry



Source: CBS

Total R&D investments in the biotechnology sector are 95 million euros. The pharmaceutical industry accounts for investments of 550 million while the medical technology sector invests 270 million.

R&D investments in the biotechnology sector are expected to show further strong growth.

Information regarding R&D expenditure within the biotechnology and medical technology segments is difficult to obtain. The figures quoted by various reports are extremely divergent. However, an estimate based on the Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008 suggests that investments have risen substantially in recent years, particularly in the biotechnology segment. The estimated annual R&D investments by the three segments are: 95 million euros by biotechnology; 550 million by the pharmaceutical industry and 550 million and 270 million euros by the medical technology segment.[12] Total R&D investments within the life sciences and medical technology sector as a whole are therefore close to one billion euros per annum, and it is expected that this figure will continue to rise in the years ahead. The Biotechnology Report 2008, produced by independent analysts Ernst & Young, suggests double-figure growth and a marked increase in the number of products in development.

Given the high level of scientific research and the growing realization that the results of this research do indeed lead to the development of new products, we see an increasing number of spin-off companies set up by universities, knowledge institutes, and further to public-private research projects. Activities within the life sciences and medical technology sector are now demonstrating marked clustering, with increased activity noted in the immediate vicinity of several Dutch universities. This clustering would appear to be useful in terms of the development and generation of important breakthroughs in both technologies and products.[13]

Convergence of technologies renders cooperation between the research field and the private sector essential if the new knowledge is to be applied in the form of new products and services. The geographic clustering of knowledge institutes and universities, together with the creation of

[12] R&D investments in each segment of the life sciences and medical technology sector have are calculated further to the findings of the Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008.
[13] See also TNO (2002) and EIM (2006).

Convergence of technologies calls for cooperation, clustering and the creation of central institutes.

(bio)science parks, plays an important facilitative role. A parallel development is the creation of various 'top institutes' in various areas of the life sciences and medical technology. Institutes such as TIPharma, CTMM, BMM and NGI exist to promote cooperation between the various parties involved.

Bringing the parties and their knowledge together will help to increase innovative strength. However, it is also essential to promote the sharing of knowledge and experience in terms of the management and organization of complex innovation projects. This is an important function of the top institutes with a view to increasing the level of enterprise within research organizations and universities. The interviews conducted further to this study reveal that experience and expertise in creating new companies and partnerships does much to determine their subsequent success.

Table 2.1 Knowledge institutes in the Dutch life sciences and medical technology sector

Programme	Objectives	Subsidy	Period
TI Pharma Founded: 2006	To achieve a leading position in pharmaceutical research; to shorten the development process for new drugs by increasing research capacity; to create knowledge which will enhance the effectiveness and efficiency of pharmaceutical research.	€ 130 mln (government) € 65 mln (private sector) € 65 mln (universities)	2007-2011
BioMedical Materials Program (BMM) Founded: 2006	To strengthen the Netherlands' existing leading position in the field of biomaterials; to promote the development and exchange of knowledge which will enable the development of new, cutting-edge biomaterials and successful medical applications.	€ 45 mln (government) € 45 mln (private sector and universities)	2008-2013
Centre for Translational Molecular Medicine (CTMM) Founded: 2006	To play a leading role in the development of molecular diagnostics and molecular imaging which enable early-stage diagnosis and personalized patient care.	€ 150 mln (government) € 75 mln (private sector) € 75 mln (universities)	2007-2009
Netherlands Genomics Initiative (NGI) Founded: 2002	To ensure that the developments in genetics benefit both society and the economy when applied in the areas of healthcare, food and diet, sustainability and security.	€ 280 mln (government) € 220 mln (private sector and universities)	2008-2012

The 'Life Sciences and Health' innovation programme is a key instrument in promoting public-private cooperation.

A key component in encouraging public-private partnership is the Life Sciences & Health innovation programme, which focuses on the continuity and growth of start-up companies, and on the valorization of knowledge generated by universities and knowledge institutes. The programme is a joint undertaking by the Ministry of Economic Affairs, the private sector (both the SME sector and multinationals) and the knowledge and knowledge institutes. It will make a substantial contribution to the cohesion of public-private initiatives such as the TI Pharma, CTMM, BMM and NGI. Partners within the programme include the university medical centres, universities, public sector bodies, small and medium-sized companies and the leading industrial multinationals.

2.3 R&D investments, innovation and commercial results in the Dutch life sciences and medical technology sector

R&D investments play a crucial role within the Dutch life sciences and medical technology sector.

Within the life sciences and medical technology sector in the Netherlands, innovation and modernization are inextricably linked. The skills required to undertake R&D activities at an appropriate level now require redefinition. Both the emergence of new technologies and the integration of existing technologies render it essential for all three segments - biotechnology, the pharmaceutical industry and medical technology - to push back the existing boundaries and broaden their outlook. R&D investments therefore play a crucial role within the sector as a whole. The importance of such investments, and hence the ability to develop new drugs and medical devices, is clearly illustrated by the findings of recent Erasmus Innovation Monitors. Approximately 18% of the total workforce is engaged in R&D (EIM, 2006). Given the proportion of time and staffing costs devoted to R&D, and the number of Dutch patent applications as a proportion of the worldwide total, we may conclude that the Dutch life sciences and medical technology sector represents an important basis for innovation and modernization.[14]

2.3.1 R&D investments, innovation and revenue growth within the three segments

The development and application of new technologies does much to determine growth in revenue and profits.

The Dutch life sciences and medical technology sector is a particularly knowledge-intensive industry in which the development and application of new technologies does much to determine growth in revenue and profits. The sector's R&D investments expressed as a proportion of turnover are therefore higher than the national average of 4.7%.

Table 2.2 Average R&D investments as percentage of turnover

	Average percentage of turnover devoted to R&D
Biotechnology	28%
Pharmaceutical industry	13%
Medical technology	8%
National average	4.7%

Biotechnology is extremely knowledge-intensive: 28% of turnover is reinvested in R&D activities.

The pharmaceutical industry devotes 13% of turnover to R&D and the medical technology sector approximately 8%.

As we see from Table 2.2, the biotechnology segment's R&D investments are far above the national average when expressed as a proportion of turnover, and are indeed higher than in the life sciences and medical technology sector as a whole. Biotechnology is therefore one of the most knowledge-intensive segments in the Netherlands, investing a particularly high percentage (28%) of turnover in R&D. The figure for the pharmaceutical industry is approximately 13%, while that for medical technology is approximately 8%. These figures indicate an extremely capital-intensive innovation process within the sector, and particularly in biotechnology and pharmaceutical industry. Given the complexity and intensive nature of technology development and product innovation, the ability to attract capital is an important factor within the innovation process of biotechnology companies, and particularly the smaller companies in this segment[15].

[14] According to the EIM report (2006), the total R&D staffing costs in the Dutch life sciences and medical technology sector exceed one billion euros.

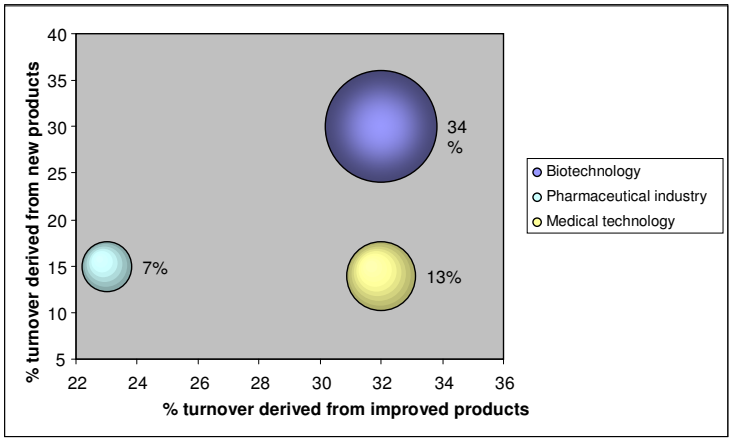
[15] This report draws attention to the importance of cooperation and capital in the innovation process. We return to these points in Chapter 4 and 5 of the current document.

Growth within the pharmaceutical industry has failed to keep pace with the national average. Over the past three years, the average growth rate has been 7%.

The average growth rate for biotechnology is 34%; that of medical technology is 13%.

The Erasmus Competition and Innovation Monitor 2008 reveals that the Dutch private sector as a whole has seen an average 12% growth in revenue over the past three years. As illustrated by Figure 2.6, however, the growth rate in the pharmaceutical industry has been somewhat lower, at 7%. Revenue growth in the medical technology segment has been slightly higher than the average, at 13%. The biotechnology segment can be seen to be one of the fastest-growing industries in the Netherlands, with an average growth rate of 34%.[16]

Figure 2.6 Innovation, productivity and revenue growth within the Dutch life sciences and medical technology sector



The pharmaceutical industry lags behind in terms of the proportion of turnover derived from new products.

Greater attention must be devoted to turnover from new products.

Figure 2.6 reveals a clear trend in the turnover derived from new products, that derived from improved products, and the overall revenue growth achieved. Those segments which have increased the percentage of revenue derived from both the new and the improved products have also enjoyed noticeably higher revenue growth. The pharmaceutical industry has lagged behind in terms of turnover derived from new products (14%) and also that from improved products (23%). In view of the conspicuously lower growth in revenue achieved by the pharmaceutical industry, it is appropriate to devote greater attention to new product development and the creation of new applications for existing technologies. Both strategies should be integrated within the corporate strategy of pharmaceutical companies. Enterprise, horizontal knowledge exchange and external cooperation (with knowledge institutes, universities and biotechnology companies) must be further encouraged.

Productivity in the biotechnology segment could be further improved by professionalizing management.

The biotechnology and medical technology segments achieve a greater proportion of their turnover from new and/or improved products than the pharmaceutical industry. Various studies confirm that the Dutch biotechnology segment is indeed innovative. No less than 30% of turnover is generated by new products, while over 32% comes from improved versions of existing products. Biotechnology companies have therefore demonstrated their flexibility in developing new technologies as well as in being able to apply new knowledge to create new solutions. Productivity in the segment could be further improved by professionalizing management. Managers should create opportunities for an even higher degree of innovation while pursuing ongoing improvements in productivity and efficiency.

[16] Growth rates vary significantly within the biotechnology segment. The study identified companies with zero growth as well as those with growth in excess of 150%. This variance is above average and above that of the pharmaceutical and medical technology segments.

Companies in the medical technology segment derive approximately 14% of their revenue from new products and services. Additional turnover of 32% is generated by improving existing products and services. The segment therefore fares above average in this regard. With overall revenue growth averaging 13%, the producers and suppliers of medical technologies would seem to have laid a firm foundation for further value creation. However, to guarantee a competitive advantage in the long term, companies in this segment must devote greater attention to developing new products. Improving existing products will provide growth and income for the immediate future, but increasing competition and the resulting pressure on prices will demand that new, more advanced solutions are devised to meet the increasing demand for healthcare services. Greater creativity, enterprise and cooperation are therefore essential.

Attention must be devoted to the development of new products if the long-term competitive advantage is to be maintained.

2.3.2 Performance: innovative versus non-innovative organizations

The study distinguished between two categories of organizations: 'innovative' and 'non-innovative'.[17] In recent years, innovative organizations have not only been able to develop new products and services, but are often also the first to launch such products on the market. Enterprise, entrepreneurship and renewal are essential to increasing the innovative ability of the Dutch life sciences and medical technology sector.

Entrepreneurship can be organized internally by creating new teams or departments, but it can also be encouraged by setting up new ventures and spin-offs. These aspects enable organizations to increase enthusiasm for innovation. Innovative organizations enter new national and international markets, generate new product lines, and start new activities by means of internal ventures or external spin-offs.

The Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008 reveals that innovative organizations achieve markedly better results than their non-innovative counterparts. By increasing the innovation component, turnover growth can be increased by 12% and profitability by 17%. Product innovation and modernization of processes clearly have their rewards in the life sciences and medical technology sector. The development of new treatments for certain medical conditions and the invention of cutting-edge medical devices have created new income which can be used to finance ongoing innovation projects.

Innovative organizations achieve noticeably better results: 12% higher turnover growth and 17% higher profit growth.

[17] An 'innovative organization' is one which is in the top 25% of the organizations studied in terms of innovation and process modernization. Over the past three years, the members of this group have regularly been the first-to-market with innovative products and services, have actively explored new sales markets, and have been particularly dynamic in terms of product and process innovation. The study also looked at the degree of advancement in terms of expanding national and international activities, creating product lines, and setting up new ventures and start-ups. The 'non-innovative' organizations are the 25% of the organizations studied which achieve the lowest scores for these indicators.

Table 2.3 Performance of innovative and non-innovative organizations

Performance indicator	Innovative v. non-innovative Organizations
Turnover growth	12% higher
Profit growth	17% higher
Ability to attract new customers	11% higher
Growth in market share	14% higher

Profit margins can be improved by ensuring a continuous flow of innovation processes.

Innovation and modernization must be placed high on the agenda. Technological developments, changes within the healthcare market and increasing international competition will place prices under further pressure. In the long term, profit margins can only be maintained or improved by ensuring a continuous flow of innovative solutions. Innovative organizations are better equipped to ensure that innovation and the development of new products and services is not just a 'flash in the pan'. They invest in ongoing renewal by means of parallel innovation processes. Continuity of profit relies not only on effective commercial exploitation of the products, but on effective management of the innovation processes in the various stages of development.

The degree of difference in performance between the innovative organizations and their non-innovative counterparts varies according to segment (see Table 2.4).

Table 2.4 Innovative v. Non-innovative organizations: performance by segment

	Biotechnology	Pharmaceutical industry	Medical technology
Performance indicator	Innovative v. non-innovative organizations	Innovative v. non-innovative organizations	Innovative v. non-innovative organizations
Turnover growth	13% higher	16% higher	10% higher
Profit growth	2.2% higher	25% higher	10% higher
Ability to attract new customers	2.5% higher	22% higher	3% higher
Growth in market share	4% higher	19% higher	8% higher

The pharmaceutical industry can achieve a significant improvement in results by increasing its innovative strength.

The difference in organizational performance is greatest in the pharmaceutical industry and the medical technology segment. While the biotechnology segment can be seen to be particularly effective in increasing turnover by means of innovation (+13%), innovative organizations in the pharmaceutical industry have done most to increase profits (+25%).

Focusing solely on cost reductions and efficiency improvements will undermine performance and competitiveness in the long term.

The development of new product lines and the application of new technologies would appear to be most effective in increasing turnover and profits within the pharmaceutical industry and medical technology segment. Organizations in the pharmaceutical industry are able to achieve significant growth in both turnover and profits primarily by attracting new customers (+16%) and by increasing their market share (+19%). Innovation and modernization should therefore be even higher on the

agenda of these organizations. Focusing solely on cost reductions and efficiency improvements will undermine performance and competiveness in the long term.

Biotechnology is already notable for a high degree of innovative ability

The effect of product innovation on financial results would seem to be far less marked within the biotechnology segment. Table 2.4 shows that innovative companies in this segment have achieved a significantly higher growth in turnover (+13%) but have not been able to improve their profit growth significantly more than the non-innovative companies (+2.2%). In addition, the ability to attract new customers (+2.5%) and growth in market share (+4%) are somewhat lower than in the other two segments. The effect of innovation in the biotechnology segment would therefore seem to be less significant in terms of improving financial results. One explanation for the minor difference may be that the Dutch biotechnology segment is already notable for a high degree of innovative ability. As we see from Figure 2.6, approximately 30% of turnover in the biotechnology segment is derived from new products which have been developed within the last three years, while a further 32% of turnover derives from improved products. The Dutch biotechnology sector can therefore be seen as one of the most innovative within the national economy as a whole.[18] Accordingly, the relative difference between the innovative and the non-innovative organizations is not proportional to R&D investment. Nevertheless, it remains necessary to make more resources available in order to increase the yield of R&D activities in the biotechnology segment. The minor difference may also be attributable to the fact that, while R&D investments do indeed lead to new products and services, the revenue derived from those products and services is not enough to cover the costs incurred. Experience and management quality are therefore also essential in increasing productivity and thus reducing the costs of product innovation yet further. Innovation, productivity and effective management of parallel innovation projects must be combined if biotechnology companies are to remain successful in the long term.

2.3.3. The current status of innovation within the Dutch life sciences and medical technology sector

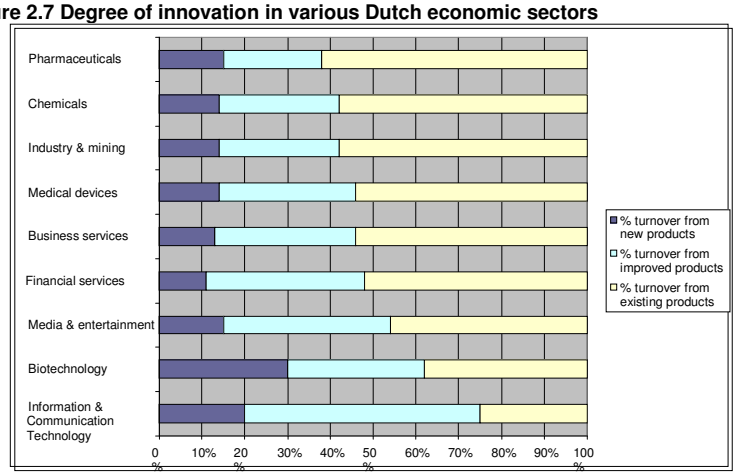
Countries such as China and India pose a threat to the Dutch life sciences and medical technology sector.

Product development demands the development and application of knowledge.

As we have seen, innovation and (process) modernization are becoming increasingly important. Technological developments, changing market demand, increasing international competition and the resultant pressure on prices demand the development of new knowledge and the application of that knowledge. The competitive position of the Dutch economy will no longer be based on cost advantages such as lower wages, but on the added value provided by a unique combination of knowledge, infrastructure and dynamic knowledge flows. Countries such as China and India are rapidly becoming high-quality research centres. The Dutch life sciences and medical technology sector can only remain successful in the longer term if the high level of knowledge within its knowledge institutes, universities and private sector companies is used in product innovation, and if the innovation processes can be shortened.

[18] Elsewhere in this report, the life sciences and medical technology sector is compared to other sectors of the Dutch economy. This comparison reveals that the biotechnology segment, like Information and Communications Technology, is one of the most innovative sectors within the economy as a whole.

Figure 2.7 Degree of innovation in various Dutch economic sectors



Biotechnology companies are among the leaders in innovation in the Netherlands.

Figure 2.7 compares the biotechnology, pharmaceuticals and medical technology sectors to a number of other important sectors within the Dutch economy. As we have seen, the biotechnology sector is one of the most innovative in the country. No less than 30% of turnover is derived from new products, with a further 32% from improved applications developed within the past three years. Biotechnology companies are therefore the leaders in value creation through innovation and process modernization. Of the other sectors, only Information and Communication Technology achieves above-average revenue (20%) from new products. However, it is interesting to note that companies within both the ICT sector and media & entertainment achieve a higher proportion of revenue from improved technologies and products. The biotechnology segment must therefore increase the degree to which existing technologies and products can be improved. Various spin-offs of existing technologies should be developed, possibly in association with knowledge institutes, universities or other companies. By implementing parallel development processes for new product development and the improvement of existing products, biotechnology companies will be able to increase their cashflow and will therefore be in a better position to finance further development projects.

The pharmaceutical industry is lagging behind in terms of the ability to derive turnover from new products.

This point – increasing the ability to combine existing knowledge within organizations and to find new applications for existing technologies and products – is one to which companies in the pharmaceutical industry and medical technology segments must also devote attention. While the Dutch private sector as a whole derives 35% of its revenue from products and services which have been updated and improved in the last three years, the pharmaceutical industry derives only 23% of revenue from such products, and the medical technology segment 32%. Moreover, turnover derived from new products and services is not particularly high, at 15% for the pharmaceutical industry and 14% for the medical technology segment.

The pharmaceutical and medical technology sectors show middling performance when it comes to deriving turnover from improved products.

Given the increasing complexity of the innovation process, the convergence of various technologies and the increasing international competition in the life sciences and medical technology sector, Dutch companies must not only be able to increase the yield of their R&D investments, but must also safeguard the productivity and efficiency of the innovation and development process. To achieve appropriate balance between innovation and productivity forms a major challenge to modern organizations. In the pharmaceutical industry in particular, innovation and process modernization call for far greater autonomy, daring and entrepreneurship. By contrast, the

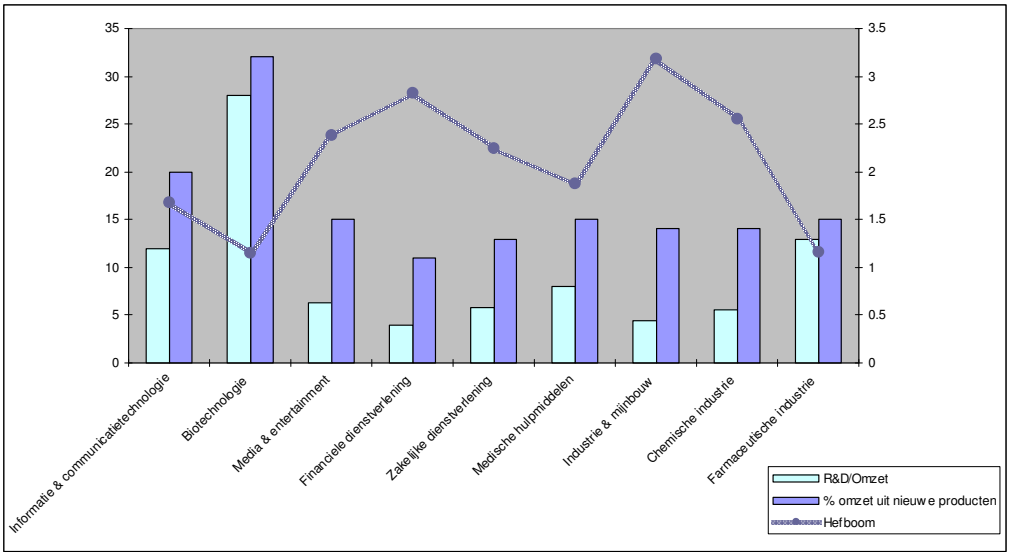
The balance between 'exploration' (R&D and innovation) and 'exploitation' (production and improvement) is one of the main management challenges within the Dutch life sciences and medical technology sector.

improvement of existing products and services calls for greater control, efficiency and speed. The balance between 'exploration' (R&D and innovation) and 'exploitation' (production and improvement) therefore becomes one of the main management challenges within the Dutch Life sciences and medical technology sector. To achieve this balance demands excellent management skills, visionary leadership and external cooperation with various partners.[19]

R&D yield is relatively low in the biotechnology, pharmaceuticals and medical technology segment.

The urgency of increasing the productivity and efficiency of the innovation process (in addition to increasing the capacity to create new applications for existing technologies and products) is amply illustrated by Figure 2.8, which shows the R&D investments per sector against the revenue generated from new products and services. A key indicator of the effectiveness of R&D investments is the relative contribution of R&D investments (expressed as a percentage of revenue) to the turnover which is eventually derived from the resultant products. Within the Dutch life sciences and medical technology sector, this 'leverage factor' is slightly higher than 1. In the Dutch private sector as a whole, it is somewhere between 2 and 2.5. The biotechnology segment and the pharmaceutical industry have a conspicuously low yield from R&D investments, at 1.1 and 1.2 respectively.

Figure 2.8 Yield from R&D investments in the Netherlands



Source: RSM Erasmus University

The complexity of the innovation processes calls for uniform and efficient innovation processes.

The lower R&D yield in the biotechnology and pharmaceutical segments can be partly explained by the complexity of the innovation process. The development of new drugs and devices generally involves a long project lead time. Complicating factors include the high degree of unpredictability and rigid legislative requirements, whereby pharmaceutical innovation projects are among the most challenging and complex projects there are. Any delay in the registration of a new drug could represent lost turnover running into millions of euros. Uniform and efficient business and innovation processes are therefore extremely valuable and are very important in establishing a long-term competitive advantage.

The complexity involved also has a major influence on the development time and means that the process of bringing a new drug onto the market takes an average of between ten and fifteen years. Within the medical technology segment, the innovation process is slightly less complex and patent

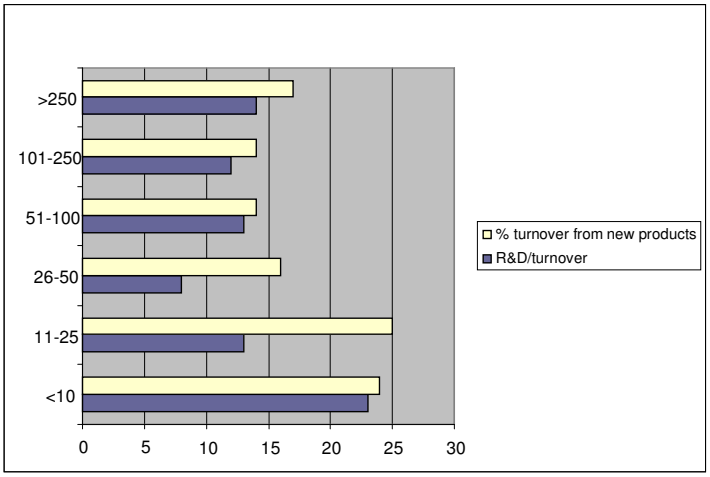
[19] Later in this report, we devote extensive attention to aspects of management, organization and cooperation within the Dutch life sciences and medical technology sector.

rights are somewhat easier to protect. Furthermore, innovations in medical technology carry a lower risk in terms of the success percentage and financial risk. This segment therefore has shorter development and product lifetime cycles, smaller R&D teams and lower R&D investments.

R&D yield is lower among smaller companies (<10 employees) and larger organizations (>50 employees).

The yield from R&D investments within the Dutch life sciences and medical technology sector would appear to vary according to the size of the organization concerned. Figure 2.9 shows that both smaller companies and those with over 51 staff achieve a lower R&D yield: the effectiveness of R&D investments in relation to the turnover generated by new products and services is slightly higher for organizations with between 11 and 50 employees.

Figure 2.9 R&D yield by size of organization



The main factors influencing R&D yield include management quality, leadership, experience in cooperation and the more radical nature of product development within smaller organizations.

Within the Dutch life sciences and medical technology sector, the effectiveness of the innovation process can therefore be enhanced, particularly on the part of the smaller companies (with fewer than ten employees) and the larger organizations (with more than 50 employees). Both groups have lower yield than the medium-sized organizations (with 11 to 50 employees). The determining factors are likely to be management quality, leadership and the degree of experience in external cooperation. In addition, smaller organizations in the biotechnology segment are noted for their more radical approach to technology development and product innovation, whereupon there is a higher capital requirement and higher demand for R&D investments.

2.4 Social innovation: a summary

Innovation is seen as the main challenge faced by modern organizations. Traditional organizations structures were perfectly adequate in the relatively stable business setting of past decades. However, the globalization of markets, rapid technological developments, shorter product life cycles and increasing aggressive competitors have radically changed the rules of competitive business in the 21st century. Companies must now innovate more rapidly. However, devoting due attention to innovation as well as the day-to-day operations of the company is difficult, and is one of the main hurdles that management must overcome.

In the Netherlands, discussions about innovation generally centre on the importance of *technological* innovation and hence on a policy which will serve to encourage investments in R&D and technological innovation. Another type of innovation – organizational or social innovation – has been largely ignored. The Ministry of Economic Affairs' *Innovation Essay* (2004) calls for greater attention to be devoted to the non-technological determinants of innovation, i.e. management and organizational aspects. Doing so can also increase the yield of R&D investments. In 2004, the AWVN employers' federation, acknowledging the relevance of these non-technological determinants, published a Social Innovation Manifesto which sets out nine basic principles. In 2005, the Social Innovation Taskforce began to champion a restructuring of the labour organization and more effective use of competencies in order to promote the development of talent and improve business performance. In a policy document published by the Innovation Platform (*Vitalisering van de kenniseconomie;* Wijffels and Grosveld, 2004, p.23) we read: "innovation takes place not only in the laboratory but also, and mainly, on the workfloor." The document goes on to examine the influence of 'flat' (non-hierarchical) organizational structures, forms of interactive management, creating opportunities for experimentation, dedication on the part of senior management and commitment on the part of all staff. The term 'social innovation' embraces all these essential building blocks of innovative, forward-looking organizations.

Flexible organizational structures, dynamic management and effective cooperative alliances enable organizations to recognize new knowledge promptly, to assimilate that knowledge and to exploit it for commercial purposes. This 'absorptive ability' would appear to be one of the most important aspects in promoting innovation. However, the international rankings published by the World Economic Forum reveal that the Netherlands still scores rather poorly in this respect.[20]

In the Netherlands, organizational renewal and management skills would therefore appear to be neglected determinants of innovation. The ability to manage innovation and change on an ongoing basis is the most vital and demanding challenge facing commercial organizations. To remain innovative and successful in the long term, the life sciences and medical technology sector must devote attention to the non-technological determinants of innovation. Indeed, the 'softer' aspects of innovation, such as leadership, culture and cooperation, appear to be decisive factors in the success of all innovation, including product innovation.

[20] World Economic Forum.

2.4.1 Definition of Social Innovation

Social innovation entails the development of new management skills, the adoption of innovative organizational structures and the achievement of excellent labour relations.

We define 'social innovation' as the development of new management skills (dynamic management), the adoption of innovative organizational structures (flexible organization) and the achievement of excellent employment relationships ('smarter' working practices and talent development) in order to increase both productivity and competitive edge.[21]

By means of a series of interrelated changes in management, organization and partnership arrangements, together with the implementation of social innovation, companies will be in a better position to take advantage of the existing knowledge base. Social innovation will enable them to combine new knowledge derived from R&D activities with the existing knowledge already available within the organization. The resulting horizontal connections within the organization and with its external partners are crucial to increasing the R&D yield. As diverse backgrounds, experiences and forms of technological expertise meet, new applications will emerge and can lead to various promising spin-offs.

Companies which can be seen to have implemented social innovation include Virgin, Dell, IKEA, Xerox and Southwest Airlines. Richard Branson's (Virgin) highly successful style of entrepreneurship is based on his understanding of future developments in markets and technologies, whereupon he proactively creates new opportunities to meet demand from new and existing customers. Michael Dell's visionary concept of selling personal computers directly to the customer, sidestepping the usual intermediaries, created a new and highly successful business model. IKEA's equally visionary idea of cash-and-carry self-assembly furniture put an end to the four month delivery times in the lower end of the market. Similarly, the Xerox vision of the paper-free office and Southwest Airlines' unique approach to efficiency have had far-reaching consequences for the data communications and aviation industries. These success stories centre around management's ability to understand and respond to the collective impact of various competitive forces. The result is a revolutionary concept of the future in terms of new products, services and business models, alongside the development of new management skills and an effective organizational structure (Volberda and Baden-Fuller, 2003). A revolutionary outlook of this can lead to the creation of an entire new industry, or to the abandonment of existing rules within an industry (Hamel, 2000). Further examples of new management skills include the learning capacity demonstrated by Honda (which discourages hierarchy, gives responsibility to more junior staff and supports confrontation) and the extremely innovative culture of 3M, whose motto is "Thou shalt not kill new ideas for new products".

2.4.2 Technological innovation versus social innovation within the Dutch life sciences and medical technology sector

To date, the innovation debate in the Netherlands has been largely confined to technology-related macrovariables, such as the low rate of investment in private R&D and the low number of research staff. One of the reasons for the paucity of R&D investments is the natural trend to rationalize existing and overlapping R&D activities with a view to greater efficiency in the new integrated Europe (Soete, 2002). The net effect of this migration of R&D activities is not yet clear. (Erken *et al.*, 2003). Alongside attempts to identify the weaknesses besetting technological innovation, the debate in the Netherlands is dominated by the question of which technologies are seen as most

[21] See: Volberda, Van den Bosch & Jansen (2005), *Slim Managen en Innovatief Organiseren*; Erasmus Competition and Innovation Monitor 2005-2008.

promising. The underlying belief seems to be that if a small country wishes to pursue innovation, it must focus on a limited number of key technologies, such as nanotechnology or biotechnology.

R&D investments account for 25% of innovation success; the remaining 75% is due to social innovation (organization, management and cooperation).

The Erasmus Competition and Innovation Monitor 2005 examined the relative importance of investments in R&D (technological innovation) and management, organization and cooperation (social innovation) in terms of the success of innovation in the Dutch private sector. This analysis, which involved input from various representative bodies, reveals that technological innovation, usually driven by R&D and ICT investments, accounts for *25%* of the overall success. Social innovation, comprising management, organization and labour aspects, accounts for *75%* of that success.

Dutch organizations must pursue more effective R&D investments.

Although technological innovation by industrial organizations does lead to new knowledge and ideas for product improvement, this new knowledge must eventually be applied to create successful new products and services. Dutch organizations must now pursue *more effective* R&D investments.

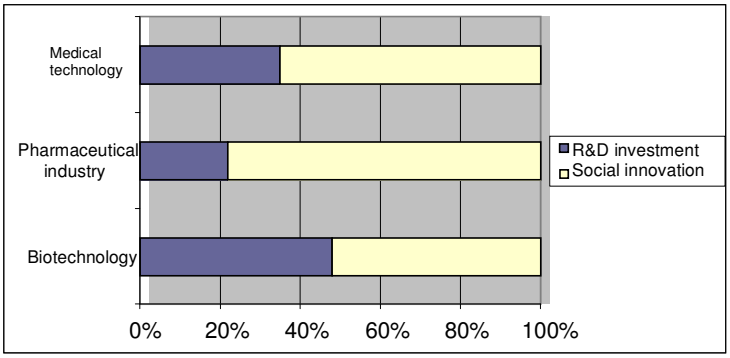
The Erasmus Innovation Monitor for the Life Sciences and Medical Technology sector has also examined the relationship between R&D investments (technological) and social innovation. The degree of social innovation was measured in terms of (1) flexible organization, (2) dynamic management (3) the degree of external cooperation. Flexible organization is characterized by a combination of innovation and efficiency activities, horizontal cooperation and shared decision-making within the organization. Dynamic management relies on there being an experienced management team with various backgrounds, visionary leadership and rewards based on team performance. The degree of external cooperation is measured in terms of the intensity and diversity of the external partnerships into which organizations enter with a view to product development.

In the Dutch life sciences and medical technology sector, 30% of innovation success is due to R&D investments and the remaining 70% to social innovation.

As shown by Figure 2.10, approximately 30% of innovation success within the Dutch life sciences and medical technology sector is determined by R&D investments, which therefore form an important basis for the development of knowledge and competencies. The remaining 70% is due to investments in flexible organization, dynamic management and external cooperation[22]. The relative importance of the two forms of innovation within the life sciences and medical technology sector is therefore broadly in line with the average of the Dutch private sector as a whole.

[22] The ratio of 30% R&D investments to 70% social innovation relates to the Dutch life sciences and medical technology sector as a whole, and is therefore the average of the figures for the three component segments: biotechnology, pharmaceuticals and medical technology.

Figure 2.10 Determinants of innovation success; relative importance of R&D and social innovation



Social innovation (organization, management and cooperation) is a decisive factor in the success of innovation.

Despite the relatively high level of R&D investments in the biotechnology segment and pharmaceutical industry, we see that social innovation - management, organization and cooperation – is the main determinant of the success of the innovation process. The new knowledge and ideas which emerge from R&D activities must be applied within the product development processes in a prompt and effective manner. Organizational and management aspects play and important part here. Enthusiasm, knowledge sharing and the collation of new insights can, through the use of cross-functional teams and joint decision-making, lead to cutting-edge products and services. Despite the relative importance of social innovation within the life sciences and medical technology sector as a whole, however, differences between the segments can be observed.

In the biotechnology segment, R&D investments (48%) and social innovation (52%) are of broadly equal importance to the success of innovation.

Within the biotechnology segment, R&D investments (48%) and social innovation (52%) are of more or less equal importance to the success of innovation. In the case of the pharmaceutical industry, social innovation plays a far more significant role. Here, almost 80% of innovation success is attributable to management, organization and external cooperation, which means that only 20% is due to the level of R&D investment. Our study suggests that 35% of innovation success in the medical technology segment is due to R&D investment and 65% to social innovation. Again, social innovation can therefore be seen to make a substantial contribution to the end result of the innovation process in this segment.

Social innovation is crucial within the pharmaceutical industry, accounting for some 80% of the success of innovation.

These results highlight the relevance of R&D investments and the importance of having access to sufficient capital. Nevertheless, social innovation remains extremely important. In the pharmaceutical industry, in which almost 80% of innovation success is attributable to management and organizational aspects, companies must devote attention to management development, organizational structure and streamlining external cooperation. It is not necessarily essential to increase R&D investments, but management, organization and cooperation must be given additional support. Within the Dutch life sciences and medical technology sector as a whole, the complexity and integration of technological developments have rendered partnerships increasingly important, and this is particularly true in the pharmaceuticals segment. To facilitate the exchange of knowledge with external partners, management and organizational aspects must be optimized. After all, these aspects determine the form and course of cooperation, the manner in which knowledge is shared between partners, and the manner in which this knowledge is then integrated within the development process.

3. Management, organization and innovative performance

3.1 Introduction

This chapter describes the management and organizational aspects of the Dutch life sciences and medical technology sector. Based on the results of the Erasmus Innovation Monitor for Life Sciences and Medical Technology, we set out the main factors which determine the success of innovation. These aspects fall under two main headings: flexible organization (differentiation, horizontal cooperation and joint decision-making) and dynamic management (experience, diversity, visionary leadership and team rewards).

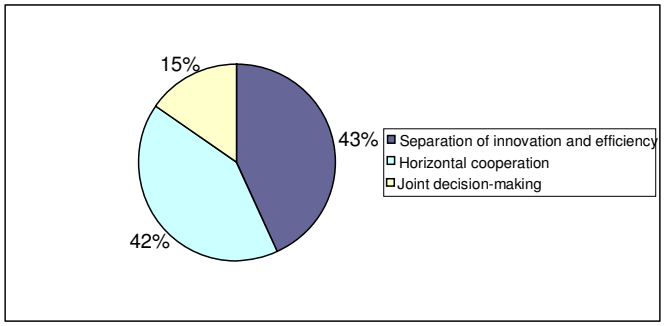
3.2 Flexible organization and innovation performance in the Dutch life sciences and medical technology sector

The Erasmus Innovation Monitor for Life Sciences and Medical Technology examined the extent to which flexible organization contributes to innovation performance. In many companies, the role of managers has shifted from vertical coordination in a hierarchical control structure to providing appropriate organizational support to horizontal knowledge sharing. Companies can thus transform themselves from closed, hierarchical organizations with a high degree of vertical control and separate areas of expertise, to a level and open network organization. A network organization is based on self-managing teams with overlapping areas of expertise and horizontal knowledge processes between various locations.

Flexible organization involves differentiation of innovation and efficiency, horizontal cooperation and knowledge exchange, and joint decision-making.

Flexible organization involves three main aspects: (1) separation of innovation and efficiency activities at different locations; (2) horizontal cooperation and knowledge sharing, and (3) joint decision-making. As Figure 3.1 illustrates, the performance of R&D activities on the one hand, with more generic efficiency-driven activities on the other, all performed at various locations within the organizations, does much to promote the organization's innovation performance. Managing innovation (R&D) and efficiency within the organization would therefore seem to be one of the most significant management challenges facing the life sciences and medical technology sector. Innovation and efficiency often appear to be virtually irreconcilable. While innovation demands daring, delegation and fewer rules and procedures, efficiency demands centralized responsibility, short-term results and greater formalization in order to increase productivity. Attempts to combine the two lead to friction and confrontational management. Companies in the Dutch life sciences and medical technology sector should therefore identify their R&D activities and more regular activities, and then separate them into separate organizational components. This enables the individual activities to be managed in a consistent manner and creates clarity with regard to objectives and expectations.

Figure 3.1 Flexible organization and innovation performance



Approximately 42% of innovation success is further to the combination of innovation and regular activities at various locations.

Horizontal cooperation and knowledge sharing account for 42% of innovation success.

Besides separating the innovation activities and those further to efficiency into different organizational units, companies in the life sciences and medical technology sector should also seek to enhance horizontal cooperation. Some 42% of the overall success of innovation is determined by the appointment of cross-functional teams and the encouragement of horizontal knowledge exchange between departments. Differentiation and horizontal cooperation may therefore be seen to go hand in hand. The implementation of both aspects will account for some 85% of the innovation success. The remaining 15% will be further to the adoption of join decision-making processes. This improves the decision process by bringing together and integrating various areas of expertise and experience. Moreover, joint decision-making and the introduction of cross-functional teams will facilitate self-management. Self-organization means that managers function more as 'stewards' and devote their managerial capacity to establishing the critical values and the frameworks within which staff at lower levels of the organizations can exercise their initiative and entrepreneurship.

The Dutch life sciences and medical technology sector must separate innovation and efficiency activities.

The influence of the three aspects of flexible organization appears to be evenly distributed among the three segments of the life sciences and medical technology sector. As Table 3.1 shows, the combination of innovation and efficiency within various organizational units is most relevant to the biotechnology segment. In these (often smaller) companies, there is often less separation between innovation and regular activities. This can create a lack of clarity on the workfloor: when is a good time to leave the everyday activities and devote time to research and development? How can we reconcile the conflicting management requirements? How should we reward our staff?
Efforts to reconcile innovation and regular activities can frequently lead to problems. Biotechnology companies, no matter how small, must decide at an early stage how innovation and regular activities can be separated, either in terms of (1) people, (2) organizational units, or (3) time. Doing so will greatly enhance the effectiveness and speed with which development projects can be conducted. The same requirement applies to companies in the pharmaceutical industry and, to a lesser degree, to those active in medical technology.

The second important aspect – horizontal cooperation and knowledge exchange – contributes to the success of innovation in all three segments. The appointment of workgroups and cross-functional, and the professionalization of middle management will provide a sound basis for innovation success.

Table 3.1 Flexible organization and innovation success by segment

Flexible organization	Biotechnology	Pharmaceutical industry	Medical technology
Separation of innovation and efficiency at different locations	+++	+++	+
Horizontal cooperation and knowledge sharing	++	++	+++
Joint decision-making	+	++	+

To promote horizontal cooperation requires the use of temporary workgroups and cross-functional teams, and a collective sense of ambition.

The third aspect of flexible organization – joint decision-making – is of particular importance in increasing the effectiveness of innovation processes within the pharmaceutical industry. Restructuring of the internal organization and the introduction of self-organization will bring rewards in this segment. Like those in the other segments, pharmaceutical companies can encourage self-organization by placing responsibilities at lower levels within the organization. This means that staff are given greater freedom to decide how the objectives are to be pursued. Our study clearly reveals the joint decision-making in all three segments does much to determine innovation success. An important managerial responsibility is to create the necessary preconditions and to promote close social networks between staff. Such networks create a collective ambition and make staff enthusiastic about achieving the objectives. The creation of social networks and cross-functional teams enables a continuous horizontal knowledge flow to be established.

Table 3.2 shows the current 'state of play' within the three segments of the life sciences and medical technology segment, indicating the proportion of organizations which achieve a high score for the various aspects of flexible organization[23].

Table 3.2 Flexible organization: current status within the segments

Flexible organization	Biotechnology		Pharmaceutical industry		Medical technology	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
Separation of innovation and efficiency at different locations	21%	79%	35%	65%	42%	58%
Horizontal cooperation and knowledge sharing	17%	83%	17%	83%	22%	78%
Joint decision-making	8%	92%	31%	69%	23%	77%

Although crucial, the separation of innovation and efficiency activities has not yet been pursued to any great degree.

Separation of innovation activities from regular activities has been pursued to only a limited extent within the biotechnology segment, with the pharmaceutical industry in second place. Previous research findings indicate that the separation of R&D activities which are then conducted within autonomous organizational units is a decisive success factor in both segments. Only 21% of biotechnology companies have done so, and 35% of pharmaceutical companies. To increase the success of innovation it is therefore essential to pursue further separation. This can be achieved by creating independent units within the organization or by cooperating with external partners.

[23] A 'good' score is one of eight out of ten or higher.

Only 17% of companies in both the biotechnology and pharmaceutical segments, and 22% of medical technology companies, achieve a good score for horizontal cooperation and knowledge sharing.

The most important aspect of flexible organization, and hence the one that demands greatest attention, is horizontal cooperation and knowledge sharing. Only 17% of companies in both the biotechnology and pharmaceutical segments, and 22% of medical technology companies, achieve a good score in this respect. In other words, over 80% of companies achieve a poor score and should now further professionalize their middle management. Middle management (or senior staff) are essential in creating and maintain the horizontal connections within the organization. The appointment of temporary 'gatekeepers', temporary workgroups or cross-functional teams will do much to encourage the flow of knowledge between various departments. This knowledge sharing, although crucial to innovation and process modernization (see Table 3.1) is at a particularly low level within the Dutch life sciences and medical technology sector.

Only 8% of biotechnology companies have a system of joint decision-making.

The current status of joint decision-making presents a similar picture. Only 8% of biotechnology organizations have implemented joint decision-making. In the pharmaceutical industry, where joint decision-making has the greatest effect in terms of innovation performance, the concept has been adopted by just over 30% of companies. The remaining 70% will have to move responsibilities lower down in the organization in the years ahead, and must give staff more freedom of action further to a system of self-management. Visionary leadership and the creation of collective ambition are crucial.

3.3 Dynamic management and innovation performance in the Dutch life sciences and medical technology sector

A management team in the life sciences and medical technology sector must be able to identify new ideas and pursue their development. The management team forms the basis for the long-term success of the organization, particularly in the case of smaller companies. The Erasmus Innovation Monitor for Life Sciences and Medical Technology therefore examined the extent to which dynamic management contributes to innovation performance.

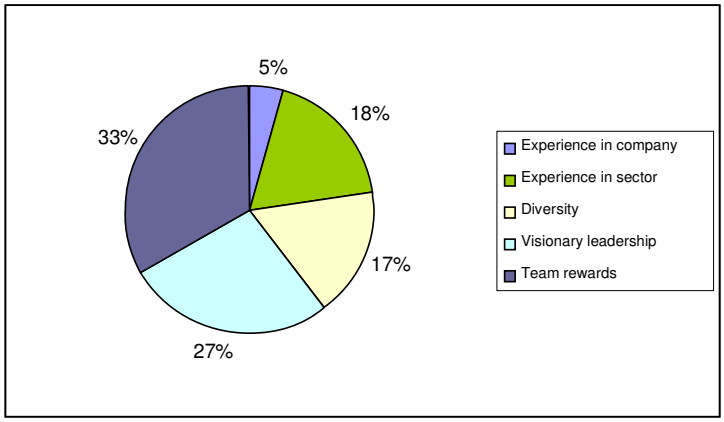
The management team initiates innovation by developing a clear vision and long-term strategy.

The management team plays a crucial role in the innovation process, not only by developing a long-term strategy but by bringing together various insights, identifying external developments and implementing new short-term policy. Social innovation in the life sciences and medical technology sector is therefore largely determined by the management team, or to be more precise, by the dynamic management of knowledge development and knowledge application.

Management experience within the sector, rather than in the organization itself, promotes innovation success.

Dynamic management involves four aspects: (1) knowledge and experience, (2) diversity of expertise and backgrounds, (3) visionary leadership and (4) team rewards. As Figure 3.2 illustrates, it is not so much the experience within the company (5%), but that which the CEO and the other members of the management team have gained within the sector (18%) which influences innovation performance. It is interesting to note that experience *within the sector* is three times more important than experience within the organization. Although experience gained within the same organization will help managers to gain an accurate picture of the possibilities, it is far more important to have people on the management team who are relative newcomers to the company itself, but have worked in the life sciences and medical technology sector for some time.

Figure 3.2 Dynamic management and innovation performance



Diversity in expertise and backgrounds contributes 17% of innovation success.

Diversity in expertise and backgrounds within the management team also has an influence on the innovative ability of companies in the Dutch life sciences and medical technology sector. Here, diversity refers not only to qualifications and experience, but also to demographic considerations such as age and gender. These too determine the degree of innovation achieved. Almost 17% of overall innovation performance is due to the diversity of expertise and backgrounds represented by management team members. Diversity enables the management team to broaden the knowledge base and to gain new insights through the combination of technological and non-technological knowledge. Diverse management teams are able to identify new developments more quickly, to understand those developments and to translate them into new policy. In smaller companies in particular, it is essential to have not only technological knowledge, but also management quality and the ability to direct an organizations.

Visionary leadership accounts for over 25% of innovation success.

Alongside knowledge, expertise and diversity, visionary leadership can be seen to be one of the most important factors which enhance innovation performance. Visionary leadership enables companies to create an attractive and realistic vision, setting out the collective ambitions and how these are to be achieved. The required skills, talents and resources must be identified and developed. A clear vision will encourage ambition on the part of staff and will create a clear and convincing basis for the innovative path to be followed by the organization. Visionary leadership encourages creativity and enthusiasm, and represents and extremely important management skill in having innovation adopted within the organization.

Visionary leadership offers opportunity for enterprise.

Visionary leadership provides opportunities for initiative and enterprise. The picture of the future organization prompts staff to develop various new initiatives. A clear and challenging vision within the organization also creates room for experimentation and learning, within the policy framework. Shared standards and values form the basis of policy activities and internal cooperation. However, visionary leadership is not simple. It demands both management quality and charisma. Theses qualities relate to the ability to present a shared vision which offers an attractive identity and a convincing interpretation of the actual situation. The process of permeating the organization with shared values and a collective ambition is gradual, and gives those concerned a distinctive identity.

Another important factor in encouraging cooperation and knowledge sharing is a rewards structure which recognizes team performance rather than that of individuals. The findings of the Erasmus Innovation Monitor for the Life Sciences and Medical Technology 2008 reveals that the introduction of remuneration based on common objectives has the greatest impact on innovation performance

Rewards based on common objectives encourage cooperation and knowledge sharing.

(33%). Such a system creates a common interest. The salaries and bonuses of management team members rely in part on the performance of others, whereupon all will be more inclined to be helpful in order to achieve good joint results. Previous studies have shown that the implementation of a team reward structure is particularly useful within organizations in which members of the management team have conflicting interests. It results in greater cooperation being sought, better knowledge sharing, and encourages the management team as a whole to pursue the common objectives. Because innovation has various consequences in terms of the functioning of the management team, a remuneration structure based on team performance is particularly appropriate.

The table below shows the relative influence of various management characteristics on innovation within each of the segments of the life sciences and medical technology sector.

Table 3.3 Dynamic management and innovation performance by segment

Dynamic management	Biotechnology	Pharmaceutical industry	Medical technology
Experience within the organization	---	+	+
Experience within the sector	++	+	+
Diversity in knowledge and backgrounds	+	+	++
Visionary leadership	++	+++	+
Team rewards	-/+	+	++

In biotechnology, experience in the sector is more important than experience within the organization.

Within the biotechnology segment, experience within the organization seems to have an adverse influence on the innovative ability of that organization. The longer CEOs have been with the company (and therefore score higher for 'experience within the organization'), the lower the degree of product development. However, experience within the sector does lead to more product development. This striking finding shows that experience in starting up an organization is not the same thing as experience in building up and managing a growing organization. As confirmed by the findings of the interviews, biotechnology companies must carefully consider who is to form part of the management team, and what role the founders of the organization are to play in its later stages. It is essential to recruit team members who have experience elsewhere in the sector.

Biotechnology companies must assemble their management teams carefully.

The diversity within the management team and the team rewards structure are of secondary importance in the biotechnology segment in terms of improving innovative strength. Visionary leadership, however, is a very important factor in achieving product innovations. Management must devote greater attention to the development of a shared vision, and to communicating the frameworks within which staff are able to exercise their own judgement and initiative.

Visionary leadership is particularly important in biotechnology and the pharmaceutical industry.

In the pharmaceutical industry, visionary leadership is by far the most important management competency in terms of improving innovation performance. This segment comprises larger and more formal organizations: senior management therefore play an important role in encouraging entrepreneurship and horizontal cooperation. A clear and challenging vision provides direction for the future and engenders passion for change. A vision is inspiring, and calls for internal discussion leading to the adoption of shared values and common objectives. A collective ambition provides a

firm identity and establishes the relationships between various departments and units. By developing and communicating a shared vision, larger pharmaceutical companies can do much to promote cooperation and knowledge sharing. It is the convergence of various types of knowledge drawn from various organizational units that contributes so much to innovation performance.

Team rewards structures should be introduced in the medical technology sector.

In the medical technology segment, the greatest opportunities for increasing innovation performance are offered by diversity within the management team and the adoption of a team rewards structure. These factors are interrelated. Diversity in management ensures diverse knowledge development at various locations, while the team rewards structure promotes solidarity and is an incentive to internal cooperation. The two aspects should therefore be considered in tandem.

The table below shows the current status of dynamic management within the three segments of the life sciences and medical technology sector.

Table 3.4 Dynamic management by segment[24]

Dynamic Management	Biotechnology		Pharmaceutical industry		Medical technology	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
Experience within the organization	56%	44%	39%	61%	53%	47%
Experience within the sector	75%	25%	48%	52%	40%	60%
Diversity in knowledge and backgrounds	39%	61%	48%	52%	22%	78%
Visionary leadership	33%	67%	39%	61%	30%	70%
Team rewards	37%	63%	65%	35%	32%	68%

The life sciences and medical technology sector scores well in terms of management experience.

The Dutch life sciences and medical technology sector achieves a relatively high score with regard to experience within the organization and within the sector. In the biotechnology segment, the majority of CEOs and management team members have considerable experience in the sector. Over 75% of companies therefore achieve a high score in this respect, and most have senior managers with over twelve years' experience in the sector. The other segments, and particularly the pharmaceutical industry, are notable for having CEOs and management team members with relatively little experience in the organization, with 61% of managers having been with their company for less than twelve years. The standard of qualifications and experience in the life sciences and medical technology sector as a whole is relatively high.

The medical technology segment must now pursue greater diversity in expertise and background within management teams.

The medical technology segment must now pursue greater diversity in expertise and background within management teams. This is a particularly important factor in determining the success of innovation, but only 22% of companies in this segment can currently be said to have a diverse management team. Efforts in this regard must also be made by the biotechnology segment (currently 39%) and, to a lesser degree, by the pharmaceutical industry (48%).

The life sciences and medical technology sector as a whole must devote greater attention to the development of visionary. In the case of biotechnology and pharmaceuticals, this is one of the most

[24] In the calculation of percentages relating to experience within the organization and within the sector, 'good' equates to over 12 years' experience with the organization and over 16 years within the sector. These reference figures are based on the average experience of CEOs and managers in the life sciences and medical technology sector.

Visionary leadership can be seen in only some 33% of biotechnology companies and 39% of companies in the pharmaceutical industry.

important management competencies offering the potential of a marked increase in innovation performance. However, only 33% of biotechnology companies and 39% of those in the pharmaceutical industry can be said to have visionary leadership. Greater attention for long-term strategy, vision development and management development is essential to successful innovation processes in these segments.

The adoption of a team-based rewards structure, in which individual remuneration is based (at least in part) on the attainment of joint objectives, will enable medical technology companies to improve innovation performance. Although only 32% of companies have adopted such a system to date, this particular aspect of dynamic management is seen to be a key determinant of innovation success.

4. Cooperation and innovation

4.1 Introduction

This chapter examines the various aspects of cooperation in pursuit of innovation. In the Dutch life sciences and medical technology sector, as elsewhere, cooperation with external parties is an increasingly important factor in being able to develop new products quickly and effectively. The chapter therefore begins with a general overview of the various forms of cooperation and the types of partners with whom companies will work. We then look at a number of trends affecting cooperation within the Dutch Life sciences and medical technology sector.

4.2 Cooperation and innovation: a summary

In the Dutch life sciences and medical technology sector, it is almost unthinkable that a company would undertake the entire process, from generating new ideas to launching the resulting product on the market, alone and unaided. Cooperation with various partners and in various stages of the development process has become increasingly important in recent decades. This trend towards a more open style of innovation will certainly continue in the future.

4.2.1 Open innovation

In his book *Open Innovation: The New Imperative for Creating and Profiting from Technology* (2003), describes the transition that companies have made from a closed innovation process to a more open style of innovation. 'Closed innovation' refers to the traditional manner, in which the entire innovation process is undertaken 'behind closed doors', i.e. entirely within the boundaries of the company concerned. As the result of various changes to the business setting, many companies have found that this style of innovation no longer leads to the desired results. First, the life cycles of both products and technologies are becoming ever shorter, while (and especially in the life sciences and medical technology sector) the costs of R&D continue to rise. Moreover, the emergence of biotechnology has added a growing number of small, start-up companies to the sector. The increased availability of venture capital has made it possible for both university researchers and those working in corporate R&D laboratories to begin their own companies. Accordingly, the setting within which existing organizations must compete with each other has changed to such a degree that cooperation is now practically inevitable. To remain competitive, it is essential that cooperative partnerships become an integral part of the company's operations. Such cooperation will result in a greater number of ideas and technologies which have been spawned externally but which can be further developed internally ('outside-in' movements), as well as the opportunity to pass on internal ideas and technologies to the external market, where these are no longer appropriate to the competences of the company ('inside-out' movements).

The life cycle of products and technologies is becoming ever shorter, while the costs of R&D continue to rise.

To remain competitive, it is essential to make external cooperation an integral part of the business activities.

The concept of open innovation was originally developed by a number of large industrial market players. However, the underlying principles of open innovation are certainly not the exclusive domain of the multinationals. In 2006, the Advisory Council for Science and Technology Policy (AWT) commissioned an EIM study into the use of open innovation in the small and medium-sized enterprise (SME) sector in the Netherlands.[25] One of the study's main conclusions was that Dutch SME companies do indeed apply the principles of open innovation "to a reasonable or even marked

Open innovation and cooperation with other parties in pursuit of new technologies and products is a key theme for companies of all sizes.

[25] Jong, J.P.J. de, 2006. Meer Open Innovatie: Praktijk, ontwikkelingen, motieven en knelpunten in het MKB.

degree", and that the importance of open innovation has been increasingly acknowledged in recent years. Open innovation, and especially cooperation with other parties in pursuit of new technologies and products, is therefore a key theme for companies of all sizes.

4.2.2 Forms of cooperation

Once two or more companies decide to cooperation, there are various ways in which their partnership can be structured. One of the most common is the 'strategic alliance', a partnership of two or more parties in which each party retains its own identity. In many cases, the strategic alliance will be formed with a particular objective in mind (e.g. the development of a certain technology) and for a set period of time. While most alliances are initiated by the parties themselves, independent organizations may also play a part in bringing together potential partners and organizing (the form of) their collaboration.

Another form of cooperation is that in which one company acquires a minority interest in another. This could be through purchasing shares in the partner, or by investing venture capital. Making a financial investment in a new start-up company serves to safeguard the continuity of its activities. In the case of new companies with a potentially ground-breaking technology, this can be of great importance. Moreover, a company which invests venture capital in a start-up is likely to derive a number of privileges, such as a place on the board which allows it to follow developments at first hand.

In some cases, it may be more attractive to acquire another company outright. In the life sciences and medical technology sector, small biotechnology companies are often the target of acquisitions by the large pharmaceutical companies. By acquiring the partner organization 'lock, stock and barrel', a company gains unrestricted access to its technology. If that technology is unique, groundbreaking and essential to the retention of a competitive advantage, the takeover is a particularly attractive option.

4.2.3 Cooperation during the innovation process

During the innovation process itself, there may be many instances of cooperation with various types of partner. The degree to which a certain type of partner or partnership is appropriate can however vary, depending on the stage of development which the product or technology has reached. In the initial phases of the innovation process, the company faces a high level of both technological uncertainty and market uncertainty. Under such circumstances, it is therefore essential to maintain maximum flexibility and to discontinue projects as soon as it becomes evident that they will not produce the required results. At this juncture, it is probably more attractive to invest venture capital in start-ups or to enter into strategic alliances rather than consider the outright acquisition of a partner.

During the innovation process, various types of partner and partnership become relevant.

In these early development stages, cooperation with universities and other knowledge institutes will also be more significant, since they are more concerned with fundamental science rather than with potential applications. As time goes on and both technological and market uncertainties subside, the relative importance of flexibility will decrease and that of *control* will increase. Once the potential of the new technology becomes fully apparent, it will be more attractive to adopt a more integrated form of cooperation demanding a higher degree of commitment. A financial investment in the partner will now represent less risk, and the potential risks of an outright acquisition will also be smaller.

Cooperation with a partner who can help in ensuring the successful launch of the product is now more important, and in this stage the possible role of the end user within the innovation process will

become clear. Throughout the innovation process, from idea to market launch, various types of partner and various types of partnership are therefore relevant. If the new innovation is to be successful, companies must therefore be aware of the various forms of cooperation available to them and the various types of partner whom they can call upon.

4.3 Cooperation and innovation in the Dutch life sciences and medical technology sector

This section discusses various aspects of cooperation and innovation in the Dutch life sciences and medical technology sector. First, we examine the role of external technology acquisition within the corporate strategy. We then look at the differences between the segments and consider the position of the 'leaders' and 'laggers' in the sector as a whole. Specific attention is devoted to the success factors of cooperative partnerships.

4.3.1 The use of external technology

Although the study respondents state that they do use external technology (34% of respondents disagreed with the proposition that all required technology is developed internally), the results clearly show that the basis of technology and product development is primarily internal. The internal development of the required technology and knowledge helps companies to maintain and protect their core business activities. It is therefore desirable for these core activities to be developed internally to the greatest extent possible. On the other hand, internal knowledge development is necessary in order to be able to recognize external knowledge and to assimilate it into the production process. Without a certain basic level of knowledge, it will be extremely difficult to assess the value of any technology offered by an external party, and to determine its added value to the organization's own development process. However, as technological developments follow each other more rapidly and the time-to-market decreases, the importance of acquiring external knowledge increases accordingly. Companies are no longer able to develop all the required knowledge required to create a new product in the short time available. Moreover, it is not always desirable to develop all knowledge internally. It will probably not be attractive to make any substantial investment in product-specific knowledge with no broader application, for example. Cooperation with a partner who possesses this knowledge may then be a good alternative.

The basis of technological development is internal, but external knowledge is becoming increasingly important.

The importance that should be attached to external technology varies by sector and by organizational size. In the medical technology segment, the importance of external technology is in inverse proportion to the size of the organization, while in the biotechnology segment its importance is more or less constant, regardless of company size. Interestingly, it is mostly the smaller companies in the medical technology segment who consider the acquisition of external technology particularly important. This may be due to the fact that smaller companies do not usually have the resources to develop everything themselves. External technology is therefore considered essential. In general, however, we may state that the acquisition of external knowledge does indeed play an important role in the life sciences and medical technology sector. Of the companies with fewer than 100 employees, 38% state that the use of external technology is an important factor in their strategy and operations.

The acquisition of external knowledge plays an important role in the life sciences and medical technology sector.

Table 4.1 shows the current 'state of play' with regard to the use of external knowledge in the three segments of the life sciences and medical technology sector.

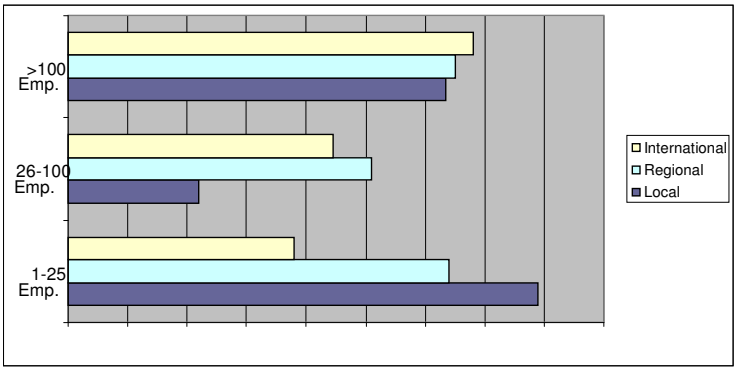
Table 4.1 Percentage of respondents attaching significant importance to external knowledge

Size of company	Biotechnology		Pharmaceutical industry		Medical technology	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
1-25 employees	25%	75%	25%	75%	40%	60%
26-100 employees	45%	55%	43%	57%	36%	64%
>100 employees	25%	75%	50%	50%	25%	75%

4.3.2 Location of partners

Cooperation with external partners is important in allowing companies to access knowledge which has been developed externally. To gain further information about the form of such partnerships, the study questionnaire included a number of questions relating to the partners, including their physical location (local, regional or international). Figure 4.1 summarizes the findings according to the size of the respondent organizations.

Figure 4.1 Location of partners, by size of respondent organization



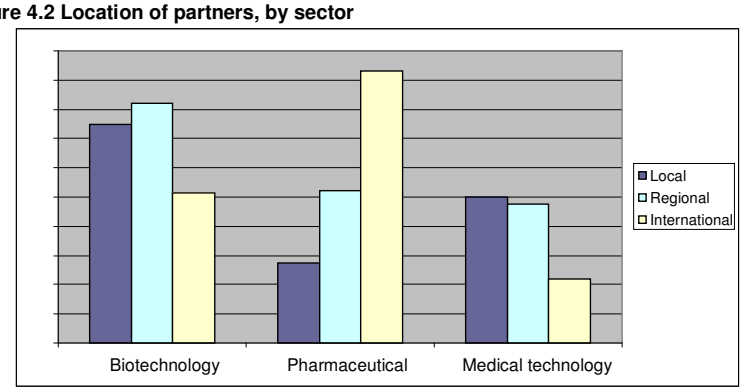
Importance of International cooperation is proportionate to size of company.

For small companies, cooperation with local and regional partners plays a significant role. As the size of the organization increases, so does the importance of international partners. International partners are of particularly importance to companies in the pharmaceutical industry, as illustrated by Figure 4.2. This sector often relies on extremely specialized knowledge which may not be available in the region. Moreover, many pharmaceutical companies are large multinationals with their own extensive international networks, whereby cooperation with international partners is somewhat easier to organize.

Local and regional partners are particularly important to biotechnology companies.

International partners are of somewhat lesser importance to medical technology companies, many of which rely mainly upon local and regional partners. However, it is in the biotechnology segment that local and regional partners are most important. Given the complexity of the technology, clustering is often essential to effective knowledge sharing. In addition, biotechnology companies are generally small companies which lack the resources to be internationally active.

Figure 4.2 Location of partners, by sector



Cooperation at local, regional and international level is essential to arriving at innovations.

The importance of cooperation, whether at local, regional or international level, becomes evident when we look at its effect on innovation. In general we can state that cooperation at one or more levels is essential to arriving at new innovations (see Table 4.2). For the biotechnology segment, regional partners make the main contribution to innovative strength, with local partners doing so to a somewhat lesser degree. International partners actually have a negative effect. In the pharmaceutical industry, the opposite applies: international alliances have the greatest impact in terms of promoting innovation, followed (again to a lesser degree) by local partners.

Table 4.2 Location of partners and their effect on innovation, by segment

Location	Biotechnology	Pharmaceutical industry	Medical technology
Local	+	+	-
Regional	++	-/+	+
International	-	+++	+

Medical technology companies benefit mainly from regional and international partnerships. Local partners seem to have a negative impact on innovation in this segment. It is therefore important for companies to devote greater attention to developing cooperation at regional and international level. Fewer than 50% of the respondents in the medical technology segment attach great importance to regional cooperation, and fewer than 30% acknowledge the importance of international cooperation.

The majority of companies make only limited use of external partners at all levels.

The current 'state of play' with regard to contacts with local, regional and international partners is shown in Table 4.3, from which it is evident that, despite the positive influence on innovative strength, the majority of companies call upon partners in all locations to only a very limited extent. Only a quarter of biotechnology companies attach major importance to local and regional partners. The figures for the medical technology segment are even lower: 20% of respondents attach importance to regional partnerships and 10% to those at international level.
Despite the evident importance of external cooperation and recent initiatives by both the government and the sector to promote further cooperation, it remains necessary to raise the level of external cooperation yet further.

Table 4.3 Current acknowledged importance of local, regional and international cooperation, by segment

Location	Biotechnology		Pharmaceutical industry		Medical technology	
	Yes	*No*	*Yes*	*No*	*Yes*	*no*
Local	26%	74%	24%	76%	40%	60%
Regional	26%	74%	35%	65%	20%	80%
International	17%	83%	47%	53%	10%	90%

4.4 Types of partner(ship)

Cooperation with a view to increase the organization's innovation performance can involve several types of partner. Current literature distinguishes between cooperation with start-ups, competitors, suppliers, universities and other knowledge institutes, as well as with (potential) end users.

Start-ups are new companies, usually specializing in one specific technology. In the life sciences and medical technology sector, most such companies are active in the biotechnology segment. The often possess the required technological expertise but lack the resources to develop or upscale this expertise. If the envisaged application is one or more pharmaceutical drugs, these young companies will usually lack the financial resources and experience required to undertake the clinical testing procedures. Cooperation with one of the larger companies in the pharmaceutical industry, or a financial injection by a venture capital organization, could provide the solution.
Similarly, existing companies in the SME sector often lack the resources to bring an innovative product to market successfully. Here, cooperation with a larger market player could be crucial.

Although cooperation with small start-ups is clearly indicated, some organizations are less than willing to cooperate with competitors. Because both the costs of R&D and the interests of the companies in the life sciences and medical technology sector are so great, cooperation with competitors is seen as undesirable. The risk of crucial information being 'leaked' is often seen as outweighing the advantages that such cooperation could bring. In view of the (commercial) interests and potential revenue in the pharmaceutical industry in particular, it is hardly surprising that companies prefer not to involve direct competitors. Only in exceptional circumstances, perhaps when the costs and risks are extremely high, will organizations abandon this stance.

Other common partners in the innovation process are universities and knowledge institutes. Large companies often work closely with leading researchers and prominent institutes, particularly in the early discovery and development phases. Doing so enables them to access knowledge relative to a new technology at a particularly early stage. Because universities and knowledge institutes are not commercial organizations, the risk of knowledge being leaked is smaller. Researchers affiliated to a university are primarily interested in being able to publish academic findings, while for the companies, it is the commercial value of the technological knowledge which is of greatest importance. This apparent conflict of interests can lead to some difficulties within the partners. Because they have no commercial interests, research institutions may adopt a timeframe which is

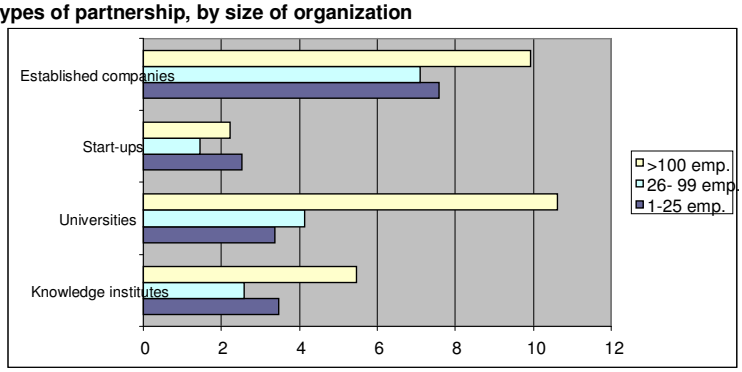
much longer than that considered desirable by the companies concerned. The ability to make firm agreements can also be hampered by the major cultural differences between the players.

Potential partners include start-ups, competitors suppliers, universities, research institutes and end users.

It may also be possible to involve the (potential) end user in the innovation process. This will be the case if a concrete product is envisaged. In product innovation processes of an incremental nature, for example, it is possible to adapt product specifications to the wishes and requirements of the end user over the course of the process. In the case of drug development, involvement of end users or patients is somewhat more difficult. Various clinical tests have to be undertaken during the early stages of product development, long before the product can actually be administered to an actual patient. By this stage, modifications to the product or technology are usually no longer possible.

To gain a better understanding of links with the various types of partner in the Dutch life sciences and medical technology sector, the study questionnaire examined four categories of partner: knowledge institutes, universities, start-ups and established companies.

Figure 4.3 Types of partnership, by size of organization

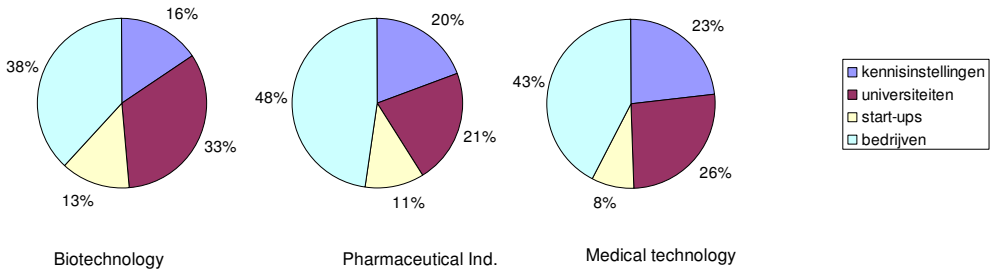


Cooperation with start-ups is not high on the agenda.

It is generally the larger companies which seek cooperation with universities.

As Figure 4.3 shows, established companies are the most important partners for organizations of all sizes. Overall, start-ups are regarded as the least interesting partners. It is interesting to note that start-ups do not even cooperate with other start-ups. It is mostly the large organizations which regard cooperation with universities as valuable. If we examine the distribution of the various types of partnership across the entire portfolio of cooperative alliances (Figure 4.4), we can further state that cooperation with universities plays an important role in the biotechnology segment (33%), while the pharmaceutical industry and medical technology segments tend to cooperate with other established companies (48% and 43% respectively).

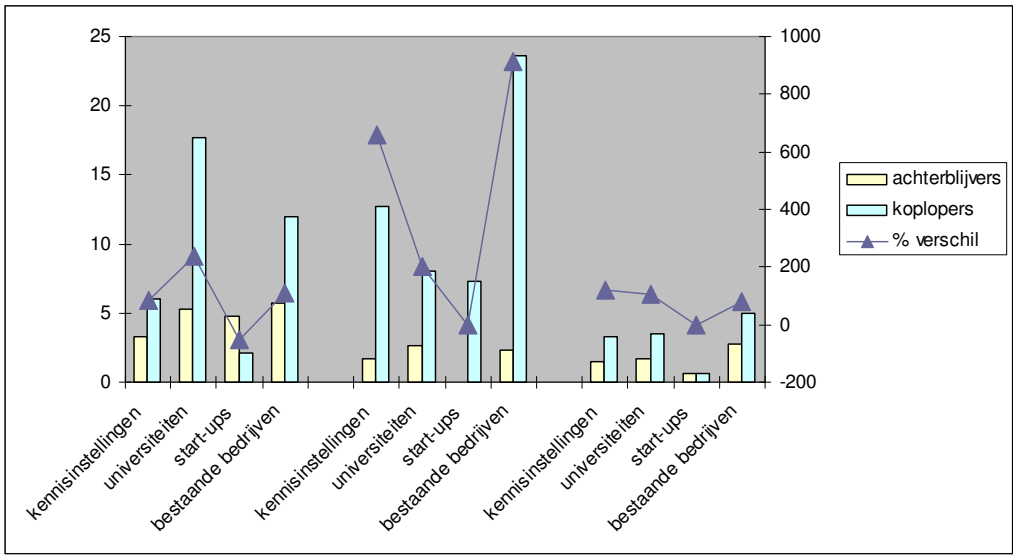
Figure 4.4 Portfolio of cooperative alliances



Many developments in biotechnology are extremely specific, and often relate to the initial phases of the technology development process. Cooperation with universities offers companies in this segment access to new knowledge at a very early stage. By contrast, the main strength of many pharmaceutical companies is the testing and production of products which have now reached a more advanced stage of development. Cooperation with other established companies can then be an effective way of gaining access to the external technology on which proof of concept relies.

In terms of the intensity of contact and cooperation with the various types of partner, we can see a significant discrepancy between the 'leaders' and 'laggers', as shown in Figure 4.5).

Figure 4.5 Leaders and laggers by type of partnership and by segment

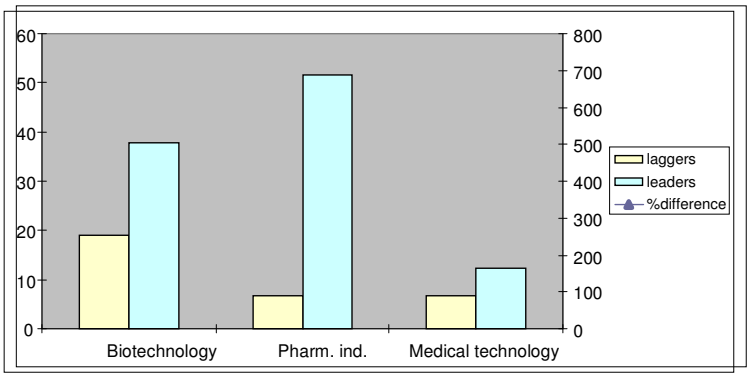


Companies which are more innovative attach greater value to cooperation with universities and knowledge institutes.

Figure 4.5 illustrates how the 'leaders' and 'laggers' in the various segments compare in terms of their cooperation with various types of partner. Overall, we may include that the more innovative companies attach greater value to cooperation with universities and knowledge institutes. In the biotechnology segment, cooperation with universities is of great importance in terms of innovation success. The universities also play a significant role within the pharmaceutical industry, as do knowledge institutes and, more particularly, established companies. In the medical technology segment, the differences are less marked. Here, cooperation with various partners does indeed influence the success of the innovation process, but its significance is somewhat less than in the biotechnology segment and the pharmaceutical industry.

This is also to be seen from Figure 4.6, which presents the total number of partnerships maintained by both the leaders and the laggers. From these findings, we may conclude that having a greater number of partners will have a positive influence on the success of innovation projects. This finding holds true for the pharmaceutical industry in particular, and to a slightly lesser degree in the other two segments. Nevertheless, almost half of all respondent organizations report that they have more than ten external partners.

Figure 4.6 Number of partnerships maintained by 'leaders' and 'laggers' in the various segments



If we then go on to examine the effect of the various types of partner on innovation, we can observe a number of notable differences (see Table 4.4).

Table 4.4 Type of partnership in relation to innovative ability

Type of partner	Biotechnology	Pharmaceutical industry	Medical technology
Knowledge institutes	++	++	++
Universities	-/+	+	++
Start-ups	-/+	+++	+
Established companies	+	-/+	+

Despite the apparent benefits to their innovative ability, companies rarely seek cooperation with start-ups.

Biotechnology companies derive greatest benefit from cooperation with knowledge institutes and established companies. Similarly, partnerships with knowledge institutes have a positive effect on the innovative strength of pharmaceutical companies, as do partnerships with start-ups and universities. This is an interesting finding, given that earlier results show that start-ups are the least sought-after type of partner.

The respondents further reported that they seek significant cooperation with established companies. As Table 4.4 shows, however, this type of partnership does not always have a positive effect in terms of innovative strength. In the medical technology segment, it is notable that all types of partnership have a positive effect on innovation performance and all make a contribution to the innovation process itself.

The current 'state of play' with regard to perceived importance of the various types of partner is shown in Table 4.5.

Table 4.5 Current importance of the various types of partnership

Type partner	Biotechnology		Pharmaceutical industry		Medical technology	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
Knowledge institutes	22%	78%	35%	65%	24%	76%
Universities	39%	61%	47%	53%	29%	71%
Start-ups	26%	74%	24%	76%	8%	92%
Established companies	35%	65%	41%	59%	16%	84%

As Table 4.5 illustrates, relatively little importance is attached to any of the different types of partner(ship). Despite the positive effects of cooperation with knowledge institutes, fewer than 25% of respondents in the biotechnology and medical technology segments regard them as important partners. This can also be seen to apply in the case of start-ups. Cooperation with start-up companies is certainly something to which these respondents should devote attention.

Cooperation is an important determinant of innovative strength in the Dutch life sciences and medical technology sector.

Overall, we may therefore conclude that cooperation is an important determinant of the innovative strength of companies in the Dutch life sciences and medical technology sector. Cooperation with universities and knowledge institutes is regarded as one of the motors of successful innovation projects. However, the results of the current study reveal that this is not necessarily always the case. This may be due to the complexity of such partnerships, and indeed this impression was confirmed during the interviews with experts drawn from various companies.

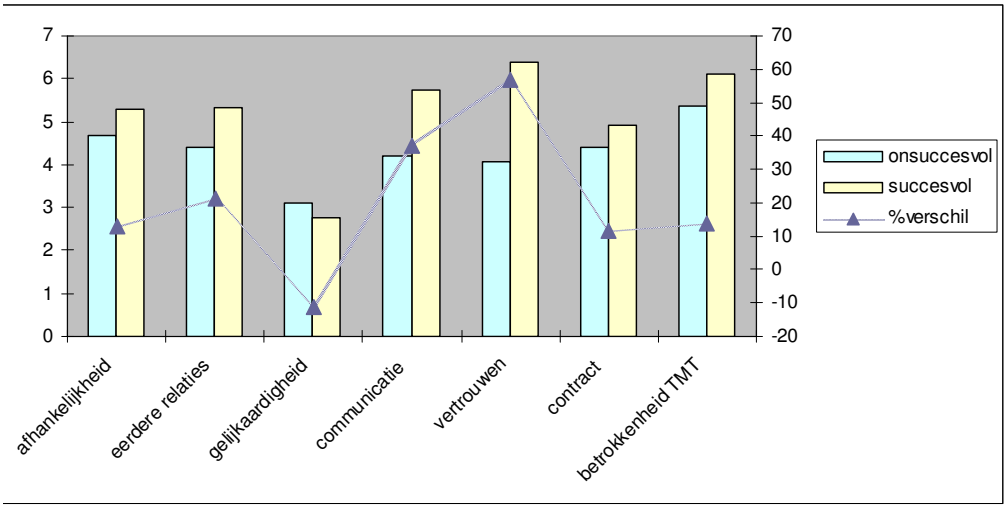
Cooperation with universities and research institutes is essential, as is making good agreements with regard to the transfer and dissemination of knowledge.

Despite the importance of knowledge institutes and universities as partners, interviewees regularly referred to the pitfalls and problems which can afflict this type of partnership. Cultural differences and disparate interests are among the points to which attention must be devoted if success is to be achieved. It is also essential to make clear agreements regarding the transfer and dissemination of knowledge, and about the creation and exploitation of added value. Many universities and knowledge institutes are currently experienced problems in organizing their technology and knowledge-sharing activities. The ‘Technology Transfer Offices (TTOs) set up to ensure good cooperation, are still not functioning as intended. Further professionalization of knowledge and expertise within the TTOs is required. At present, cooperation with universities and knowledge institutes is still too likely to lead to delays because agreements with regard to knowledge sharing have not been made, or are not being kept.

4.5 Success and failure factors for partnerships in the Dutch life sciences and medical technology sector

Alongside the questions relating to partnerships in general, the study also examined the characteristics and outcomes of some specific partnerships. Figure 4.7 shows various characteristics of both successful and less successful cooperative arrangements.

Figure 4.7 Characteristics of successful partnerships



The characteristics of successful partnerships are: Interdependency, prior relationships, good communication, mutual trust, a clear contract and close involvement on the part of senior management.

Interdependency, prior relationships, good communication, mutual trust, a clear contract and close involvement on the part of senior management are all factors which promote the success of cooperative alliances. Cooperation with various partners with various areas of expertise and backgrounds is also an important factor. Interviewees frequently cited good communication and mutual trust as aspects which determine the success of the partnership. It is therefore essential to invest in these aspects in order to produce good results.

It is interesting to note that there is little variation in the role of each factor at the different stages of the development process. The technological development process in life sciences and medical technology may be said to comprise three phases: 'research/discovery', 'development/clinical trials, and 'commercialization'. Because each of these phases involves different types of uncertainty, we might expect each to entail differences in the relative importance of the factors. However, as we see from Table 4.6, the importance of the various factors remains more or less constant throughout the three phases. The main deviations are shown by 'prior relationships' and 'similarity' (between the partner organizations). At the start of the technological development process, companies prefer to deal with partners who are complementary and thus not entirely similar to themselves. A desire for variety can have a major influence on the innovative strength of the resulting partnership. Furthermore, in the initial phase of technology development, we see greater importance being attached to cooperation with partners with whom there has been a prior relationship than in later phases. This may be due to the fact that the initial phase generally entails a greater degree of both technological and market uncertainty. Prior relationships are likely to have engendered a higher degree of mutual trust and confidence between the partners. Each knows what the other is capable of, and what each can do for the other. When there is a high degree of uncertainty with regard to technology and market value, it is particularly important to minimize the uncertainty between the partners themselves. One way of doing so is to cooperate with a partner with which the

At the start of the technological development process, companies tend to seek partners which are complementary.

organization has a 'track record'. Moreover, differences in terms of technological expertise, strategy and culture are far easier to bridge if there has been some earlier cooperation.

Table 4.6 Characteristics of successful partnerships, per phase of the development process

	Research / discovery	Development / clinical trials	Commercialization
Interdependency	++	-/+	-/+
Prior relationship	+++	-	-/+
Similarity	---	-/+	++
Communication	+	+	-/+
Mutual trust	+	+	-/+
Contract	+	+	+
Involvement of senior management	++	++	-/+

Finally, a distinction can be drawn between 'radical' innovation projects and those of a more incremental nature. Table 4.7 shows the relative importance of the various characteristics of partnerships for both types of innovation project.

Table 4.7 Radical versus incremental cooperative projects

	Radical vs. incremental
Prior relationships	**17% lower**
Similarity	**24% lower**
Involvement of senior management	19% higher
Mutual trust	19% higher
Communication	10% higher
Contract	4% higher
Interdependency	2% higher

Radical innovations benefit from cooperation with new partners showing little similarity to the organization.

In the case of radical innovations, it is important to work with new partners bearing little similarity to the organization. Differences in background and knowledge result in a higher degree of diversity

which provides an excellent seedbed for new ideas and solutions. The fact that the partners are new also helps to generate such diversity. As clearly seen from Table 4.7, the involvement of senior management in radical innovation projects is important, as are the value attached to mutual trust and good communication between the partners. Because radical innovation projects entail a particularly high degree of uncertainty, it is crucial that they enjoy the full support of senior management if they are to be brought to a successful conclusion. Trust and confidence in the partner, together with good communication, are also beneficial to the exchange of knowledge which is essential to arriving at successful innovations. The importance of these factors is particularly high in the case of radical innovations. Indeed, trust and communication are the key factors in ensuring the successful progress of projects of this kind.

5. Venture capital in the Dutch life sciences and medical technology sector

5.1 Introduction

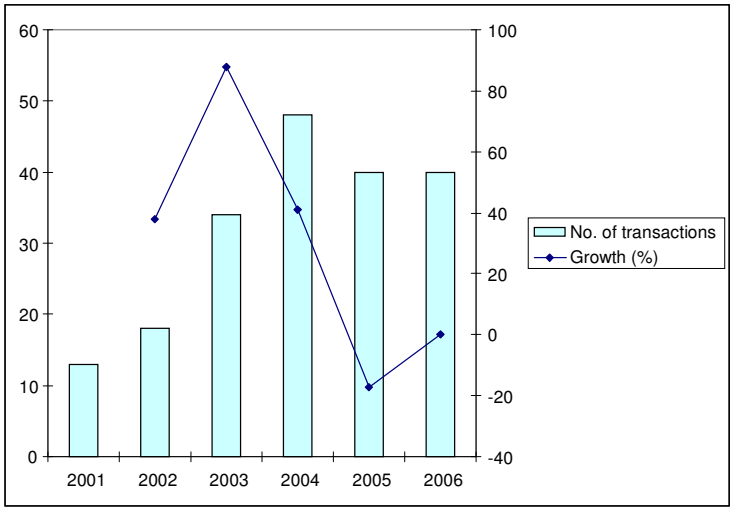
A factor which is becoming increasingly important in encouraging innovation is the availability and use of venture capital. This chapter examines this form of financing and its role in the Dutch life sciences and medical technology sector. Following an account of some general trends, we consider the importance of venture capital in terms of the innovative strength of companies in this sector.

5.2 Venture capital: recent trends and developments

'Venture capital' may be defined as direct financial investment in a non-listed company, i.e. 'private equity' investment. The term covers both investment in new, rapidly growing technology companies and that in mature, established companies (NVP, 2008). Recent years have seen a marked increase in attention for venture capital investments and their importance in terms of innovation (see Gompers, 2002; Kortum & Lerner, 2000, and others). This particular trend has been clearly seen in the Netherlands, where the number of venture capital investments increased by a factor of fourteen between 1990 and 2004. Approximately ten venture capital investments were reported for the period 1990-1994, against 140 for the period 2000 to 2004[26]. Figure 5.1 shows the rise in the number of venture capital investments for the period 2001-2006. Prior to 2004, the average rate of increase was 60%. There has been decline in growth since 2004, but the number of investments remains at a higher level than that seen prior to 2004.

Recent years have seen a significant increase in the availability of venture capital in the Netherlands.

Figure 5.1 Number of venture capital investments in the Netherlands: 2001-2006

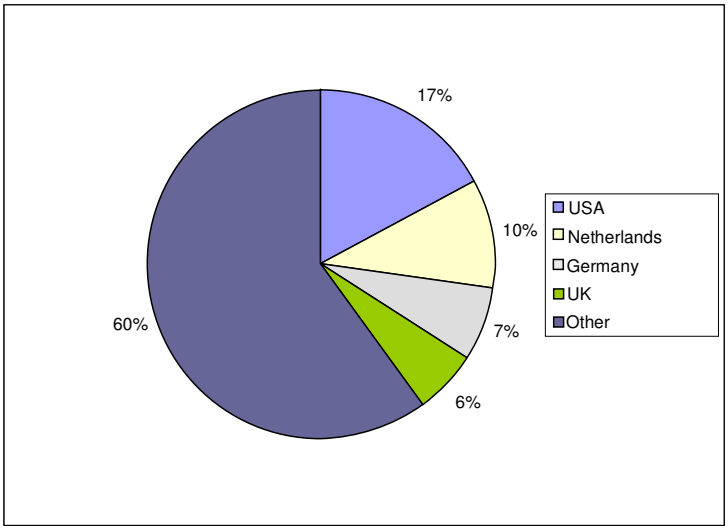


Source: NVP

[26] Source: Nederlandse Vereniging van Participatiemaatschappijen/Netherlands Association of Private Equity Investment Companies (NVP)

The largest and most prominent private equity investors in the Netherlands are Life Sciences Partners B.V., AAC Capital Partners, AlphInvest and Gilde Investment Management. Together, they account for approximately 60% of the total number of venture capital investments. Of these companies' investments, approximately 17% are made in start-ups in the United States, 10% in the Netherlands, 7% in Germany and 6% in the United Kingdom (see Figure 5.2). We therefore see that only 10% of the funds at the disposal of Dutch investors are actually directed into Dutch companies. This may be due to the general investment climate in the Netherlands, or perhaps to the relative paucity of interesting start-ups.

Figure 5.2 Geographic spread of investments by the four largest Dutch private equity companies

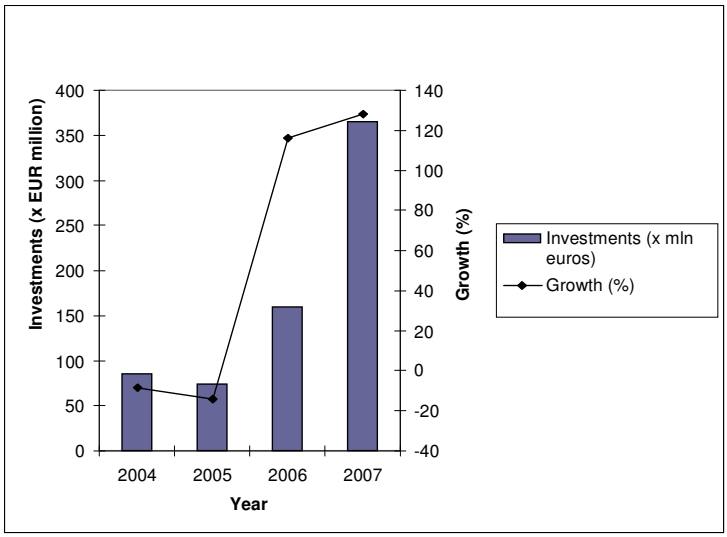


Source: Thomson VentureXpert

The Dutch life sciences and medical technology sector is among those which have seen an increase in venture capital investments in recent years.

Of the total of four billion euros in venture capital investments per annum, 365 million (9%) is now directed into the life sciences sector (source: NVP). This may be regarded as a substantial proportion. Figure 5.3 shows the rising trend over the past four years. The last three years in particular have shown marked growth. The total of investments in the life sciences sector has increased from approximately 70 million euros in 2005, to 150 million in 2006, to the aforementioned figure of 365 million in 2007.

Figure 5.3 Venture capital investments in the life sciences sector, 2004-2007



Source: NVP

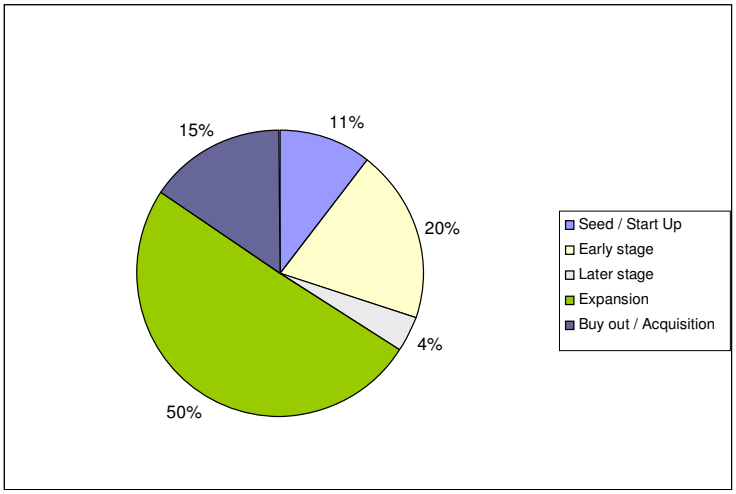
Approximately 30% of the total number of investments relate to 'seed' and 'early stage' activities.

If we examine the number of investments according to the development phase, we see that most relate to the 'later stage' and 'expansion' activities. Approximately 30% of the total relates to the 'seed' and 'early stage' phases (see Figure 5.4). However, if we look at the absolute amounts invested in each phase, we see that these rise as the company itself grows. By far the largest investment amounts are made available to finance 'buyout/acquisition', followed by 'expansion'. In other words, although 30% of the number of investments apply to the initial phases of product development, the amount concerned represents only a relatively small proportion of the total capital.

Approximately 3.5% of the capital is invested in the initial (seed/early) stage of development.

Nevertheless, recent years have seen a positive development in the financing of the first development phase. The proportion of venture capital investments devoted to 'seed' and 'early stage' activities has increased from 0.9% in 2005 to 3.4% in 2007 (NVP, 2008).

Figure 5.4 Dutch investments in the Netherlands



Source: Thomson VentureXpert

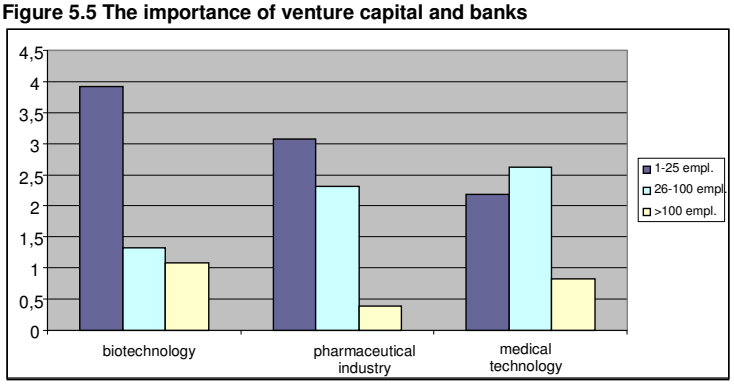
Recent years have also seen a marked increase in the availability of venture capital. However, although 30% of investments are made within the first phase of product development, approximately 3.5% of the capital is invested in the Dutch life sciences and medical technology sector itself. The *Nederlandse Vereniging van Participatie-maatschappijen* (Netherlands Association of Private Equity Investment Companies; NVP) forecasts that the availability of venture capital will increase further in the years ahead. Further growth in financing investment may therefore be expected, particularly in the seed/start-up and early stages, and in technologically oriented companies such as those in the ICT and biotechnology segments (NVP, 2008).

5.3 Venture capital in the Dutch life sciences and medical technology sector

Small biotechnology companies attach major importance to venture capitalists and banks as sources of funding.

The study questionnaire included a number of questions relating to the use of venture capital and bank finance during the innovation process. Figure 5.5 shows the importance attached to these funding flows, arranged according to the size of companies in the various segments. As was expected, it is the smaller companies in the biotechnology segment which make greatest use of external funding. After all, they do not yet have a revenue flow, but do need capital to finance research and the development of their technologies. A noteworthy finding is the importance of capital to medium-sized companies in the pharmaceutical and medical technology segments. It seems that these companies still experience problems in accessing sufficient resources to conduct their research and development activities. The importance of capital to the large companies is far lower; they have sufficient revenue to fund their own research and development, and are therefore far less reliant on venture capitalists or banks.

Figure 5.5 The importance of venture capital and banks



If we relate the use of venture capital and bank finance to the success of innovation in the various segments (as in 5.1) we find that this form of external financing has greatest positive effect in the biotechnology segment.

Table 5.1 Effect of venture capital and bank finance on innovation

Financing flow	Biotechnology	Pharmaceutical industry	Medical technology
Venture capitalists / banks	+	-/+	-/+

Relationships with venture capitalists and/or banks do enhance innovation but are not high on the agenda.

Biotechnology companies often need large financial injections, particularly in the early phase, in order to move their innovations into a subsequent phase of the development process. In the pharmaceutical industry and the medical technology segment, the maintenance of close relationships with banks and/or venture capitalists does not seem to enhance companies' innovative strength to any notable degree. This may be due to the fact that these companies have adequate resources to develop innovations, whereupon they are clearly less dependent on banks and venture capitalists. Of the respondents active in the pharmaceutical industry, 53% report that they attach little or no importance to the role of venture capitalists and banks. Even in the biotechnology segment, 39% of respondents report that relationships with banks or venture capitalists are not high on their agenda. This is remarkable, given the positive effect of this form of financing on the innovative strength of biotechnology companies.

6. Conclusions and recommendations

This concluding chapter considers the main findings of the study and presents a number of recommendations further to those findings. The authors believe that these recommendations will enable the Dutch life sciences and medical technology sector to safeguard its innovative strength in the long term. Based on the analyses conducted as part of the Erasmus Innovation Monitor for the Life Sciences and Medical Technology Sector and the interviews with representatives of that sector, we offer answers to the formulated research questions and devote attention to how the Dutch life sciences and medical technology sector can now improve its competitive position. In addition to policy spearheads for companies in each of the three segments – biotechnology, the pharmaceutical industry and medical technology – the findings should also prompt action on the point of industry representative federations, knowledge institutes and governmental bodies.

The key question of the study was: 'How can the yield of R&D investments within the Dutch life sciences and medical technology sector be increased?' This question gave rise to a number of sub-questions:

1. **What is the relative importance of R&D and social innovation with regard to a structural renewal of the life sciences and medical technology sector?**

The Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008 reveals that some 30% of innovation success is determined by R&D investments. The remainder, some 70%, relies on factors of social innovation: flexible organization, dynamic management and external cooperation. R&D investments therefore play a significant role within the innovation processes of the life sciences and medical technology sector. The ability to create new drugs and advanced medical devices is heavily reliant on new, excellent knowledge. However, if the Dutch life sciences and medical technology sector is to remain successful in the long term, it must also devote attention to social innovation. Social innovation, in the form of organization, dynamic management and cooperation, determines 70% of innovation success. Social innovation enables organizations to apply the excellent knowledge they have developed in practice to create new products and services in an efficient and effective manner. The Dutch life sciences and medical technology sector must place social innovation higher on its agenda. Greater attention to the organization and management of knowledge development and knowledge application within organizations will increase the yield of R&D investments and will enable the sector to develop new products more quickly.

Place improvement of R&D yield higher on the agenda

Changing market conditions, increasing competition and the convergence of technologies conspire to render the innovation process for new drugs and medical devices particularly complex and capital-intensive. The Dutch life sciences and medical technology sector is therefore also one of the most knowledge-intensive sectors in the Netherlands, with above-average R&D investment expenditure. Recent years have seen marked growth in R&D investments, which now total some one billion euros per annum. A long-term improvement in profit margins can only be guaranteed if a continuous flow of new and innovative solutions can be developed. By adopting flexible organizational structures and dynamic management, innovative organizations will not only be able to develop new knowledge at the required level, but can facilitate the bringing together of the knowledge which already exists within the organization. This will increase the yield of R&D. The knowledge which eventually derives from R&D investments can be used and re-used several times in the development processes for new drugs and medical devices. Increasing the innovative

strength of the Dutch life sciences and medical technology sector is therefore not only a question of increasing R&D investments. The effectiveness of those investments can be greatly enhanced by devoting greater attention to the organization and management of innovation and change processes.

Encourage enterprise, knowledge sharing and the dissemination of 'best practices'

Given the degree to which knowledge within the Dutch life sciences and medical technology sector is currently underused, and the urgency of increasing the yield of R&D, investments in social innovation must be given high priority. The sector should pursue public recognition of the relevance of social innovation. Greater attention to flexible organization, dynamic management and 'smart' cooperation will enhance innovative strength and will result in a marked increase in the yield of R&D investments.

Enterprise, or 'entrepreneurship' plays an important role in social innovation. The sector must offer greater support to start-up companies and spin-offs. The benefits of encouraging spin-offs come in the form of knowledge development about promising new technologies. Organizations can encourage spin-offs by offering starter capital and/or guaranteed re-employment[27]. Financial support for those wishing to start their own business is a significant incentive to entrepreneurship, as is practical advice about the structuring and coordination of business activities. Management competencies can be developed by organizing workshops and 'master classes' on starting a business. Educational institutes must devote greater attention to leadership and management skills. Organizations such as SenterNovem and Syntens organize regular workshops, congresses and meetings which geared to the life sciences and medical technology sector, at which entrepreneurs, researchers, policy-makers and investors can meet each other and 'network'. Enthusiastic entrepreneurs are brought together and can gain new knowledge about business practices, personnel policy, legal affairs, attracting capital, etc. This learning process for new entrepreneurs could be organized and coordinated centrally by the 'top institutes', universities or sector organizations. Professional guidance could be provided by 'twinning' experienced managers within the sector with the new start-ups. Their expertise should be cherished and disseminated.

To ensure that knowledge and experience in the field of social innovation permeates the sector, it is essential to develop and promote 'best practices' and 'next practices' with regard to product innovation. Syntens already organizes an annual 'Best Practices Summit', at which successful initiatives in various areas, including health, welfare and housing, are presented. Networks of government organizations, private sector companies and industry organizations can also play an important part. They should promote practices whereby not only the financial indicators of short-term performance are included in annual reports but also the innovation indicators, such as the proportion of revenue derived from new products, the introduction of new organizational structures, or the amount of investments in management, organization and external cooperation. It may also be appropriate to create a ranking of companies based on innovation performance and organizational change. It will then be possible to identify the most innovative and forward-looking organization(s) within the Dutch life sciences and medical technology sector.

[27] See also the WRR report *Innovatie Vernieuwd: Opening in Viervoud*, 2008

2. What are the success and failure factors of innovation? What is the importance of organization and management?

The main success factors for innovation within the Dutch life sciences and medical technology sector are flexible organization and dynamic management. The separation of innovation and efficiency at various locations within the organization and the encouragement of horizontal cooperation and knowledge sharing are particularly important within the biotechnology segment and the pharmaceutical industry. Greater opportunities for self-management must be created by the introduction of joint decision-making. Staff will then participate in strategic decision-making and will be able to exercise their own initiative and enterprise within predetermined frameworks.

A second important focus for positive change is the management team itself. It should develop dynamic management skills and thus increase the level of strategic renewal and change. In the biotechnology segment, particular attention should be devoted to diversity within the management team in terms of expertise and background, and to the development of visionary leadership. The table below shows the main indicators of innovation within the Dutch Life sciences and medical technology sector, as requested in the study terms of reference.

Table 6.1 Main indicators of innovation in the Dutch life sciences and medical technology sector

Flexible organization	**Biotechnology**	**Pharmaceutical industry**	**Medical technology**
Separation of innovation and efficiency at different locations	+++	+++	+
Horizontal cooperation and knowledge sharing	++	++	+++
Joint decision-making	+	++	+
Dynamic management			
Experience within the organization	---	+	+
Experience within the sector	++	+	+
Diversity of knowledge and backgrounds	+	+	++
Visionary leadership	++	+++	+
Team rewards structure	-/+	+	++

Source: Erasmus Innovation Monitor for Life Sciences and Medical technology 2008

Pharmaceutical companies should appoint management team members with experience within the organization; career development opportunities play a significant role here. In this segment, visionary leadership is the main determinant of successful innovation. As Table 6.1 shows, these aspects also demand greater attention in the medical technology segment. Here, a team rewards structure will do much to improve innovation performance. To ensure long-term continuity and

success, the Dutch life sciences and medical technology sector must invest more in management development.

Increase the diversity of the management team

Diversity within the management team in terms of expertise, background and qualifications forms an important foundation for change and organizational restructuring. Diversity in terms of knowledge enables the organization to respond to changing circumstances more rapidly, to develop new initiatives and to devise an appropriate long-term strategy. Diversity also ensures that more aspects are taken into consideration during decision-making processes. The quality of decision-making will be enhanced and the effectiveness of R&D investments can be further increased.

Professionalize the middle management

The importance of product development and cooperation should be acknowledged and supported through the further professionalization of the organizational structure and the management. In general, the CEO in this sector is responsible for overseeing a large number of functional tasks. In many cases, he (or she) will also take an active part in the business activities, and may well focus on R&D activities. The management culture is therefore notable for strong senior management with extensive experience. However, many organizations lack professional middle management. The role of middle management is that of 'information gatherer' (from the workfloor) and facilitator of cooperation between the various organizational units. Creating a fully professional middle management team will create new opportunities to develop a vision and strategic policy setting out the medium-to-long term goals of the organization. The CEO's 'span of control' will be reduced, and he will have more time to devote to pursuing the long-term objectives. Long-term strategy will embrace the interests of profitability and continuity, safeguarding the achievement of mid-to-long term objectives.

Develop visionary leadership

The formulation of a vision and strategy enables management in the pharmaceutical industry to make important choices and to allocate financial resources to innovation and change processes. The vision and strategy will consider not only current problems, but will ensure that time is devoted to identifying the organization's future sources of income. Long-term strategy clarifies the objectives and ensures that staff know where they stand.[28] The pharmaceutical industry should now devote greater attention to formulating an appropriate vision and strategy in order to set out the long-term objectives.

Visionary leadership can be promoted by allowing the right staff to progress into the management levels. Biotechnology companies may also consider specific recruitment efforts in order to attract people with the appropriate managerial qualities. If existing staff are to progress into management, it is essential that individual organizations or the sector federations offer training courses designed to develop management competencies. Other economic sectors in the Netherlands, including the food and manufacturing industries, already offer management training courses whereby knowledge is increased and managers have an opportunity to 'network' in an informal setting.

[28] Research by RSM Erasmus University reveals that vision-forming, professional autonomy and staff talent development are the main factors in improving innovation, and hence the financial results, of organizations of all types. The development of a vision and a long-term strategy creates opportunities to invest, to address new client wishes in a proactive manner, and to identify attractive new markets which will provide future growth.

3. What contribution does external cooperation make to successful innovation? What determines the success of external cooperation?

The results of this study reveal that cooperation with external partners does indeed enhance the innovative ability of organizations in the life sciences and medical technology sector. However, clear differences can be seen between the three segments. Table 6.2 shows that innovation success in the biotechnology segment largely relies on local and regional partners, while international partnerships play a particularly significant role in the pharmaceutical industry. In the case of medical technology companies, regional and international partners are the most important.

Table 6.2 Partners, their location and innovation in the Dutch life sciences and medical technology sector

Location van partners	Biotechnology	Pharmaceutical industry	Medical technology
Local	+	+	-
Regional	++	-/+	+
International	-	+++	+
Types of partner			
Knowledge institutes	++	++	++
Universities	-/+	+	++
Start-ups	-/+	+++	+
Established companies	+	-/+	+

Source: Erasmus Innovation Monitor for Life Sciences and Medical Technology 2008

If we examine the type of partner involved, we see that knowledge institutes and universities do much to enhance successful innovation. Notably, universities contribute somewhat less in biotechnology than in the other two segments. The interviews suggest that this is due, at least in part, to the specific difficulties which beset cooperative alliances between universities and biotechnology companies. The knowledge transfer process should therefore be significantly improved.

Although there is still a conspicuously low rate of cooperation with start-ups within the life sciences and medical technology sector (only some 10% of partnerships involve a start-up), such partnerships can indeed make a significant contribution to the innovative ability of pharmaceutical companies. Alongside efforts to encourage cooperation between companies and universities, it will therefore also be appropriate to initiate and coordinate cooperation between start-ups and pharmaceutical companies, and greater attention must be devoted to this point.

The success of cooperation is largely determined by good communication between the partners and a high level of mutual trust and confidence. However, to create *radical* innovations demands calls for organizations to work alongside new partners which are complementary rather than similar to themselves. This will ensure greater diversity of ideas and technologies.

Encourage clustering and cooperation with start-ups

The transparency of existing knowledge and experience must be placed higher on the agenda. However, this alone is not enough. The study results reveal that cooperation with start-ups offers significant added value in terms of improving innovative ability. Ongoing initiatives such as the TI Pharma, BMM, CTMM and NGI can play an important part here. To organize cluster-forming successfully, it is essential that there is close cooperation between the various institutes, public-private initiatives, regional development corporations and sector organizations. Such cooperation will serve to minimize overlap between activities and thus create greater value for the companies concerned. It is also possible to use existing knowledge and experience more effectively. The recently launched 'Life Sciences and Health ' initiative will help in this respect. One of its key objectives is to encourage cooperation with the small and medium-sized enterprise sector. By bringing diverse parties together in pursuit of a common goal, or by organizing events at which potential partners can meet each other, start-ups and established large companies can be brought into contact. Another important point is that start-ups in the Netherlands should receive appropriate guidance with regard to forming partnerships and ensuring that their intellectual property rights are fully protected, thus placing them on an equal footing with even the largest multinational.

Promote the exchange of knowledge between universities and private sector companies

Universities and knowledge institutes are an important source of external knowledge about new technologies. One of the obstacles to successful partnerships between universities and companies is the difference in organizational culture. While companies will wish to protect new knowledge, academic researchers attach greater importance to data-gathering and publications. There are therefore conflicting interests. The ownership of intellectual property is a potential source of disagreement when entering into a cooperative alliance. To facilitate the cooperation process, several universities have now established Technology Transfer Offices (TTOs). Further professionalization of the TTOs is now required to facilitate the practical application of knowledge created by universities and subject to intellectual property rights. The creation of a central database listing the competencies and IP rights of all Dutch institutes would also be a step in the right direction. National coordination of knowledge and competencies would facilitate the search for a potential partner. Once a sufficient level of scale has been achieved, it will also be possible to invest in a fully professional organization with experts in all the relevant disciplines, such as patent law, licensing arrangements, and the management of cooperative alliances. Various interviewees cited the VIB (Flemish Institute of Biotechnology) as an example of such an organization which is worthy of emulation.

Make external cooperation an integral part of business operations

Although external cooperation is becoming increasingly important in terms of the innovative strength of the Dutch life sciences and medical technology sector, it would seem that companies still attach very little importance to this aspect. By identifying the strengths and weakness of the company, its current status in terms of knowledge and technology can be established. This information can in turn be used to identify the competences it lacks but which are nevertheless essential in developing successful new products. Such 'gaps in the knowledge' form the basis for the search for external partners.

Once the knowledge requirement is known, the actual search for partners can begin. The first step is to draw up a list of potential partners at local, regional and international level. A selection can then be made. In doing so, it is important to take the characteristics of specific partners into account, as well as the advantages and disadvantages of their geographic location. Proximity, whether local or in the same region, might be a significant precondition to the successful exchange

of knowledge. If the knowledge concerned is extremely specific and complex, cooperation within local clusters may be the most appropriate solution. International partners, on the other hand, offer the advantage of being able to provide access to new markets. It is also possible that certain types of highly specialist knowledge are only available in another country.

When selecting possible partners, companies should also take the 'soft' criteria into account. Good communication and mutual trust are important conditions for successful cooperation. This is more likely to be the case if the partners have enjoyed a prior relationship, whereby they have become accustomed to each other and each other's practices thus rendering communication more efficient and effective. A similar consideration applies to mutual trust; where the partners have worked together in the past, they will know exactly what to expect of each other. The appointment of 'alliance managers', or making manpower available to coordinate contacts, will also have a positive impact.

It is important to keep the objective of the partnership in mind at all times. The objective largely determines how the progress of cooperation should be evaluated. If the project involves the development of radical innovations, cooperation with new partners with a broadly dissimilar knowledge base to that of the organization could well lead to surprising results. However, if there are major strategic interests at play, mutual trust and interdependency are even more important and due regard must be given to these aspects.

4. What is the significance of venture capital? To what extent does venture capital promote innovation?

Venture capital has become very much more important to the Dutch life sciences and medical technology sector in recent years. Investments by venture capitalists now total some four billion euros, of which approximately 365 million is made available for investments in the Dutch Life sciences and medical technology sector.

The largest proportion of the investment amount is made available for the later phases of development, and for buy-outs and acquisitions. Although only a relatively small proportion (3.5%) of invested capital addresses the early stages of product development, there has been significant growth in the amount of venture capital invested in these early stages in recent years. Moreover, the Netherlands Association of Private Equity Investment Companies (NVI) forecasts that such investments will continue to increase in the years to come.

Recent years have also seen the introduction of various national programmes designed to provide financial support to start-up companies in the life sciences and medical technology sector. The 'Life Sciences & Health' initiative, for example, offers innovation loans to small and medium-sized companies in order to help the sector finance projects with a particularly high degree of risk.

External financing in the form of venture capital and/or bank loans is most often used by smaller companies in the biotechnology and pharmaceutical segments. As shown by Table 6.3 below, venture capital has a positive influence on the innovative strength of biotechnology companies.

Table 6.3 Venture Capital and Innovation in the Dutch life sciences and medical technology sector

Venture capital	Biotechnology	Pharmaceutical industry	Medical technology
Use of venture capital	+	-/+	-/+

In the earlier stages of their existence, biotechnology companies usually generate too little revenue to cover the high costs of their desired R&D activities. External financial support can resolve this situation. In addition, biotechnology companies can take advantage of the existing knowledge to which lenders have access. Venture capitalists, for example, often have an extensive network of financiers, start-ups and established companies who may be able to assist in attracting new capital in the subsequent phases of the development process. The acquisition of capital from established companies (such as large pharmaceutical companies) can also play a major role in obtaining both information and legitimacy. Access to an extensive network of potential customers, the availability of facilities and the legitimacy that comes with cooperation with an established partner can be sound reasons for choosing this form of financing.

Research possibilities for external financing

When attempting to attract external financing, the organization should first familiarize itself with the possible sources of that finance. The degree to which the various advantages and disadvantages of each will determine the final choice is likely to vary according to the growth phase in which the organization now finds itself. In the initial phase, for example, there will be greater need for management experience in order to overcome the obstacles faced by new companies, while in the later phase access to new markets is likely to be a more important consideration. A syndicate comprising various types of investor may be one way in which to derive maximum benefit from the advantages that each has to offer.

Other possible sources of external financing include banks and government bodies. Compared to venture capitalists, they are likely to apply less rigid monitoring and will probably not offer the same degree of guidance. Moreover, they may also (and primarily) be concerned with other sectors and development phases. Almost by definition, venture capitalists tend to focus on start-up companies in the hi-tech sectors. For established companies, and especially those which fall under some governmental incentive programme, banks and government organizations do form an attractive alternative.

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Appendix B: List of interviewees

Dineke Abels	ZonMw
Dr Piter Bosma	AMC
Rene Bouma	Kwartiermakers
Dr Thijs de Boer	Organon
Prof. Joost de Bruijn	Progentix
Willem de Laat MD, PhD	TIPharma
Dr Remco de Vrueh	Biopartner/ZonMw
Dr Gerome Friesen	Philips Electronics Nederland
Johan Hanstede	Biofarmind
Prof. Hans Hofstraat	Philips Research
Remco Hoogendijk	NV Oost
Jan Jonker	NV Oost
Guido Matthée	Health Valley Nijmegen
June Nods	Saxion Universities
Dr Anne Portwich	Life Sciences Partners
Prof. Jan Raaijmakers	GlaxoSmithKline
Dr Emiel Staring	BMM
Prof. Jan van de Winkel	Genmab
Erik van den Berg, MSc MBA	AM-Pharma
Dr Martin van der Graaff	Nefarma
Dr Tessa van der Valk	University of Utrecht
Prof. Willem van Gelder	Numico Research
Dr Sandra van 't Padje	ZonMw
Edward van Wezel	Biogeneration Ventures
Laura Vis	SenterNovem