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# The Research and Development Programme of the Danish Government 1991

Ministry of Education and Research



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# The Research and Development Programme of the Danish Government 1991

Ministry of Education and Research



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## Foreword

The Government hereby presents its annual review of the main lines of research policy, its strategy for the budget year and budget estimates as they are reflected in the items for research in the 1991 budget, in addition to the status of its work and initiatives in research and development for 1990-91.

I shall here only draw attention to the extremely important reinforcement of basic research that has been achieved with the enactment of the Law on the Danish Fund for Basic Research. This enactment has meant that, over and above the resources that come from the budget, an additional annual sum of DKK 200 million will be made available to Danish basic research.

Among other matters dealt with in the annexes is a review of developments in Danish R & D during the 1980s in comparison with other countries. And we can fortunately note that the rise in our research engagement throughout the 1980s is not inferior to that of the other OECD countries.

We may likewise state that, against the background of the chapter on global tendencies, we have succeeded in devoting our resources to the areas in which development has been taking place.

The accounts that form the basis for these two annexes will be published in the near future.

BERTEL HAARDER  
Minister for Education and Research



# Foreword

The Government hereby presents to annual review of the main lines of research policy for the budget year ending 1991. The main lines of research policy are outlined in the summary statement in the appendix to this report. In addition to the status of its work and activities in research and development for 1990-91.

I shall here only draw attention to the extremely important contribution of research that has been achieved with the commitment of the Law on the Danish Fund for Basic Research. This grant has meant that over and above the resources that come from the budget an additional annual sum of DKK 300 million will be made available to Danish basic research.

Among other matters dealt with in the annex is a review of the reports to the Danish E & D during the 1980s in comparison with other countries. And we can fortunately note that the rise in our research expenditure throughout the 1980s is not inferior to that of the other OECD countries.

The main thesis is that against the background of the changes on global markets we have succeeded in developing our research in the areas in which development has been taking place. The resources that form the basis for these two annexes will be published in the book future.

Minister for Research and Innovation

1990-91



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# Main Lines of Research Policy





The Danish engagement in research increased markedly between 1979 and 1989 for, comprising 0.96% of GDP in 1979, spending on R & D in 1989 comprised 1.53% of GDP in 1989, or a sum of almost DKK 12bn. While the period was thus characterized by a significant increase in spending, the 1980s have also left a number of unresolved problems in Danish research policy.

In the 1990s, one of the major tasks of Danish research policy will be to ensure a continued strengthening of Danish research without a corresponding increase in spending from public funds. Quality and productivity are to be supported, in part via the Danish Fund for Basic Research, new guiding regulations and an increased engagement in international cooperation in research.

It is the Government's understanding that despite the measures that have been taken there is a further need for coordination, concentration and division of labour in the research system, which similarly lacks transparency. The research institutions possess too little power to govern themselves or to take risks, and confidence tends to be lacking between the research system, on one side, and the Government, parliament, public administration and the population at large, on the other. This problematic confidence is linked not least to the absence of »annual accounts« from the research system.

Any resolution of this problem must begin with the requirements posed by the growing internationalization of research. The frame of reference for any qualitative evaluation of research done must therefore be international, not national, and for this reason channelling a part of the public funds must be made dependent on the high quality of the results of research so financed.

The goal is to cause Danish research institutions to be of interest as partners worthy of cooperation with the best institutions and other similar bodies elsewhere in the world.



## **The National Goals and Research**

A modern society like that of Denmark with a technically advanced production apparatus is highly dependent on the results of research and technological development. Research is a part of the society's material and immaterial foundations of growth.

If Danish production is to continue to be competitive, a rising level of knowledge in both processes and products is required, and the existence of research competence is vital to this development.

A small country, Denmark lacks the resources needed to be active in all areas of knowledge, which implies that much of the knowledge and understanding that are preconditions for maintaining and extending the basis for Danish production - and thereby general living conditions in Denmark - must be sought internationally. Our research system must then be capable of keeping up with and drawing on knowledge from abroad.

Communication between the public research system and the business enterprise sector must be intensified. The tendency towards a constantly more rapid application of research results in specific production means that possibilities of development are lost if the necessary knowledge is not rapidly and effectively passed on from researcher to user. Moreover, it is the Government's view that researchers and users of research should work effectively together.

In connection with efforts to improve the environment, research should have an important function both in contributing to developing cleaner technologies, and to arriving at greater knowledge of the connections between the political and economic decisions that must be taken in a society, and their environmental consequences.

Research has significance for national identity and the ability to enrich Danish culture by transposing influences from other cultures and countries.

The Government wishes to cause Denmark to be a nation that, despite its modest size, is regarded as the home of research of a high international standard. As a goal for the 1990s, this may seem ambitious, but, if vigorously pursued, it can be reached.



*The Government wishes:*

- to secure the nation's fund of knowledge by means of education and research that creates the preconditions for a business enterprise sector based on research and advanced technology;**
- to have a number of research institutions that are among the foremost of their kind;**
- to strive to have only research institutions of international quality; and**
- to ensure the supply of fully qualified researchers to both the private and the public sectors.**

## **Specialization and Concentration**

Discussions about the concentration and specialization of Danish research start from the premise of the need to create effective units that can reflect the importance to national development of the research in question, while doing work that can stand comparison on the international level.

### *Specialization implies Priorities*

In the 1990s, the new technologies (information technology, biotechnology and materials technology) are expected to be more-or-less vital in most new products, processes and the like. From now on, research will become increasingly multi-disciplinary.

Supposing economic conditions to remain unchanged, any specialization of Danish research implies that some areas must necessarily receive less priority so that others may receive additional resources.

At present, there is a sensible balance between basic appropriations and programme appropriations. The basic appropriations will continue to form the most essential part of research funding.

All public research institutions are to have uniform conditions for competition but it should be possible to reward those that do best competitively. None is therefore to enjoy anything like a monopoly in relation to the programme appropriations of a ministry and other free sources of research funding. It is only through such precautions that it is possible to create the sort of specialization that is based on the quality of the research work done.



### *Concentration as a Means*

An increased concentration of the Danish research structure is not an aim in itself but only one means among several with the aim of contributing to the optimal utilization of the circumstances within which the research system must function.

With a constantly improved infrastructure within a relatively small geographical area such as Denmark, it becomes unnecessary to maintain the overlapping of research that takes place at the many - and much too small - uncompetitive Danish institutions.

The effects of competition are to permeate the whole system so that the weakest suffer the consequences. Structural changes are not to be brought about administratively but will emerge from the strength of each institution and the interest its work arouses.

The best use can be made of the economic resources devoted to the research system by creating benefits of scale.

This can come about either in the form of large, physically concentrated units or through close cooperation between smaller units, centres without walls and networks under joint management.

It should be fruitful to allow the research institutions to analyse their own situations in relation to the new demands that the 1990s will bring. In many instances this will probably lead to the recognition that units are too small for the tasks they now face.

International research evaluation will also be used as a means of assessing the quality of research institutes' work.

### *The international Implications of greater Specialization and Concentration*

Taking part in international research programmes requires increasingly larger resources and a greater basis of knowledge. In contrast to smaller institutions that have increasing difficulties in this respect, larger institutions are much better placed to be internationally active either in initiating a programme or working together with other, foreign institutions.

If Denmark is to secure an increasing share of international research programme funds, in addition to creating larger, effective units, a reasonable national market must be ensured for their skills.



This implies that national programmes must be so designed that they in part are aimed at areas of large technological and economic importance in Denmark, and in part complement what is being done, for example in the EC research programmes.

## **Management and Competition**

The Danish research institutions shall be offered help but only to enable them to compete, not to avoid competition. Means of decisive importance in this process are strengthened management and greater budgetary responsibility in the individual institutions.

### *Reinforced Management and budgetary Responsibility*

While basic appropriations for the institutions will continue to be supplied by the relevant ministries, additional funding must be sought on the 'free market' for national and international sources of research funding. By responding to offers to submit tenders and by actively marketing their skills, research institutions can win Danish and international research assignments.

Aggregate budgets will thus come to depend on the ability to attract external funding, which will make clear the relationship between scientific quality and budgetary income. A lack of ability to attract such funding ought therefore to put the research management on their guard.

Managerial responsibility in the research system shall be made visible and shall be strengthened with the necessary powers to take prompt action as soon as competitive abilities show signs of failing. One of the duties of research management will be to formulate a professional profile and a goal for their institutions.

Successful institutions will become attractive collaborators besides attracting younger researchers whom they can afford to employ.

### *"The market principle" in the Research System*

During the 1990s, the increasing internationalization of the research system will radically alter the conditions under which it works.



Introducing market mechanisms will make new demands on the institutions, and their ability to attract external funding will be a mark of their competitive skills. Another mark will be their skills in selling their results, and the market will thus contribute to enhancing the scientific quality of individual institutions.

The institutions will be moving into a more turbulent world, one in which research status will ebb and flow more rapidly than it does now.

#### *A dual-stringed System*

The growth in programme appropriations that took place throughout the 1980s did not inhibit the basic appropriations which, on the contrary, rose by about 40% in fixed prices in 1979-89. Programme appropriations rose even more, and as mentioned above, there is no intention to alter the balance between them.

Criticism from different sides has claimed that many resources are devoted to formulating applications for funds for projects and the like, but this is a natural consequence of the very considerable resources that are devoted to research in the form of programme appropriations.

Even so, the work of simplifying the system of financing research, which has begun, must be reinforced. It is intended in future to allocate the greater part of funds in the free string as framework appropriations and to long-term projects, so that the institutions' management and planning strategies can more easily take account of the funds dispensed by the Research Councils and funds granted for programmes of research.

#### *Transparency in Research*

It must be in the interest of all that transparency in research becomes greater, one means being a form of »public accounting« that combines a presentation of the results of research work done and an account of how the resources have been used.



## **More and better Researchers**

A sufficient number of qualified researchers is regarded by the Government as an essential competitive factor in raising the international standing of Danish research to even greater heights.

The Government thus intends to reinforce post-graduate training by means of cooperation on a broad scale between universities, other public research institutions, the research units of the business enterprise sector and recognized research establishments abroad. Without a programme of post-graduate training of an international standard, it is impossible to produce research of international quality which continues to furnish industry and the public sector with highly qualified researchers.

The task of improving post-graduate training must be tackled by all research institutions including government sector research institutions if the numbers and quality of trained researchers is to increase.

## **Towards a National Model**

Adapting Danish research to these new circumstances cannot be done from one day to the next, but the work has started and it is important that it continues.

- We shall work towards fewer but more effective research units that will possess a greater degree of independence.
- We shall ensure that research of an international standard is the goal of each individual institution.
- We must introduce market-like conditions into the research system, partly to make the best use of national economic resources, partly to create more competitive institutions.
- We must enlarge the scope and raise the quality of post-graduate research training.
- We must create transparency and confidence in the research system, with the aim of winning understanding and acceptance of the roles and functions of the individual participants.



**Government  
R & D Strategy 1991-94**





It is the aim of the Government that R & D funds should be utilized to the greatest possible effect. Optimal use must be made of resources invested by society in the research system to the benefit of the way of life of the population and the development potential of the business enterprise sector.

The instruments that will continue to be used in furthering this process have been described in the chapter on the main lines of research policy.

A continued rise in total R & D expenditure must take place in the private sector if an effective contribution is to be made to promoting production and employment in Denmark. For this reason the Government's economic policy constantly aims at creating the best possible climate for business, for example by reducing company taxation from 50% to 38%.

From 1993 basic research will be subject to the same productivity requirements as other state enterprise, that is 2.3% on wages and 2.0% on other expenditure. Up to now the figure for basic research has only been 0.5%.

Table 1 contains a more detailed survey of the development in state R & D appropriations for 1989-94. The table shows the distribution of funds between general scientific development, post-graduate research training, international R & D cooperation, communication and selected R & D areas.

It should be noted that the distributive limits of division are not quite clear: for instance general scientific development covers both biotechnological and environmental research. Thus the figures under the selected areas provide an approximate but not precise picture of government R & D in the areas indicated.

The following section describes Government strategy in a number of central R & D areas on the basis of table 1. It is emphasized that despite a reduction in the size of the grants to the individual areas, in a number of cases this is more an expression of the fact that special programmes are expiring while new programmes have not yet been adopted rather than that the area as such is being accorded a lower priority.

It is thus possible to continue or initiate programmes over and above those contained in table 1 provided that the expenditure can be met within the limits of the total Finance Act.



**Table 1. R&D appropriations 1989-94 <sup>1)</sup>.**

DKK million, 1991 level	1989	1990	1991	1992	1993	1994
General scientific development	2459.9	2721.8	2581.6	2588.5	2495.9	2447.9
of which:						
Natural science	534.3	591.1	507.9	512.1	480.3	470.3
Technical science	376.8	433.3	442.0	454.0	436.4	424.1
Medical science	511.0	495.3	456.3	461.8	442.8	429.6
Agricultural and veterinary science	151.8	169.3	169.7	171.3	156.1	153.7
Social science	280.6	335.7	357.9	361.9	353.8	349.7
Humanities	390.1	447.6	435.5	431.4	416.5	409.8
R&D that cannot be distributed	215.4	249.7	212.3	196.0	210.0	210.7
Post-graduate research training	328.8	314.2	315.4	314.9	313.1	311.4
International research cooperation	240.4	270.7	282.6	298.6	310.6	314.9
Communication	56.6	47.8	51.4	50.4	50.1	51.0
Selected areas:						
Materials technology	104.5	130.0	128.3	58.3	0.0	0.0
Food technology	72.8	174.6	263.1	227.4	198.7	184.7
Biotechnology	152.0	156.8	123.8	109.6	95.6	82.8
Environment	217.6	217.8	190.9	180.6	135.9	132.5
Energy	223.2	218.6	227.5	211.5	210.5	195.5
Health	106.6	96.8	99.4	100.0	101.1	102.3
Agriculture and fisheries	386.3	373.6	371.3	345.5	385.8	385.5
Industry and trade	515.5	245.8	180.0	170.0	170.0	170.0
Technological infrastructure and initiative areas	136.0	120.8	130.0	120.0	112.0	112.0
Other R&D appropriations	1081.8	798.6	974.6	759.0	851.1	775.1
<b>R&amp;D budget appropriations 1991</b>	<b>6081.9</b>	<b>5887.9</b>	<b>5919.9</b>	<b>5534.3</b>	<b>5430.4</b>	<b>5265.6</b>
Index 1991 = 100	102.7	99.5	100.0	93.4	91.7	89.0

<sup>1)</sup> In Annex D, »R&D appropriations 1989-94«, the appropriations for 1989, 1990 and 1991 are divided into basic and programme appropriations.

Tables 2 and 3 describe the distribution of state research funds by ministerial area in Danish crowns and index figures respectively.



**Table 2. Distribution of state research funds over the areas of ministerial responsibility in DKK million.**

DKK million, 1991 level	1989	1990	1991	1992	1993	1994
Ministry of Foreign Affairs	107.6	129.6	104.6	108.8	120.6	128.2
Ministry of Health	230.9	222.7	224.3	223.2	223.0	223.1
Ministry of Education	3291.3	3285.5	3283.7	3127.6	3074.6	2996.6
Ministry of Culture	262.8	292.9	295.4	290.6	287.6	287.6
Ministry of the Environment	135.5	134.5	181.7	174.5	143.9	140.2
Ministry of Agriculture	444.7	435.8	487.9	442.7	460.6	459.4
Ministry of Industry	775.8	563.2	554.0	425.0	388.0	359.0
Ministry of Energy	534.6	518.8	516.4	486.7	489.9	434.2
Other ministries	298.6	304.9	271.9	255.2	242.2	237.3
<b>Total</b>	<b>6081.9</b>	<b>5887.9</b>	<b>5919.9</b>	<b>5534.3</b>	<b>5430.4</b>	<b>5265.6</b>

**Table 3. Distribution of state research funds over the areas of ministerial responsibility, index figures.**

Index 1991 = 100	1989	1990	1991	1992	1993	1994
Ministry of Foreign Affairs	102.9	123.9	100.0	104.0	115.3	122.6
Ministry of Health	98.8	98.5	100.0	98.2	98.1	98.1
Ministry of Education	100.2	100.1	100.0	95.3	93.6	91.3
Ministry of Culture	89.0	99.2	100.0	98.4	97.4	97.4
Ministry of the Environment	75.0	74.3	100.0	96.1	79.6	77.6
Ministry of Agriculture	91.1	89.3	100.0	90.7	94.4	94.2
Ministry of Industry	140.0	98.7	100.0	76.7	70.0	64.8
Ministry of Energy	103.5	100.5	100.0	94.3	94.9	84.1
Other ministries	100.4	112.7	100.0	94.6	91.6	90.2
<b>Total</b>	<b>102.7</b>	<b>99.5</b>	<b>100.0</b>	<b>93.5</b>	<b>91.7</b>	<b>89.0</b>

The period has seen a reduction in state funds for R & D activities as a result of rising productivity in the research system and the Government's wish to strengthen R & D within the private sector.

The Government has appointed an Industry and Trade Development Council, with reference to the Act on Industrial Promotion, in order to promote private research and development and as part of its efforts to create an innovative framework for the structural adjustment and technological development of the business sector. The



Council is to advise the Government on matters of significance for the international competitiveness of Danish trade and industry. The Council is charged with paying special attention to promoting the development and utilization of knowledge about technology, management and the market and with promoting R & D in firms within the private sector.

Having examined the existing schemes for industrial development, the Council has concluded that on the whole the system is both well-run and innovative. At its coming meetings the Council will discuss a number of complex topics and will make proposals where it judges that supplementary efforts are needed regarding the promotion of R & D in the business sector, financing this activity and in general the promotion of industrial growth and development.

In May 1991 on the initiative of the Government, which would like to further support basic research in Denmark, an independent Fund for Basic Research was set up with DKK 2bn in basic capital yielding an annual sum of about DKK 200m for basic research purposes.

## **General Scientific Development**

Activities in the category of general scientific development, primarily basic research across the whole scholarly spectrum, are fundamental to Danish research and to the possibility of supplying qualified researchers to trade and industry.

General scientific development forms the basis of strategic programme ventures mainly in the areas of technology and natural science. Programme ventures in the social sciences and the humanities are exclusively in the form of strategic grants to the relevant Research Councils and can thereby be included in the category of general scientific development.

By far the greatest number of these activities were carried out at some of the government sector research institutions and at universities and institutions of higher education under the Ministry of Education.

Between 1989 and 1994 the grants for general scientific development will fall by 4.6% or DKK 112m. This is largely because of increased demands for productivity and the expiry of the Ministry of Education's researcher recruitment programme in 1993.



## **Post-graduate Research Training**

In its efforts to ensure that Danish research is increasingly competitive internationally, the Government has decided to revitalize recruitment by reforming the post-graduate research training programme.

In the spring of 1991 the Ministry of Education circulated a proposal for such a reform for comment by the universities and institutions of higher education, the Research Councils, the Educational Councils, the government departments that do or commission a significant volume of research, the labour market organizations and the like.

A reform must first and foremost ensure that the quality of post-graduate research training is improved i.a. by better organization of Ph.D. programmes and making the research environments where Ph.D. students are trained more international. The reform is also aimed at increasing the production of researchers.

It is of decisive importance to the Government that the level of grants to post-graduate research training remains stable.

## **International Research Cooperation**

The steadily increasing efforts at international cooperation on research reflects the high priority the Government has given this area. Participating in international research cooperation is a vital precondition for increasing the quality of national research. International cooperation means that Danish researchers will have access to knowledge they would otherwise not have had and that contracts will be placed with Danish companies for developing equipment and apparatus.

Between 1989 and 1994 R & D funds for this area will be raised by 31% or DKK 75m.

Most of this money will go to cover contributions to Danish participation in space research (ESA), nuclear research (CERN) and in the EUREKA programmes.

The Government will work for an increase in the number of programmes in these areas in the context of both the EC and the Nordic Council of Ministers. There has been a significant increase in the number of EC research programmes not least due to the efforts of Denmark.



National endeavours to increase the benefit of taking part in these programmes will continue via the initiating programmes, 'Start', aimed at government sector research institutions and 'Feasibility Study' aimed at small and medium size enterprises.

## **Communication**

The major part of funds granted for this purpose are for preserving and passing on knowledge about Danish cultural heritage. This broadly based scholarly activity is primarily carried out at museums, research libraries and archives.

It is the opinion of the Government that it is important that research be done on questions pertaining to our linguistic and cultural identity and its background with a view to strengthening national consciousness in the European context we are becoming part of.

In addition the Government attaches importance to libraries, archives and museums retaining their position as key elements in the infrastructure of research not least at a time when higher priority is to be given to research as a whole. In this connection it is vital to stress the necessity of safeguarding for instance library service to areas of research that are upgraded.

## **Materials Technology**

In 1988 the Government initiated the 5 year Materials Technology Development Programme (1988-1992) which will cost a total of DKK 495m. The programme is aimed at promoting the utilization by Danish industry of the most recent R & D in the area. The following main activities are covered by the programme:

- carrying out use-oriented basic research and technological research at an international level with a view to future industrial exploitation of the results of this research;
- the technological development of some existing materials/processes and their application;
- transfer of technology and communication of knowledge to broad categories of Danish companies: this would include demonstration activities.



The programme is also aimed at creating a foundation for both renewing the content and increasing the quality of university degree courses and vocational training.

The programme includes establishing 5 centres, 9 framework programmes and single projects with the cooperation of departments at the universities and institutions of higher education, the government sector research institutions, the technological service institutes and development-oriented industrial enterprises. The expiry of the programme in 1992 explains the decrease in the size of the grants for materials technology.

## **Food Technology**

To strengthen the position of the Danish food industry on the international market, the Government has set aside DKK 525m for a research and development programme that runs from 1990 to 1994.

Primarily aimed at companies in the food industry and at R & D environments at universities and other centres of expertise, the programme concentrates on three main areas:

- increased R & D cooperation between the private and public sectors via cooperating on projects;
- building up a couple of large, public Danish centres for research and development where the emphasis is placed on quality, international competitiveness and participation in international cooperation;
- increasing the senior research staff at the institutes of higher education as well as boosting post-graduate research training including the Industrial Research Education Programme.

Furthermore research will continue into the storage, processing and other industrial exploitation of fish products.

In all DKK 874m has been set aside as programme and basic funds for food technology for 1990-94.

## **Biotechnology**

Efforts to boost both basic research and strategic research in biology and biotechnology will continue.

Biotechnology is one of the most internationally oriented areas of Danish industry where R & D is on an international level and way above the average for Danish industry as such. This together with



the strong national tradition in basic research in biology and the increasing application of biotechnology in many sectors places Denmark in a favourable position.

For this reason, from 1991 to 1995 the Government will devote over DKK 450m to a special biotechnological research programme that will seek to make full use of the dynamism and initiative characteristic of the area.

## **Environment**

The environment is the area where the greatest number of Government ministries are involved in R & D. The decrease in budget appropriations for the period 1992 to 1993 is due to the expiry of research programmes that have been carried out in connection with the Action Plan for the Aquatic Environment.

Because of the great number of Government ministries involved, the scope of environmental research is very broad. It includes research on the working environment, water and marine environment, pesticides and the environment, nutrients and the cycle of organic substances.

The Government is designing a development programme for environmental technology, the aim of which is to promote the possibility for Danish industry to exploit its industrial potential, as well as to promote the development of cleaner technology, recycling technologies and other environmental technologies.

The Government has requested the Danish Council for Research Policy to appoint a coordination committee to organize the planning of a coordinated, strategic programme of environmental research between 1992 and 1996. The programme will aim at creating the framework for concentrated research activity that will improve the basis of knowledge for the social and political decision-making process.

Finally it should be mentioned that at its 39th session the Nordic Council of Ministers adopted a proposal for a Nordic environmental research programme for 1993 to 1997. The programme is to cover three themes: research on climatic change; environmental research cooperation on the Baltic; instruments of control and environmental economy. The Nordic Council of Ministers has decided to grant DKK 25m annually to the programme from 1993 to 1997.



## **Energy**

The main purpose of R & D funds in the energy area is to ensure that the technological basis of Denmark's energy policy is safeguarded; this includes making sure that the technical bases are available for promoting energy production with a low environmental impact, for the recovery and utilization of domestic resources of energy and for the development of new energy technologies.

The development in the figures in the energy area in table 1 is based on the present Government programme and reflects the general requirements as to productivity. If the CO<sub>2</sub> tax is imposed the given figures for the energy area may be corrected.

## **Health**

The Government's preventive programme has a very high priority in health research; this includes monitoring the general level of health and carrying out research on the health service, disease prevention and the treatment of widespread diseases. The establishment of a research centre for environmental medicine is another initiative that honours the intentions in the preventive programme.

The Government will upgrade long-term epidemiological research thereby supporting behavioural and motivation research in the health sector and will also take the initiative to investigating stagnating mean life expectancy in Denmark.

## **Agriculture and Fisheries**

The Government intends to concentrate R & D in the agricultural sector by amalgamating the Danish Institute of Forest Technology and the Danish Government Forest Experiment Station. Furthermore the Royal Veterinary and Agricultural University and the research and experimentation units under the Ministry of Agriculture are at present working on a general cooperation agreement.

There will be an international evaluation of Danish agricultural research in 1991 and 1992.

In the area of fisheries work will continue in two areas: further strengthening basic R & D, and experimental fishery.



## **Trade and Industry and the Technological Infrastructure**

The drop in appropriations to these areas is a direct result of the Government's wish to provide a new foundation of capital for the business enterprise sector by reducing company tax. This should make it possible for Danish companies themselves to initiate R & D independently and without state funding.

The present decline in the level of budget appropriations for industrial promotion initiatives should be seen in the context of the Government's ongoing efforts to create a favourable economic climate for the R & D activities of trade and industry in Denmark. These efforts include low business taxes, a low level of inflation and a stable framework for industrial economy. The decline should also be regarded as an integrated part of Government policy for a general reduction of state subsidies to the business sector in the EC; this policy includes promoting equal competition. The position of the Danish Government is that state subsidy to this sector should be reduced and that it should also be temporary and degressive. The purposes for which state subsidy is available must be made very clear: first and foremost for promoting development in the less prosperous regions, for research and development and for developing small and medium size enterprises.

The Government finds that in the period just before the Single Market becomes a reality, many benefits are accruing to trade and industry in Denmark partly due to increased growth in Europe and by participation in European R & D. The Government finds that these initiatives conducted under the auspices of the EC are of great value as they promote the development of trade and industry on a common European basis.

However, there will still be a need for public efforts in order to promote R & D in the business sector. These efforts will have to be aimed at establishing good, stable, general conditions and concentrating on developing the areas of business and resources that can lead to industrial growth. A good business climate that stimulates increased growth in the business enterprise sector in Denmark can only be created through a goal-oriented and long-term process. The objective is to make it attractive for both Danish and foreign firms to operate in Denmark which means that implementing R & D activi-



ties, and exploiting the results, must lead to growth in the Danish economy.

By appointing the Industry and Trade Development Council, the Government laid the ground for a cohesive and coordinated survey of development and competition in the business enterprise sector, including conditions for promoting R & D in the private sector. There are a number of conditions that influence the incentive of the business sector to conduct R & D: the technological infrastructure; promoting knowledge about technology, management and the market; promoting the adjustment to new conditions for competition such as consideration for the environment; promoting appropriate development in the areas of the infrastructure, education and training and the capital market and in the general conditions for the business sector as a whole, for instance taxation.

The Industry and Trade Development Council has not yet completed its deliberations regarding proposals for future areas where efforts could be made to further promote industry. However, a number of areas where some efforts have been made, also in the area of R & D, have already been identified: productivity development, improving and extending education and training as well as in-service training, a number of connected areas of industry and resources such as food technology, environmental technology, transport and logistical areas such as the maritime sector, the medicine/health area and the area of house building. The special potentials present in the Danish service sector should be pointed out as should the special problems caused by the structure of Danish industry: the many small and medium size enterprises and the problems having to do with financing and R & D encountered by the new innovative companies and initiators.

Coordinated political efforts to promote conditions for competition and development in the business enterprise sector should be made in those areas that show a potential for creating growth and development. It is therefore an important task for R & D policy to coordinate measures with the areas identified by business policy as being areas of growth and development. The purpose is to ensure that cohesive and coordinated efforts can be made to promote growth and development, efforts that are broadly market and internationally based.



**Government's  
R & D Programme:  
Status for 1990-91**





The following is an account of major R & D activities adopted or completed in the period from 1990 to 1991.

## **Concentration and Priorities**

### *Concentration in Areas under the Ministry of Education*

It has been decided to amalgamate several university departments in connection with the implementation of a free faculty experiment in the natural sciences at the University of Aarhus which will leave it with six departments. It has also been decided to reduce the number of departments at the Royal Danish School of Educational Studies from 15 to 7.

The Dental College in Copenhagen is to concentrate the present 13 departments into two large departments when the College is integrated into the Faculty of Medicine at the University of Copenhagen.

### *Concentration and Boosting of the Technological Service Network under the Ministry of Industry*

The Ministry of Industry has continued to concentrate and boost the technological service network. The goal is to gather the various activities into about ten large institutions with sufficient resources and professional competence to be able to offer efficient support to development efforts in the business enterprise sector. It is expected that structural adjustments will largely have been completed in the course of 1991.

### *The Ministry of Agriculture: Research in the Areas of Dairies and Building*

The Ministry of Agriculture closed the Government Dairy Research Institute on 1 July 1990 as part of the Government's plan for cutting down on bureaucracy. While a great deal of research in this area will now be the responsibility of the business sector, more basic dairy research will be continued in a newly established institute of dairy research at the Royal Veterinary and Agricultural University.

In 1991 research into agricultural buildings has also been concentrated as the agricultural section of the Danish Building Research Institute (Ministry of Housing) has been transferred to the National Institute of Agricultural Engineering.



*The Ministry of Fisheries: Research reorganized and concentrated*

Some of the institutions formerly under the Ministry of Fisheries have now been integrated into the new, large institution under the Danish Academy of Technical Sciences, DIFTA (the Danish Institute of Fisheries, Technology and Aquaculture). The position of the Division of Freshwater Ecology in Silkeborg was boosted when it achieved the status of an independent government sector research institution. The appointment of the Advisory Research Committee of the Ministry of Fisheries and the external professional groups appointed for each institute serve to strengthen consultancy and control which are coordinated in the new research secretariat of the Ministry.

*Amalgamations in the Area of the Ministry of the Environment*

The Wildlife Ecology Station has been put under the National Environmental Research Institute as the Division of Flora and Fauna Ecology.

From January 1, 1991, the Danish Geological Survey has a new structure leading to greater inter-disciplinary problem solving, increased internationalization and increased efficiency. The future basic structure will consist of 7 research units and three research and service units.

*The Ministry of Labour: Coordination and Priorities*

On February 1, 1991, it was decided to establish the Advisory Research Committee of the Ministry of Labour. The objectives of the committee are

- to ensure a comprehensive view and coordination of labour-market research and its border areas both nationally and internationally
- to improve the quality of the research initiated by the Ministry of Labour
- to promote the degree of application of scientific evaluations of trends on the labour market, and
- to improve the interaction between researchers and the central administration.



#### *The Danish National Laboratory at Risø*

In 1990 the organizational structure of the Danish National Laboratory at Risø, a part of the Ministry of Energy, was re-organized and concentrated. This has meant that the structure of Risø, which was essentially a structure into divisions organized according to the basic categories of natural and technical science, has progressed to a structure adapted to the technological perspectives of research done at Risø. As a result of this R & D has been concentrated on strategic areas within energy, environment and materials research.

#### *The Danish Centre for Atmospheric Research (DCAR)*

The Danish Centre of Atmospheric Research was set up in the spring of 1990 in the wake of the international evaluation of environmental research in Denmark that took place in 1988. DCAR is a centre consisting of six groups of researchers from the universities, the government sector research institutions and private firms. Each of the six groups does research in its own field and taken as a whole, this research can chart the environmental impact of pollution. The primary objective of the Centre is to coordinate research in the area and then to formulate a large-scale research programme for atmospheric research making it different from other centres which are often created as part of a research programme. In January 1991 the Centre entered into an agreement on cooperation with the environmental institute at the Joint Research Centre, Commission of the EC, that opens the possibility for DCAR and the EC environmental institute to exchange ideas, staff and equipment.

#### *The Centre for Advanced Technology (CAT)*

The Centre for Advanced Technology is a fund set up by Risø National Laboratory, the National Environmental Research Institute and Roskilde University. The Centre is a research park established with a view to putting both large and small enterprises in direct contact with research results thus facilitating savings in product development and ensuring the enterprises a place in the front line of technological development. Companies can rent a place at the centre with an R & D group. Being attached to the centre means easy access to knowledge and advanced facilities for experimentation and construc-



tion (with students, researchers, experimental equipment, research libraries and other research facilities).

## **High Priority Research Areas**

### *Biotechnology*

DKK 456m has been earmarked for biotechnological research in the period 1991 to 1995. The programme will take its point of departure in and further develop the experiences and recommendations in the midway evaluation of the 1987-90 biotechnology programme.

The programme appropriations will be gradually cut down during the period as the research is expected to increasingly become anchored in the participating institutions. Annual appropriations will fall from DKK 114m in 1991 to DKK 68m in 1995.

The programme will be administered by the Natural Science Research Council, the Health Science Research Council, the Agricultural and Veterinary Research Council and the Council for Technical Research. Following a process of advertisements and applications received, the Councils have decided to establish 11 centres and 2 minor framework programmes. In 1991 the appropriations for a centre is between DKK 6.8m and DKK 13.7m, and DKK 1.7m for a framework programme.

Expenses for completing Ph.D studies started under the previous programme, but which really belong outside of the new centres from the point of view of content, will be met from programme funds.

At the start of the programme the Research Councils laid down guidelines for evaluating the programme in the final phase. There are, moreover, specific requirements as to the dissemination function of the centres to ensure that the research benefits the business enterprise sector and society in general.

The principle of multi-annual block grants has been carried over from the previous programme where joint financial control in each centre has resulted in efficient utilization of resources.

### *Environmental Research*

A coordinated, strategic environmental research programme for 1992-96 is at present being planned. Although strategic, which means use-oriented, the programme will be based on the criteria and



methods of basic research. The objective is for the results and competence achieved to be utilized when strategies are selected, when the effects of politically selected control instruments are being evaluated and in any subsequent development of commercial methods and products in the business enterprise sector.

The programme will be coordinated by virtue of the fact that its main elements are to intensify cross-ministerial coordination of environmental research. Coordination with other national research programmes is a criterion when selecting areas of research and the programme will also be clearly related to international programmes of research.

Priorities are made in the programme by choosing a limited number of areas where efforts are to be made thus concentrating research resources on a couple of selected areas where Danish research is of particular strategic importance or is especially competent. Areas where Denmark is distinguished as having internationally strong research environments are chosen.

A significant proportion of the activities of the programme is to be carried out in the form of coordinated actions including centres, networks and framework appropriations. The following possible sub-areas have been proposed:

- atmosphere and climate
- society and culture
- groundwater - a resource
- coastal regions, watercourses and lakes and the inland Danish waterways - resource and recipient
- the surface of the earth/ the upper soil strata - resource and recipient
- the effect of environmental impact on ecosystems, in particular the effects of environmentally hostile substances
- human sub-programme.

The Ministry of Health has drawn up a long-term research programme for environmental medicine and has established a so-called centre without walls for research in environmental medicine.



### *Arctic Research and Climate Research*

In order to maintain and strengthen the position of Denmark in the 4 year European Science Foundation Greenland Icecore Project (GRIP), and in polar and climate research in general, in 1991 the Ministry of Education and Research has set aside an extra appropriation of DKK 10m over a 5 year period (1991-95).

The funds are to be used for two purposes: building a cold store for the icecore bored out of the ice cap in Greenland and for developing research activities in connection with the GRIP icecore. Storing the icecore on Danish territory will give Denmark certain advantages in connection with the scientific analyses.

### *Food Technology*

In 1990 an R & D programme was initiated in the area of food technology with the aim of consolidating and boosting the position of the Danish food industry on the international market.

There is a total of DKK 525m in programme funds available for the period 1991 to 1994; DKK 200m of this sum comes from the Ministry of Industry, at least DKK 175m from the Ministry of Agriculture and DKK 150m from the Ministry of Education and Research. As of 1 January 1991, three centres were established using the funds from the Ministry of Education and Research: two centres for food research, one each at the Royal Veterinary and Agricultural University and the Technical University of Denmark, and one centre for lactic bacteria at the Technical University of Denmark. One framework programme was also set up for market-controlled process and product innovation at the Technical University of Denmark. Cooperation projects carried out by binding cooperation on selected, large R & D assignments are a cornerstone in the part of the programme financed by the Ministries of Industry and Agriculture. The participants may be business enterprises, technological service institutions as well as researchers and research institutions in the public sector. The enterprises that take part are normally expected to meet approximately 50% of the costs.



### *The Centre for Micro-electronics*

In 1990 a new centre for micro-electronic research was established at the Technical University of Denmark. At the head of the centre is a board of nine, from among whom the Minister for Education and Research appoints a Chairman. The Minister also appoints four of the board members on the basis of recommendations from the Council of Technology, the Danish Academy of Technical Sciences (ATV), the Danish Council for Technical Research and the Association of Electronics Manufacturers. The other four members come from the Technical University of Denmark.

It is the task of the centre to contribute to a sorely needed intensification of R & D in the area of micro-electronics in Denmark in close cooperation with Danish enterprises which have long-term R & D interests in the area.

### *The Informatics and Information Technology Programme*

PIFT, a programme for informatics and information technology, has been set up with the objective of carrying out strategic research with a view to strengthening Danish research environments and promoting cooperation about the information technology of the future between these environments and the business enterprise sector. DKK 180m has been earmarked for 1991 to 1994: the funds come from the Research Councils for Natural Science, Agriculture and Veterinary Science and Technical Science which coordinate their use and cooperate on activities in order to ensure that they achieve sufficient dimensions and are inter-disciplinary in nature.

After a pre-qualification round, final applications have been invited for approximately 15 large research projects; each project will receive between DKK 2m and DKK 5m in 1991 and this sum will increase in the following years.

## **Completed Programmes**

### *Completion of the NPO Research Programme*

On May 31, 1985 the Danish Parliament adopted the »Resolution to reduce pollution caused by nutrient salts and organic substances«.

On the same occasion it was decided to initiate a research programme the results of which would be used as tools in future decisions in this area.



The Parliament appropriated DKK 50m for this purpose and resolved that the research programme should run for five years from 1986 to 1990. The National Agency of Environmental Protection was charged with supervising the programme which was called the NPo (Nitrogen, Phosphorus, Organic substances) programme.

Proposals for projects having been invited, a list of priorities was drawn up on the basis of a comprehensive evaluation of the aims of the programme. 60 projects within the areas of soil-air, ground water, water courses, lakes and marine areas were selected. Emphasis has been laid on inter-disciplinary activity and cooperation and on achieving the greatest degree of cooperation with on-going research. 50% of the funds went to university departments, 35% to government sector research institutions under the Ministries of Agriculture and the Environment while the rest was granted to the Danish Academy of Technical Sciences and other private research institutions. In all more than 100 researchers and 26 institutions have been involved.

It is estimated that c. 20% of the funds have been spent on basic research and c. 10% on the management of projects and dissemination of their results by the National Agency of Environmental Protection by issuing reports and holding meetings and the like. Partial support has been granted to 6 Ph.D. programmes.

At the beginning of 1991 the National Agency of Environmental Protection issued both a Danish/English language report and 56 project reports about the NPo research programme. At the same time the results and the model tools developed have formed an important technical basis for the Agency's report on the plan for the aquatic environment, »Environmental impacts of nutrient emissions in Denmark«.

The results were evaluated on the national level at a consensus conference in January 1991 on nitrogen, phosphorus and organic substances in the land and aquatic environment. In addition an international NPo conference was held in May 1991 where the results were presented to international researchers.

Parts of the NPo research programme were included in the European environmental research programme in 1988. The results of the programme concerning nitrogen leaching in arable soil and root zone modelling have attracted European attention and the Commission of the EC have asked for a presentation of these models with a view to further developing them under the auspices of the EC.



### *Completion of the Research for Technological Development Programme*

"The Research for Technological Development Programme" was initiated in 1985 as a 5 year programme with a total budget of DKK 293m divided over 7 sub-programmes of varying dimensions. The programme had three objectives: to produce new knowledge to illustrate long-term technological potentials in the business enterprise sector; to introduce new knowledge from other countries; and finally to train researchers with a view to employment in the private sector.

After some initial problems - not least with the first selection of projects - the programme entered a systematically controlled course where during the second and third years, the Research Councils largely decided the programmes that were to be carried out together with their economic framework.

In spite of there being no general shortage of jobs for researchers in this area, many researchers have been trained through these projects. It is estimated that over 100, or more than half of these researchers, have completed a Ph.D.

Another important element in the programme was disseminating the research results which mostly took place in the form of direct cooperation between the enterprises and the institutions via the projects which received support. However, there is no cooperation of any kind reported on almost a quarter of the projects.

In 1986 and again in 1989 Research for Technological Development seminars were held where on both occasions over 100 selected projects were presented to the circle of users and other interested parties.

At the turn of the year 1987/88 a database was set up where all the projects which enjoy support are registered so as to give the central information about the course of the project including a short presentation of its content, its progress and the results achieved. The database can be searched in via terminals.

The third objective of the programme was to accumulate knowledge of international developments in the area in question. The Research Councils have promoted this objective i.a. by providing extremely favourable conditions for inviting guest researchers and by providing support for study trips and attendance at congresses abroad. The programme has functioned extremely well on this point.



The authorities responsible for the projects are of the opinion that the programme has had an innovative effect which has improved their chances of, for instance, taking part in the new, special research programmes (biotechnology, materials technology, food technology and informatics). Through the programme the users have i.a. been introduced to knowledge about developments abroad, knowledge that could be of importance in the long term.

Finally the Research for Technological Development Programme, the first large-scale programme under the auspices of the Research Councils, has provided them with valuable experience of cooperation across the boundaries of the Councils and support for large, long-term research activities.

#### *Completion of the Research Programme in Biotechnology, 1987-1990*

In 1987 the biotechnological research programme was started up as a 4 year programme with a total budget of DKK 475m of which DKK 385m was set aside for biotechnological research centres, DKK 20m for technology evaluation and information and DKK 70m for education and training and recruitment of researchers.

The aim of the programme was to »strengthen basic biotechnological research« while simultaneously »ensuring more applied research in areas of social importance«. Significant emphasis was also laid on education and training, recruitment and training of researchers in this area.

14 research centres of quite different sizes were set up under the programme following two rounds of applications. Most of these centres have had programmes running for three years while some have had 2 years and 4 months in which to work.

In the autumn of 1989 there was a midway evaluation of the programme, one of the most important conclusions of which was that the centre structure has indeed provided the flexibility and institutional cooperation that was one of the main objectives of the programme.

The Ph.D. programme included extending courses in biotechnology and increasing the numbers of graduates by awarding completion scholarships. At the biotechnological research centres about 340 researchers completed a Ph.D.; of these about 170 were paid from programme funds. Some of the programmes experienced recruitment problems.



Disseminating research results was an important part of the programme. To this end, each year the centres held public information meetings aimed at industry in particular. In addition the research programme has been presented in a general information folder and at two exhibitions in connection with the 5th European Congress on Biotechnology.

In 1988 the biotechnology projects were included as a sub-base in DANDOK, the Danish research database, and in BIOREP, the EC's experimental database; there is open access for on-line searching to both of these. The database was last updated in 1990.

The accumulation of international knowledge was promoted by providing particularly good conditions for inviting guest researchers and by supporting study trips and participation in congresses.

In general the management of the centres and those responsible for the projects are of the opinion that the programme has improved and extended inter-disciplinary cooperation and in the long term strengthened Danish biotechnological research. Danish industry has also stated that the centres have become important collaborators.

## **Stimulation of R & D for the Benefit of the Business Enterprise Sector**

### *Act on the Promotion of Business Enterprise*

In June 1990 the Danish Parliament adopted a law to promote business enterprise: the Act came into force on January 1, 1991. In connection with this, the Industry and Trade Development Council was set up. It consists of 19 members representing commercial, local, regional, technological, financial and social expertise.

The main task of the Council is to advise the Government on matters of essential importance to production and for the development of business in general. It is the intention that the Council should play a central role in coordinating initiatives aimed at the business enterprise sector.



### *Projects on Industrial Cooperation*

In order to encourage Danish companies to cooperate on commercial research and development, the Ministry of Industry has set up a scheme whereby binding and long-term R & D cooperation between at least two private companies can be partially financed. Centres of expertise can also participate either as partners or as sub-contractors. Projects thus initiated will very often be the first phase in a multi-phase cooperation project with a duration of 3 to 5 years. Research and service institutions' participation in international projects on behalf of private companies and in particular participation in EC and EUREKA projects can also be partially financed. DKK 180m is the budget appropriation in 1991 for these purposes.

### *Making better use of Advanced Equipment*

At the end of 1990 the Ministry of Industry set a new initiative in motion with the aim of improving the competitiveness of business enterprises by ensuring that the resources already present in industry are better exploited. In the initiative the focus is on the advanced equipment already at the disposal of the enterprises because, despite considerable investments in new production equipment in recent years, significant growth in the results achieved has not ensued.

The initiative is mainly aimed at measuring productivity, projects in progress in the enterprises, and the dissemination of information and knowledge. From a framework budget of DKK 50m, grants will be given for the initiative in the period 1990 to 1992.

### *New raw Materials Strategy in Greenland*

As part of a new strategy in the area of raw materials, the Ministry of Energy has taken a number of initiatives to attract the international oil and mining industry to invest in investigating and exploiting raw materials in Greenland. This includes boosting applied geological research in Greenland conducted by GGU, the Geological Survey of Greenland as well as improving and extending GGU's communication both of data relevant to raw materials and of its research results to industry with the aid of modern technology.



*Tax Exemptions for foreign Researchers  
with special Research Assignments in Denmark*

The Government will investigate the possibility of granting tax exemptions to foreign experts including researchers in order to make it easier to attract key figures from abroad to Denmark.

*Tax Exemptions for Companies participating  
in international Research Cooperation*

In its Bill on the alteration of Tax Assessment (Research and Development), the Government has put forward a proposal to enable business enterprises to deduct 125% of the expenses they incur when participating in a number of international research programmes. The deduction is to encourage Danish firms to participate in EUREKA's research projects, in programmes under the Nordic Industrial Fund, in EC programmes in accordance with the framework programme for the Community's activities in the field of research and technological development, and in the EC's THERMIE programme. In other words the firms that participate receive an award of a kind for taking part in joint Nordic and joint European research projects. The Ministry of Industry has estimated that the annual cost to Danish firms for participating in the projects covered by the Bill will be approximately DKK 300m in the period 1991 to 1993. Total annual extra deductions are thus expected to be approximately DKK 75m and the loss of tax yield approximately DKK 30m.

## **Internationalization**

### *START*

As part of the Government's endeavours to increase Danish participation in and benefit from international research cooperation, the Ministry of Education and Research has initiated a START programme which is aimed at public research institutions, not least universities and institutions of higher learning. The programme is intended to contribute to increasing the number of research projects involving cooperation with leading international partners.

Programme funds are granted in connection with the participation of Danish research environments in formulating and planning international research projects with Danish participation. The programme



will run until the end of 1992 and the support granted will be in the order of DKK 50,000 to 200,000 per activity. A total of DKK 8m has been set aside for the programme which will be administered by the Research Councils.

### *EC*

In continuation of the adoption of the third framework programme for research and technological development in the EC for 1990 to 1994, the EC Commission has proposed 15 special programmes that put the framework programme into practice.

The special programmes include research in the six priority areas of the framework programme: information and communication technology, industrial and materials technology, environment, life science and biotechnology, energy and human resources.

In addition to this a proposal has been put forward for central action for communicating and utilizing experiences and results from the special programmes for which 1% of approximately DKK 46bn, the total budget of the framework programme, has been earmarked.

Denmark has made an active contribution to the negotiations about the new special programmes thanks in part to the effectively coordinated national structure with contributions from hearings, reference groups, committee members and the like. This has meant that such elements as basic research, training researchers and quality have been granted a special position in these programmes. In addition Danish influence has made itself felt in specific areas of research such as in the programmes on bio-medicine and health, industrial and materials technology (including the working environment), and the programmes on telematics systems within long distance teaching, medicine, transport and electronic language processing.

For a number of years now, Denmark has been receiving approximately 3.5% of the EC's research funds, a percentage that fell in 1989 as the most important funds offered that year were in areas where Denmark as yet has no particular expertise. Provisional figures for 1990 suggest a significant increase in relation to 1989.

However, the most important benefits that accrue from research cooperation within the EC come from goal-oriented, cross-border cooperation and the mutual exchange of knowledge derived from



this cooperation where Danish companies and institutions participate.

The relationship between the R & D programmes of the EC and Denmark is stated in Annex C. If the programme funds and the basic funds are examined together, it will be seen that Danish and European programmes have to a certain extent been synchronized. This does not mean that the EC programmes are being copied on the national level but rather that the necessary basis of dimensions and quality has been built up in order for Danish research environments to be competitive participants in the EC's programmes.

As part of the Single Market Initiative of the Ministry of Industry, funds have been set aside for promoting the participation of Danish companies and technological service institutions in the EC's programmes for research and technological development (the Research for Technological Development Programme). Grants are given for carrying out feasibility studies where the companies can identify possible projects and cooperation partners within the terms of the framework programme. The programme runs from 1989 to 1991 and DKK 12m has been set aside for feasibility studies.

#### *Coordinating European Research Initiatives*

On the initiative of the Italian and the Danish Ministers for Research, in 1990 Ministers for Research from the EC member states informally discussed the possible coordination of European research activities within, for instance, the EC, EUREKA, ESA, ESO, CERN and EMBL.

The general objective of a European strategy in this area is better utilization of resources, both national and international, in the fields of science and technology. Not least in the light of developments in Central and Eastern Europe, this would in the first instance be on the European level, but later on the global level.

#### *EUREKA*

The Ministry of Industry contributes to strengthening Danish participation in international programmes of research and technological development among them EUREKA. The aim of EUREKA is to improve the global competitiveness of the European business enter-



prise sector in the use of new technology in products, processes, systems and services for civilian use.

For this reason, since 1986 the Ministry of Industry has run this scheme which is financed under industrial cooperation projects. In 1990 approximately DKK 84m was used for this purpose and in the coming years the level of expenditure is expected to be about DKK 60m. While private companies can have their participation in EUREKA financed by up to 50% of their costs, the research institutions can have their additional expenditure fully covered.

## **Boosting basic Research**

### *The Danish Fund for Basic Research*

The Act on the Danish Fund for Basic Research, adopted in May 1991 following a Government proposal, lays down that a fund with a basic capital of DKK 2bn shall be set up with a view to long-term strengthening of the development potential of Danish research. This sum of money, gained from privatization, is to be transferred to the fund by the state. A yearly amount of c. DKK 200m, the yield from the Fund's means, is to be used for unique research in the international class.

The fund is to be managed by an independent Board and is also to be independent of state financing and the established world of research. It is up to the fund itself to decide how the means should be used in order to best encourage Danish basic research and to facilitate basic research activities on the highest international level.

The establishment of the Danish Fund for Basic Research is an important element in official industrial policy as it is the objective to promote the long-term competitiveness of the Danish economy.

### *Special Appropriation for basic Research*

The 1991 Budget contains a non-recurrent appropriation of DKK 60m for strengthening basic research at the institutions of higher education.

In allocating the money, attention has been paid to the individual institution's on-going activities in the area of basic research, the ability of the institutions to attract external research funds in 1989 and the number of Ph.D. students who completed their programmes in 1987-89. These achievement aims have been balanced against the institutions' yearly, ordinary budget appropriations for research.



As the appropriation has only been distributed in general terms, the institutions will be able to encourage areas that have a high priority in accordance with their own plans.

#### *Research Council Professorships*

In 1990 the six national Research Councils had the opportunity of awarding 5 year professorships (Research Council professors) which can be placed at the institutions of higher education, the government sector research institutions and private research laboratories. These professorships are intended to provide specially talented researchers with better research conditions for a period of 5 years.

The scheme was used in 1990: the Research Council for the Humanities awarded two research professorships and the Health Science Research Council 5 (of which 3 are privately financed). In 1991 the Health Science Research Council and the Agricultural and Veterinary Research Council have each announced one professorship.

#### *Professor Planning*

The 1990 Budget contains an appropriation for a pool of 30 man-years without any specified description with a view to establishing ordinary professorships at the institutions of higher education in the period from 1990 to 1993. This is part of the endeavours to enhance quality, improve promotion prospects and strengthen professional management. In 1990 and 1991 the pool was used to ensure the permanent appointment of a number of temporary professors.

## **Training of Researchers**

#### *The Danish Research Academy*

In last year's research programme, the Government stated that researcher training would be stepped up and that the Danish Research Academy would have a central role in the close and intensified cooperation between the universities, other public research institutions and the research units of private enterprises.

As a consequence, and following a hearing, it was decided to continue the Danish Research Academy. Apart from its central role in



facilitating cooperation between research environments, the Academy has contributed to enhancing the quality of researcher training and to making the Danish researcher training system as a whole visible.

The quantity has also been significantly increased; as can be seen from the table below, the number of Ph.D. students enrolled between 1985 and 1990 has tripled. Another welcome development is the increasingly higher proportion of women enrolled in Ph.D. programmes.

#### Number of Ph.D. students according to year of enrollment

Year of enrollment	Men	Women	Women %	Total	Ph.D. degrees awarded
1985	172	39	18	211	( )
1986	222	69	24	291	(529*)
1987	304	92	24	396	( )
1988	459	177	28	636	237
1989	464	222	32	686	255
1990	516	221	30	737	301

\*) Total Ph.D. production between 1985 and 1987.

Source: The Danish Research Academy.

At the time of writing (March 1991) there are 2,520 Ph.D. students enrolled at universities and institutions of higher education. Because of the sharp rise in enrollments in recent years, it is expected that the annual number of completed Ph.D.s will rise to about 500 in the course of the next few years.

#### *Experiment at the Faculty of Natural Science at the University of Aarhus*

The Faculty of Natural Science at the University of Aarhus has, as an experiment, admitted the first Ph.D. students to a more formalized and intensive research training programme that starts at the end of the fourth year of study. Total time of study for the Ph.D. will be 8 years. The aim of the programme is i.a. to see if it is possible to produce younger Ph.D.'s.



The following table shows the results of the experiments conducted in the laboratory. The data are presented in the form of a table, and the results are discussed in the text.

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# Annexes to the Programme





## Annex A

### **Developments in Danish R & D and Comparisons with other Countries**

Danish research and development (R & D) does not differ markedly in its composition and patterns of financing from that of other small OECD countries. The sum of funds devoted to R & D is relatively low, however, for while the proportion of public funds in relation to GDP is close to the average for the EC, the Danish business enterprise sector conducts relatively little research. This can be explained in essentials by the predominance in Danish industry of branches that have a low research intensity and of many small and medium-sized enterprises. Despite this, a number of small and middle-sized enterprises have a pronounced capacity for innovation.

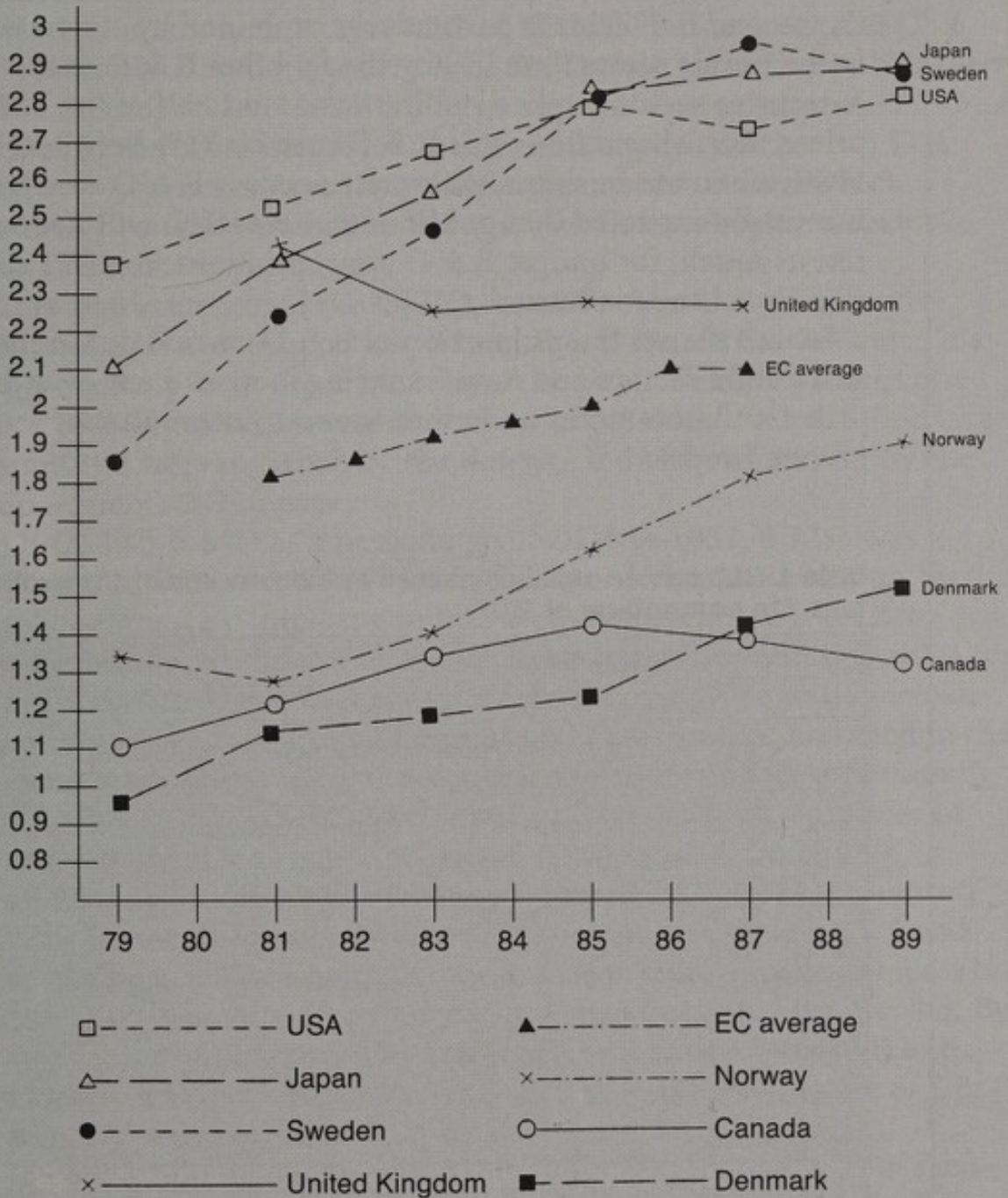
Danish industry is relatively weakly represented in advanced technological branches but is strongly competitive in a number of low-technological ones. In almost all the OECD countries, it is precisely the high-technological branches that are characterized by rising shares in employment, production and exports, while the opposite is so for the low-technological branches: a structural problem for Danish industry, that calls for considerable ability to change.

#### *Size and Composition of total Danish R & D*

During the 1980s, resources devoted to research rose more rapidly in Denmark than in a number of other countries (see Figure 1); in 1979, R & D expenditures in Denmark were only 0.96% of the gross domestic product (GDP), but in 1989 this figure had risen to 1.53%; during the 1980s, particularly in the business enterprise sector, R & D rose, from 0.4% (1979) to 0.84% in 1989. Denmark devotes relatively fewer resources to R & D than do other countries with which comparison is normal. Using almost DKK 12bn in 1989 that corresponded to 1.53% of GDP, Denmark lay after the leaders - Sweden, the Federal Republic of Germany, Japan and the USA - which used between 2.7% and 2.9% of GDP on R & D.



Figure 1. Developments in R&D expenditures as % of GDP 1979-1989 <sup>1)</sup>



<sup>1)</sup> If the figures given are not for 1989, they are from the most recently available information. For a number of countries the 1989 figures are based on prognoses.

Source: OECD: «Main Science and Technology Indicators 1991:1», Paris 1991.



Figure 1 shows furthermore that R & D expenditures rose sharply in the first half of the 1980s but stagnated in a number of countries in the second half. This is particularly explained by stagnation in R & D in the public sector, but also by the fact that R & D in the business enterprise sector levelled out in the second half of the 1980s. In fixed prices, Danish public-sector R & D rose by 11% between 1987 and 1989, when the business enterprise sector's R & D rose by only 8.5%. It must be expected that public-sector research will not continue to rise as much, for budget R & D appropriations for 1991 show a slightly falling tendency.

Table 1 shows the proportion of R & D carried out in the private and public sectors and how financing is spread out over the enterprises, public sources and other sources (international sources and private funds).

**Table 1. R&D carried out and financed by industry and by the public sector, 1989 <sup>1)</sup> in percentage of GDP.**

	Research carried out in % of GDP		Financing in % of GDP			
	Enter- prises	Public institutions	Enter- prises	Public sources	Private sources and abroad	Total
USA	1.99	0.81	1.37	1.37	0.06	2.80
Japan	1.99	0.73	2.04	0.49	0.19	2.72
EC average	1.39	0.71	1.09	0.88	0.13	2.10
Sweden	1.90	0.94	1.70	1.06	0.09	2.84
United Kingdom	1.46	0.74	1.13	0.80	0.27	2.20
Norway	1.17	0.74	0.92	0.92	0.07	1.91
<b>Denmark</b>	<b>0.84</b>	<b>0.69</b>	<b>0.72</b>	<b>0.69</b>	<b>0.12</b>	<b>1.53</b>
Canada	0.74	0.59	0.56	0.59	0.18	1.33

<sup>1)</sup> If the figures given are not for 1989, they are from the most recently available information. For a number of countries the 1989 figures are based on prognoses.

Source: OECD: »Main Science and Technology Indicators 1991:1«, Paris 1991.



In the larger OECD countries (the USA, Japan and the Federal Republic of Germany) and in Sweden, R & D in the business enterprise sector amounts to over 65% of the total but in 1989 R & D in this sector in Denmark was 55% of the Danish total. The public sector in Denmark accounts for almost as great a proportion of R & D as it does in the other countries in this comparison. Danish R & D is first and foremost lower than that in the countries with which we normally compare ourselves because the Danish business sector's R & D is relatively modest.

It is characteristic of the OECD countries that the public sector finances a greater proportion of total R & D than it carries out. This is particularly so in the USA, where the public sector finances one third of the business enterprise sector's R & D: this is because a large part of the relevant work by the defense industry is paid for by the Department of Defense.

Of Danish R & D as a percentage of GDP in 1989, 0.72% was financed privately and 0.69% was financed, as appropriations, by the public sector. In comparing public-sector financing of R & D, it should be kept in mind that as the taxation and depreciation rules for R & D investments differ from country to country, comparison can be difficult as any national losses of tax yields are not included in the statement in Table 1. The public-sector financed R & D in Denmark (being 0.69% of GDP) is still somewhat lower than in a number of the other countries (in 1989 between 0.9% and 1.4% of GDP).

Of Danish R & D, a relatively large part (0.12% GDP) is financed by private funds or international sources and the like. In 1979 and 1989 foreign funds financed 1.7% and 3.1% respectively, not least because EC research appropriations rose sharply during this period. By way of comparison, international sources finance 1.6%, 2.3% and 1.5% of R & D in Sweden, Holland and the Federal Republic of Germany respectively.

In conclusion, it can be stated that, with respect to R & D in Denmark, its composition and financing does not differ markedly from that in the other smaller OECD countries. In relation to national GDP, it is internationally relatively modest, but during the 1980s expenditures on R & D rose more rapidly than in a number of other countries.



### *Public-sector R & D*

In 1989, the public sector conducted R & D costing almost DKK 5.5bn; in terms of GDP, it was 0.69%, as against 0.48% in 1979. This rise from 1979 to 1989 is thus somewhat greater than the average for the OECD countries.

The OECD classifies public-sector R & D in three main groups: »universities and institutions of higher education, government research, and private, non-commercial institutions (for example the Danish Cancer Society)«. Table 2 provides a survey of the division of research between these three sectors in 1989.

**Table 2. Relative distribution of public sector R&D between universities, government sector research institutions and private, non-commercial institutions; in 1989 <sup>1)</sup>; in percentages.**

	Universities and institutions of higher education	Govt. sector research institutions	Private, non- commercial- institutions	Total
USA	52	39	9	100
Japan	48	35	17	100
EC average	48	47	5	100
United Kingdom	43	46	11	100
Sweden	87	13	0	100
Norway	56	42	2	100
<b>Denmark</b>	<b>55</b>	<b>42</b>	<b>3</b>	<b>100</b>
Canada	53	44	3	100

<sup>1)</sup> If the figures given are not for 1989, they are from the most recently available information. For a number of countries the 1989 figures are based on prognoses.

Source: OECD: »Main Science and Technology Indicators 1991:1«, Paris 1991.



Table 2 shows that universities and institutions of higher education typically account for about half the public-sector research, while government sector research accounts for a little less than half; Sweden is an exception, in that much research that elsewhere is done in government sector research institutions is done in universities. In most countries, private non-commercial institutions do only a very small part of public-sector R & D.

For public-sector R & D in Denmark in 1989, universities and institutions of higher education did 55%, government sector research institutions 42% and private institutions 3%; this relative distribution is little different from that of 1979, when it was 54%, 44% and 2% respectively.

#### *Financing public-sector R & D*

For public-sector research institutions during the 1980s, external funding for research<sup>1)</sup> rose much more sharply than did basic budget appropriations: in the 10-year period 1979-89, the two rose by factors of 1.4 and 3.0 respectively. As Table 3 shows, this development is identical for universities and institutions of higher education and for the government sector research institutions.

1. External funding is that part of an institution's funds that is not allocated through its ordinary budget. It can comprise, for example, public funds for a programme or funds from a private or international source.



**Table 3. Indices of developments in basic budget appropriations and external financing at universities and institutions of higher education and at government sector research institutions. 1979 = 100 (1979 prices). 1979-1989.**

	1979	1981	1983	1985	1987	1989
Universities and institutions of higher education	100	109	117	130	152	173
Basic budget appropriations	100	109	115	123	137	143
External financing	100	105	127	167	239	339
Government sector research institutions	100	111	117	125	149	160
Basic budget appropriations	100	111	115	119	136	137
External financing	100	111	127	153	211	266
Aggregated financing	100	110	117	128	151	167
Basic budget appropriations	100	110	115	121	136	141
External financing	100	108	127	160	225	303

In 1989, external financing accounted for 29% of public-sector research, while in 1979 the percentage was 16%. Public funding accounted for almost two-thirds of this financing, while private funds and organizations, Danish enterprises and international sources provided the last third.

Even if the part of public-sector R & D financed externally rose during the 1980s, it is internationally still only modest: in 1987, external financing of university R & D accounted for 23% (rising to 29% in 1989) in Denmark, 35% in Finland, 28% in Norway and 40% in Sweden; in France and the USA the figures were about 50% and about 75% respectively.



### *The Results of scientific Research*

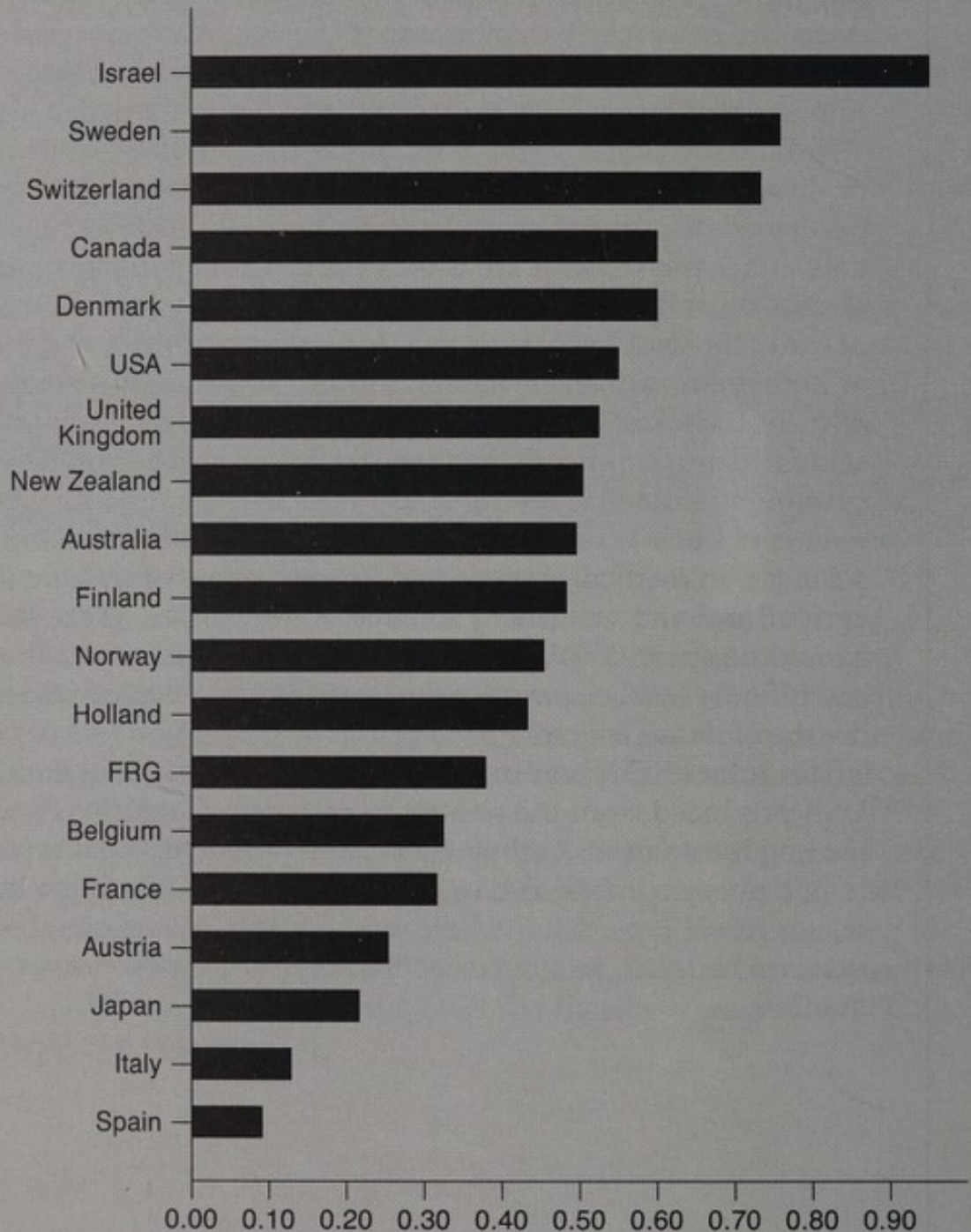
It is far more difficult to assess the results or quality (output) of scientific research than to measure the expenditures used for R & D (input). Because assessing output often calls for qualitative evaluation, making international comparisons is problematic.

In recent years, especially bibliometric data have been used to evaluate output, being expressed in the form of numbers of articles published or number of citations in internationally recognized journals. Bibliometric data are used on the grounds that scientific articles are the most important means of disseminating scientific results, especially those of basic research done at universities and institutions of higher education. In the humanities, social sciences and some parts of technical science, books or reports, rather than articles in scholarly journals are often more important means of disseminating results. Bibliometric methods can thus only be used to evaluate the results of basic research in particular for work in the natural sciences, in medical science and in some areas of technical science, agricultural and veterinary science. Furthermore, great caution should be exercised when using bibliometric data to evaluate interdisciplinary studies, or over short periods of time, or when the degree of detail is great.

The Science Citation Index (SCI) is an international database in the USA produced from the annual registration of articles from 3,200 leading international scholarly journals that employ a referee system: before an article is accepted for publication it is evaluated by one or more experts in its field, and for this reason eventual publication can be taken as a measure that the article possesses a certain quality.



Figure 2. Numbers of SCI articles per 1000 inhabitants, 1981-86.



Source:  
Forskningspolitikk 3-4/1990: »Hvordan står det til med norsk forskning?«. (Research Policy 3-4/1990: »What is the position of Norwegian research?«). NAVF, Oslo 1990.



Figure 2 shows the numbers of SCI articles per 1000 inhabitants between 1981 and 1986. Denmark was fifth, with a figure of 0.6 SCI articles per 1000 inhabitants, being together with Israel, Sweden, Switzerland and Canada among the most active countries in this respect.

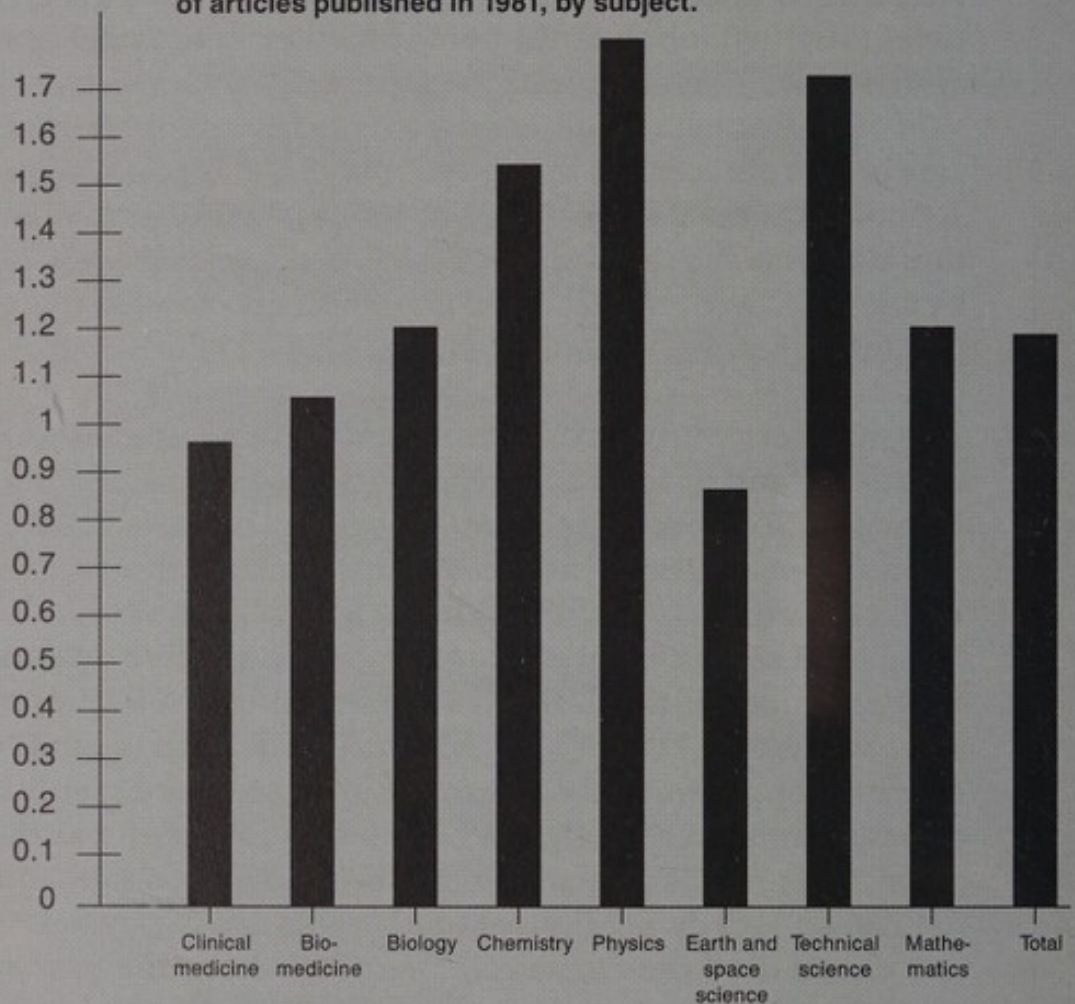
In 1988 Danish researchers accounted for about 0.8% of the articles in this database, a figure that may be compared with the Danish spending on research at universities and institutions of higher education that was the equivalent of 0.5% of all spending for this purpose by the OECD countries; these countries account for the greater part of all international spending on R & D.

The number of times an article is cited is also used as an indicator of its quality and of the research that it reports, this relationship being supposed to be probably a valid measure; but, as a method, it is naturally not without problems and its results should be interpreted with caution.

Figure 3 shows, by area of research, the relative international level of the number of times articles published by Danish researchers in 1981 were cited between 1981 and 1986. A level of citation of 1 (for example, approximately that for clinical medicine) signifies that articles by Danish researchers were cited as frequently as the average for all SCI articles in 1981. The figure shows that in a number of the natural and medical sciences (and especially in physics, technology and chemistry), the Danish figures were above the average. This suggests that Danish research in these fields is of a good international quality.



Figure 3. The relative number of citations in the period 1981-86 of articles published in 1981, by subject.



Source: Calculated on the basis of Tor Noertranders and Tarjei Haaland: »Dansk dynamit. Dansk forsknings internationale status vurderet ud fra bibliometriske indikatorer«. (»Danish dynamite. The international status of Danish research evaluated from bibliometric indicators«). The Danish Council for Research Policy, 1990.

#### *Research done in the Business Enterprise Sector*

Danish industry carries on in general less research than do the industrial sectors in a number of the other countries with which Denmark is usually compared. In many respects this is a problem as investments in R & D should have the effect of renewing industrial production so that enterprises can strengthen their competitive advantages. In 1989, R & D for over DKK 6.5bn was carried out in the



business enterprise sector in Denmark. In this respect industry comprises 1) industrial enterprises, 2) other business (e.g. transportation, building and construction, trade and technical advisory services) and 3) technological service institutes. Their spending on R & D is shown in Table 4.

**Table 4. Business enterprise sector's spending on R&D in 1989.**

	DKK million	Percent
Industrial enterprises	4,858	74
Other business enterprises	1,036	16
Technological service institutes	647	10
Total	6,541	100

Branches of industry differ greatly in spending on R & D in proportion to growth in value added. In Denmark the industries spending most on R & D are medicine, followed by measuring instruments and electronics: their figures are 18.1%, 14.5% and 9.5% respectively of growth in value added. In the machinery and food industries, by contrast, the figures are 4.6% and 1.2% respectively.



**Figure 4. Research intensity in selected branches of industry in 1989 measured in R&D expenditures as percentages of value added.**

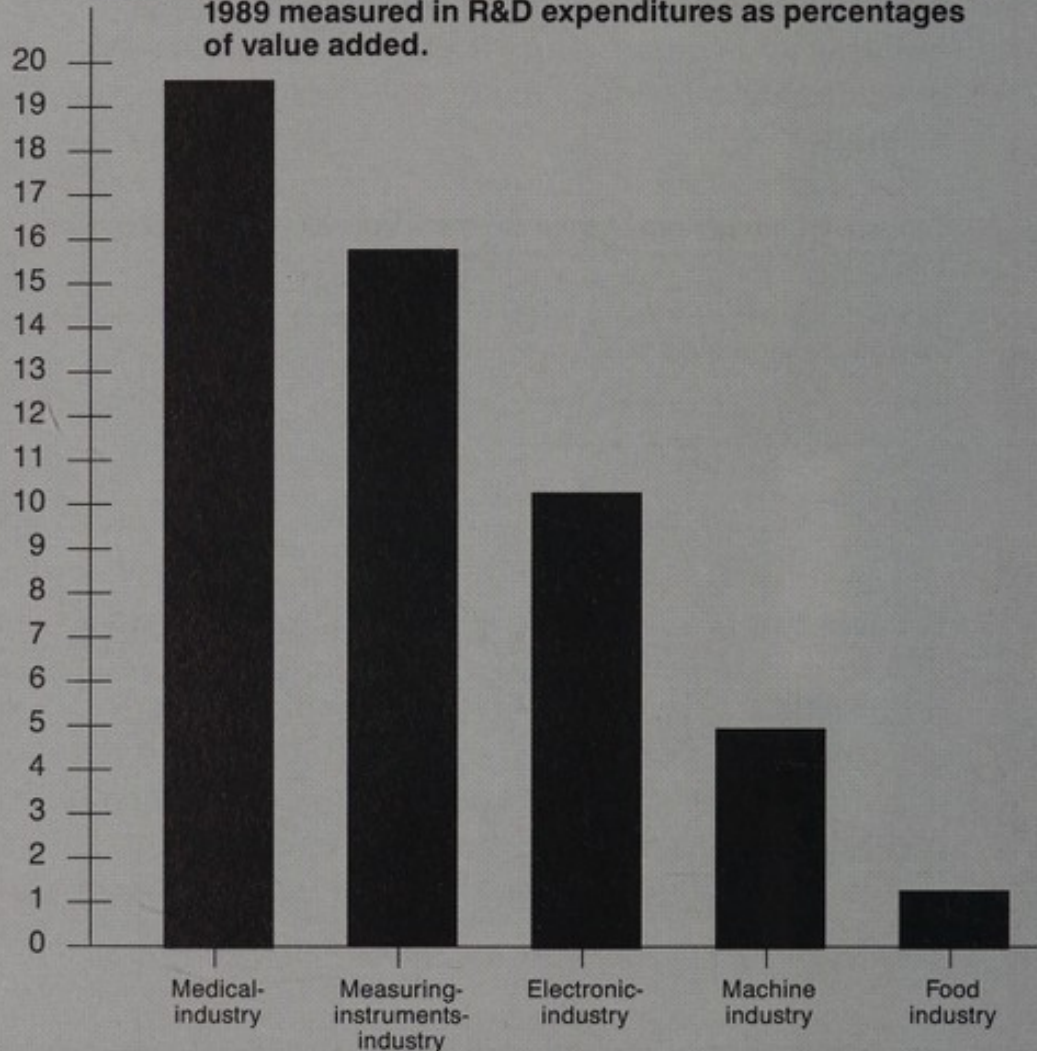


Table 5 shows that research intensity in Danish industry is somewhat lower than in most other countries, being less than half that of either the USA or Sweden.



**Table 5. Research intensity measured as industry's R&D expenditures in relation to growth in value added. 1981 and 1987. In percentages.**

	1981	1987
USA	6.7	8.2
Japan	3.9	5.9
Sweden	5.3	7.8
United Kingdom	4.9	5.0
Norway	2.6	4.0
Finland	2.2	3.7
<b>Denmark</b>	<b>2.5</b>	<b>3.4</b>

Source: The OECD database for R&D statistics.

This low research intensity is due to the branch structure of Danish industry with an over-representation of branches with low research intensity (for instance the food industry) and an under-representation of research intensity branches such as the electronics industry (including telecommunications) and the aviation industry.

However, the branch structure cannot alone explain the low research intensity; the special structure of the business enterprise sector with many small and medium-size enterprises and only a few large enterprises is another and perhaps more important contributory cause. Table 6 contains a comparison between enterprises that carried out research in Denmark and Sweden in 1987.

**Table 6. R&D Spending related to industries classified by numbers of employees. In 1987.**

Number of employees	Shares of total R&D spending		Average number of employees in the group		Average R&D in DKK/employee <sup>1)</sup>	
	Denmark	Sweden	Denmark	Sweden	Denmark	Sweden
50-99	6%	2%	69	75	25,000	43,000
100-499	29%	8%	201	223	24,000	26,000
500-	53%	90%	999	1226	37,000	64,000

<sup>1)</sup> The calculation presumes that the enterprises in each classification that conduct R&D have average numbers of employees equivalent to the average for all enterprises in these classifications.

Source: »Nordisk FoU-statistikk för 1987 och statsbudgetanalys 1989«. Nordisk Industrifond, Oslo 1989. (»Nordic R&D statistics for 1987 and national budget analysis, 1989«. Nordic Industrial Fund, Oslo 1989).



It is evident from Table 6 that research is much more intensely concentrated in larger enterprises in Sweden and, for those employing over 500 people, Swedish enterprises spend much more per employee than do Danish enterprises.

It is highly characteristic that some of the largest Danish enterprises are active in the shipping, food and the construction and housing sectors, none of which is R & D intensive; only a few of them spend money on R & D for strategic purposes. The relatively modest spending by Danish industry on R & D may thus be ascribed both to branch composition and the structure of enterprises.

#### *The Ability of Danish Enterprises to innovate*

There is probably no direct link between what by international standards is a low level of R & D intensity in Danish industry and its ability to innovate: low research intensity is no indication of a lack of innovative skills. R & D is a partial aim for companies' developmental activities, as R & D only indicates the research content in the companies that produce a given product. The process technology by which this takes place is thus excluded from consideration. A number of Danish enterprises devote resources to improving their technological abilities to compete in the form of investments in advanced, high-technological equipment rather than in research of their own. In addition, means other than R & D and new technology, including production planning, industrial design, prototype production and staff training, can be regarded as important activities in the enterprises endeavouring to ensure technological renewal.

The particular structure of Danish industry that comprises many small and medium-sized, and a few large, enterprises, crucially affects the nature of industrial innovation. The particular technological strength of Danish industry lies in its ability constantly to improve the technology of all phases of production, but this includes only a few radical innovations. Even so, the sum of many small innovations can be very considerable. A large part of the internal development of the small and medium-sized Danish companies occurs primarily not in connection with research projects but stems from an ability to apply present skills to meet novel needs by making use of new technical possibilities.



Enterprises develop first and foremost on account of their internal knowledge and their intensive contacts with customers and suppliers. The technological service network and public-sector research institutions are indirectly vital preconditions for companies' own R & D. The technological service network is peculiar to Denmark and makes its real contribution in allowing Danish companies to keep up to date with international technological developments. For many companies, however, their technological development is less dependent on direct contact with the network or with the public-sector research institutions.

An investigation of the innovative activities of Nordic companies<sup>1)</sup> suggests that Danish companies have a greater part of their turnover of products in an introductory phase on the market than is the case for Finnish and Norwegian companies (see Table 7). In the investigation, the companies were asked, with respect to their three most important product groups, to indicate its stage of development (introduction, growth, stagnation and decline). The part of a company's turnover that derives from the introductory phase can be taken as an output indicator for innovation.

**Table 7. Share of companies' turnover from products in the introductory phase, and share of companies' turnover from products introduced within the past five years. For Denmark, Finland and Norway. In percentages.**

	Share of companies' turnover: products in introductory phase	Share of companies' turnover: products introduced within past 5 years
Denmark	6.5	30.0
Finland	5.9	22.6
Norway	6.0	18.8

The share of companies' turnover derived from products introduced within the past five years can be seen as an indicator of companies' innovative activities. Of the present turnover of Danish companies,

1. »Innovative activities in Nordic countries«. Nordic Industrial Fund, 1991. It must be emphasized that this investigation questioned first and foremost the most R & D intensive industries in the Nordic countries, and its results should therefore not be generalized to all industrial activity in these countries. Comparison between them, however, is possible.



30% consists of products introduced within the last 5 years, while the figures for Finland and Norway are 22.6% and 18.8% respectively.

While this statement should be interpreted cautiously, the ability of Danish industry to develop new products seems to be at least as good as that of the industries of Finland and Norway. This must be regarded in the light of the fact that research intensity is lower in Denmark than in industry in these two other Nordic countries. This suggests that the internationally low level of research intensity in Danish industry does not necessarily imply that Danish innovative abilities are lower than, for example, those of other Nordic countries. While there are only a few large, research-intensive enterprises in Denmark, the country has a number of small and medium-sized companies that are markedly innovative: many of them have become specialist, niche-producers on the international market.

*Danish Export Specialization in high-, medium- and low-technological Branches of Industry*

The export specialization ratio<sup>1)</sup> can be used as a measure of a country's propensity to export a given product group in relation to the

**Table 8. Export specialization ratio for high-, medium-, and low-technological branches of industry. 1980 and 1987.**

	1980			1987		
	High	Medium	Low	High	Medium	Low
USA	1.57	1.07	0.67	1.70	0.90	0.66
Japan	1.42	1.05	0.75	1.54	1.10	0.50
EC average	0.84	1.00	1.08	0.80	1.01	1.13
United Kingdom	1.22	1.08	0.81	1.17	0.97	0.93
<b>Denmark</b>	<b>0.75</b>	<b>0.63</b>	<b>1.54</b>	<b>0.77</b>	<b>0.63</b>	<b>1.65</b>
Sweden	0.79	0.88	1.24	0.74	0.93	1.27
Finland	0.36	0.47	1.90	0.47	0.59	1.91
Norway	0.38	0.94	1.35	0.42	0.92	1.49

Source: OECD Foreign Trade database.

1. This ratio shows exports in a given product group in relation to the relevant country's total exports; this fraction is divided by the same figure for the OECD countries as a whole. It is in fact a measure of a country's relative export structure. Table 8 shows this ratio for high, medium, and low technological branches of industry for 1980 and 1987.



average for the OECD. Table 8 shows this ratio for high, medium, and low-technological branches of industry in 1980 and 1987.

Table 8 shows that, with the exception of the Federal Republic of Germany, and in relation to the OECD average, all the larger OECD countries are more specialized in high-technological industries and have a greater competitive advantage. The opposite is the case for the smaller OECD countries: they have specialized in and have competitive advantages in low-technological industries.

Beyond this, throughout the 1980s, there has been a tendency in Denmark further to specialize in low-technological branches of industry, and the specialization index in such branches (foods, furniture, clothing and metal goods) has increased between 1980 and 1987 from 1.54 to 1.65. Remarkably enough, in contrast to the other smaller OECD countries, Denmark is relatively more specialized in the high-technological than in the medium-technological branches of industry; the country is thus relatively weaker competitively in the typically large medium-technological industries (transportation, parts of the chemical industry) than in the high-technological branches.

Denmark apparently has a good competitive ability in a number of low-technological branches of industry<sup>1)</sup>, but manages less well in high-technological branches with the exception of isolated areas including medicine and part of the measuring equipment industry. This is a structural problem for the country's industry, in that employment, production and exports are still rising in high-technological branches of industry but not in the low-technological ones.

1. Budget Department, Danish Ministry of Finance: *Finansredegørelse 90* («Financial Accounts 1990»), Copenhagen 1990.



### *Conclusion*

Spending on Danish R & D rose sharply during the 1980s, in the public and not least the private sectors. In composition and financing Danish research did not differ greatly from that in the other smaller OECD countries. In relation to GDP, public-sector R & D was close to the EC average while, in an international context, and despite strong growth over the past ten years, R & D in the business enterprise sector remains modest. Danish industry is predominantly one with a low research intensity and its structure is characterized by many small and medium-sized, and only a few large, enterprises.

Study of bibliometric data suggests the conclusion that basic research in a number of the natural and medical sciences is of good international quality.

The research intensity of Danish industry is low in international terms, but despite this a number of small and medium-sized companies are markedly able to innovate. This innovative quality - whether in the form of developing new products or successfully applying new technology - is at present absolutely vital as a parameter of competition in just about all manufacturing industry.

Some of the larger OECD countries are investing strategically in branches of the electronics industry, parts of the chemical, aviation and aerospace industries (the high-technological branches), with a view to being in the front line of new, high-technological products. During the 1980s, high-technological industries expanded in terms of employment, production and exports, and therefore it is important that Danish industries enjoy strongly competitive positions in these markets.

Looking relatively far into the future, it is problematic that Danish export specialization is concentrated in areas of technically less advanced products, in which competition can certainly be expected to grow from the newly industrialized countries. It is thus important that by renewing their products and exports, companies increase their chances of competing on the rapidly growing markets served by research-intensive industries.



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# Annex B

## Global Tendencies

### *Introduction*

The Triad, as it is called, - the USA, Japan and Western Europe - is achieving a constantly stronger position on the global scene. The primary reason is the ever increasing internal economic and political integration of these countries, but a further reason is the crumbling of the Eastern Block as an economic and political polarity.

Integration in Europe is increasing as a consequence of the realization of the EC Single market and the inclusion of the countries of eastern Europe into the commercial division of labour. Integration within the Triad is being increased through the trans-frontier cooperation of companies.

This implies for any small country like Denmark that, if it wants to maintain and if possible improve its position in the international economy, it must be constantly aware of what roles are possible and desirable in the international division of labour. For national research policy, as regards public resources this implies a need to try to evaluate where the areas of growth will be internationally in research, technological development, production and markets over the coming 10 to 30 years. On this basis it is then necessary to try to decide what possibilities are open to Denmark.

Against this background, some main themes of global trends in the 1990s for research, technology, production and trade are summed up below. By way of introduction, attention is given to those parts of developments in international business enterprise that are particularly influenced by the international companies. Aspects of the demographic developments in the advanced industrialized countries are then examined before, by way of conclusion, the consequences of expected developments in public and private-sector demand are examined, together with features of the derived development of R & D spending and policies in the OECD countries.



### *The Global Scene*

The growing internationalization of the world economy finds expressions in many ways. Global trade is rising faster than global production, and the fastest rises in trade are occurring between the same business sectors in the different countries. At the same time, between twenty and thirty per cent of the foreign trade of countries like the USA, the UK and Sweden is between the parent and subsidiary companies of transnational groups. Production is being divided into more and more specialized units that - being located in different countries - need increasingly to interact closely in what are called networks of companies.

Another expression of the establishment of these networks is increases in direct international investments that have grown by 20% annually since 1986. The total foreign investments made by American, British, French, German and Japanese companies was \$570 bn in 1988, and is expected to exceed \$1,700 bn in 1995. Transfrontier mergers and takeovers among the one thousand largest companies in Europe rose in number from 25 in 1985 to 210 in 1988, and during these years these companies acquired US companies for \$ 40 bn.

What urges on this development is not least the steadily increasing demand for resources prompted by pioneering research and technological development. Especially in the case of information technology and biotechnology, basic research and technological development often costs more than single nations can afford, and this is why large transnational companies have urged that large EC programmes of research be started in these areas.

### *A and B Groups in the Triad*

In countries and regions within the Triad, further contrasts are expected between what have come to be called the A and B groups. The first comprises well-educated, well-paid and fully-employed persons together with the elderly who have managed to save not inconsiderable capital sums during their working lives; the B group comprises people who, having little education, are badly paid when they are employed, and who are often out of work, together with the elderly who have not managed to accumulate any savings worth mentioning during their working lives.



This so-called »dualization« into A and B groups that exists not only between countries but also within even the most industrialized countries, is caused by two main groups of factors.

*Technological development* on the one hand standardizes production especially in traditional industries, and in a number of instances, while production can remain in the industrialized countries where demand for such products is stagnant, this leads to lower levels of employment. In other instances, this leads to production being shifted to second or third-division countries, and again to a decline in employment in the industrialized countries.

On the other hand, technological developments make it possible to develop new products and a greater demand for new goods and services. Employment undoubtedly benefits in such cases and the question is which tendency will have the greatest effect on employment during the 1990s. The general estimate is that, for employment in the first-division countries, the growth of new products cannot wholly balance the decline in their traditional industries.

*Demographic developments* will lead to larger proportions of the populations of the industrialized countries being older: in 1950, 65-year-olds in Western Europe comprised 10.1%, but by 2025 they will comprise 20.9%. For OECD countries in the aggregate, the rise will be from 8.1% in 1950 to 17.6% in 2025. The costs only of the pensions entailed by this development will be more than twice their present levels in the USA and Japan, but only about 25% more in Denmark.

#### *Important Areas of Development*

Regardless of which of the advanced countries provides the point of view, the growth perspectives of the 1990s are very much the same.

*Within the area of private consumption*, the strongest growth will probably occur in health. With 1960 as the base year (index = 100), expenditures on health are expected to rise to 300 by the year 2000. The next largest area is that of »leisure and culture«, where the index is expected to rise to about 225 by 2000; the proportions of private spending devoted to food, transport and housing will fall.

Growth is expected to derive in part from the demographic change towards greater numbers of elderly persons in the population, in part from the generally steadily greater priority accorded to health.



Among other things, technological developments will make it possible to meet new needs, and as a group persons take it for granted that other material, social and security needs and the like are met, they will be able to devote increasing attention not least to advanced health needs.

*Growth in leisure and cultural consumption* (of entertainment and home electronics, photo and video cameras, PCs, sports equipment, film, theatre, music and the like) emerges from the same background, as does the expected sociological change in construction and housing, as housing stocks are adapted to the changed demographic conditions.

If the point of departure is in the development of social housekeeping, the greatest growth in demand is expected to derive from environmental areas that include extensions of recreation areas, treatment of waste, environmentally-friendly methods of production and the like. For the traditional environmental equipment area alone, annual growth in the 1990s is expected to be up to 7%, giving an aggregated OECD market of \$250 bn in 2000. Demand for waste handling is expected to increase enormously.

### *Technological Challenges*

The new technologies of information, biological sciences, and materials will be more or less central to the research that will generate new products and processes on the advanced industrial markets. In relation to the discussion in the 1980s, attention is less on the technologies themselves than on the needs that products and processes are to meet.

Research policy increasingly acknowledges that the themes of research in the 1990s will be more complex and interdisciplinary than has been the case hitherto. Research into technological science, for example, can no longer be seen in isolation but in its social, employment and environmental aspects.

Information technology will remain the central area of development, partly because it is and will be the link between many different sectors and areas of use. British research suggests that more than half the resources devoted to private-sector R & D in the industrialized countries has to do with the development and use of information technology. While its share varies from sector to sector, it is ab-



sent from none, and rising in all. In many respects it contributes to making production of goods and services far more efficient but, once again in contrast to the 1980s, it is the use rather than the nature of information technology that attracts most attention.

The development of biotechnologies has not yet proceeded very far, and their use is largely confined to relatively limited areas that include agriculture, food, forestry, pharmaceuticals, health and water purification; effects on employment are as yet modest. On the other side of the year 2000, however, things will probably be quite different: in usage, not least in health matters including new diagnostic methods in treating disease, and in agriculture, giving greater productivity and higher quality of agro-industrial products.

In materials technology, the forecasts ten years ago of futures for ceramic compounds and the like similar to those now foreseen for information and biological technologies have given way to less extravagant expectations. One reason is that commercial possibilities are limited to fewer sectors and a commercial breakthrough is further off in time than had at first been foreseen.

Compared with the use and employment effects of information technologies, the OECD experts estimate that material technologies will come to be used in half the number of sectors, and to have one fifth of their effect on employment.

#### *Trends in Research Policy*

An overriding research policy trend is that international programmes of research are increasing, especially within the European Community, and there especially for information technologies. The ambition is to create the »European Technology Community«, the means being not only the decidedly research programmes such as ESPRIT and RACE; other important means include new structures, new forms of cooperation and a new knowledge of possibilities for research and cooperation over frontiers. Efforts to promote the mobility of both students and researchers can prove to be at least as important for development as taking part in the EC's »normal« research projects. As yet, the Community's research projects are equivalent to no more than 5% of those undertaken by the member countries as a whole.



In looking at publicly-financed research in the individual OECD countries, it may be stated that, as a proportion of total expenditures on research, it varies greatly but is falling in most countries.

Publicly-financed research in the OECD countries in the 1980s has characteristically fallen in terms of appropriations to research on energy; in this period, other stagnating areas have been research into agriculture, infrastructure, civil aviation, social and health matters, the environment, and the use of the sea. Public appropriations have risen for general scientific development, industrial development and not least space research and defence.

Qualitatively the most remarkable developments in the OECD countries have affected the relation between two principal elements of the traditional research system:

1. The research infrastructure consisting of universities, institutions of higher education and independent research and investigation institutions of various sorts and affiliations.
2. Companies' central research laboratories and developmental departments.

In the first place, new research consortia are being established across the traditional sectors, often within areas given special priority, when otherwise knowledge would have been transferred or research conducted either later or at a lower level of ambition. The European Community's research programmes in particular have facilitated this, bringing together companies and research institutions and the like from the different countries.

Secondly strategic alliances have been formed, often between private companies, to conduct research and development of new technologies.

Finally, development is characterized by attempts to reorganize not least the research done at universities and institutions of higher education, so that its structure becomes more transparent and its efforts devoted to more specific goals.



### *Conclusion*

The global tendencies suggest that areas of future growth in the industrialized countries will be mainly linked to health, leisure, culture and the environment.

The areas for research efforts are expected to continue to be in information technology, biotechnology, and materials technology. In the Danish perspective, food technology must be added on account of the important position of the food industry enjoys in the Danish economy.



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# Annex C

## Danish and European Community Programmes

Under the heading of »Danish Programmes« are given only those measures that have been taken to increase Danish research work in areas where EC programmes have been initiated. In addition to those mentioned here, programmes of research work, financed through basic appropriations, are conducted in all the areas where EC programmes have been set up.

The term »basic appropriations« is used to indicate areas in which no particular programmes have been set up to enhance the research already being conducted.

### EC Programmes (1990-94)

*Information technology (ESPRIT III)*

Expected budget: DKK 10,816m

*Communication technology*

*(RACE II)*

Expected budget: DKK 3,912m

*Development of telematic*

*systems in areas of*

*general interest*

Expected budget: DKK 3,040m

*Industrial and material*

*technology*

Expected budget: DKK 5,984m

### Danish Programmes

*PIFT (1991-94)*

Ministry of Education and Research

Budget: DKK 180m

*Informatics in farming (1988-92)*

Ministry of Agriculture

Budget: DKK 44m

*Micro-electronic Centre (1990-94)*

Ministry of Education and Research

Budget: DKK 91m

*PIFT (1990-94)*

Ministry of Education and Research

Budget: DKK 180m

*Centre for electronic*

*language processing*

*(EUROTRA) (1991-95)*

Ministry of Education and Research

Budget: DKK 15.5m

*The materials technology*

*development programme*

Ministries of Education and

Research, and Industry

Budget: DKK 406m



*Measurements and Tests*

Expected budget: DKK 1,120m

*Environment*

Expected budget: DKK 3,312m

*Marine research and  
technology*

Expected budget: DKK 832m

*Biotechnology*

Expected budget: DKK 1,312m

*Basic appropriations*

*Marine-environmental  
research (1988-92)*

Ministry of the Environment  
Budget: DKK 75m

*Waste-water research (1988-91)*

Ministry of the Environment  
Budget: DKK 30m

*Pesticides (1989-92)*

Ministry of the Environment  
Budget: DKK 44m

*Recycling projects (1988-92)*

Ministry of the Environment  
Budget: DKK 50m

*Greenland Icecore Programme  
(1988-92)*

Ministry of Education and Research  
Budget: DKK 12m

*Agriculture and the environment  
(1987-92)*

Ministry of Agriculture  
Budget: DKK 90m

*Marine-environmental research*

Ministry of the Environment  
Budget: DKK 75m

*The biotechnology research  
programme (1991-95)*

Ministry of Education and Research  
Budget: DKK 456m



*Agriculture and agro-industries  
(including fisheries)*  
Expected budget: DKK 2,600m

*Biotechnology (1988-92)*  
Ministry of Agriculture  
Budget: DKK 30m  
*Product development  
in processing agricultural  
production (1988-92)*  
Ministry of Agriculture  
Budget: DKK 395m  
*R & D programme for technology  
(1987-91)*

Ministry of Fisheries  
Budget: DKK 30m  
*R & D programme for  
food technology (1990-94)*

Ministries of Education and Research,  
of Industry, and of Agriculture  
Budget: DKK 525m

*Biomedicine and health*  
Expected budget: DKK 1,063m

*Basic appropriations*

*Biosciences with respect to  
developing countries (STD 3)*  
Expected budget: DKK 888m

*Basic appropriations*

*Non-nuclear energy*  
Expected budget: DKK 1,256m

*Research programmes of  
the Ministry of Energy*  
Ministry of Energy  
Budget: DKK 104m annually

*Safety in connection  
with nuclear fission*  
Expected budget: DKK 1,590m

*Basic appropriations*

*Controlled thermo-nuclear fusion*  
Expected budget: DKK 3,660m

*Basic appropriations*

*Human resources and mobility*  
Expected budget: DKK 4,144m

*Intensification programme  
of the Danish Research Academy*  
Ministry of Education and Research  
Budget: DKK 20m annually



**Tables of public  
R & D Appropriations  
1989-94  
(Annex D)**



## Natural Science

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	432.9	96.1	529.0	488.8	95.3	584.1	400.9	99.6	500.5	504.7	473.0	463.0
Ministry of Culture	4.0	0.0	4.0	3.9	0.0	3.9	4.3	0.0	4.3	4.3	4.2	4.2
Ministry of the Environment	0.3	0.0	0.3	0.5	0.0	0.5	0.5	0.0	0.5	0.5	0.5	0.5
Ministry of Energy	1.0	0.0	1.0	2.6	0.0	2.6	2.6	0.0	2.6	2.6	2.6	2.6
<b>Total</b>	<b>438.3</b>	<b>96.1</b>	<b>534.3</b>	<b>495.7</b>	<b>95.3</b>	<b>591.1</b>	<b>408.3</b>	<b>99.6</b>	<b>507.9</b>	<b>512.1</b>	<b>480.3</b>	<b>470.3</b>

## Technical Science

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	268.3	107.5	375.8	341.6	91.6	433.3	351.3	90.7	442.0	454.0	436.4	424.1
Ministry of Energy	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Total</b>	<b>269.3</b>	<b>107.5</b>	<b>376.8</b>	<b>341.6</b>	<b>91.6</b>	<b>433.3</b>	<b>351.3</b>	<b>90.7</b>	<b>442.0</b>	<b>454.0</b>	<b>436.4</b>	<b>424.1</b>

## Medical Science

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Health	123.4	12.5	135.9	123.1	10.9	133.9	123.3	10.9	134.2	134.2	134.2	134.2
Ministry of Education	308.6	62.5	371.1	291.4	66.0	357.5	251.0	66.9	317.9	323.3	304.5	291.3
Ministry of Culture	4.0	0.0	4.0	3.9	0.0	3.9	4.2	0.0	4.2	4.3	4.1	4.1
<b>Total</b>	<b>436.0</b>	<b>75.0</b>	<b>511.0</b>	<b>418.4</b>	<b>76.9</b>	<b>495.3</b>	<b>378.5</b>	<b>77.8</b>	<b>456.3</b>	<b>461.8</b>	<b>442.8</b>	<b>429.6</b>

## Agricultural and Veterinary Science

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ministry of Education	95.3	50.7	146.0	123.2	46.1	169.3	118.9	50.8	169.7	171.3	156.1	153.7
Ministry of Agriculture	4.4	0.3	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>Total</b>	<b>99.7</b>	<b>52.0</b>	<b>151.8</b>	<b>123.2</b>	<b>46.1</b>	<b>169.3</b>	<b>118.9</b>	<b>50.8</b>	<b>169.7</b>	<b>171.3</b>	<b>156.1</b>	<b>153.7</b>

## Social Science

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	8.3	0.0	8.3	9.2	0.0	9.2	12.6	0.0	12.6	14.5	14.9	15.4
Ministry of Education	208.3	36.6	244.9	262.2	37.6	299.8	280.0	38.1	318.1	320.2	311.9	307.3
Ministry of Culture	27.3	0.0	27.3	26.6	0.0	26.6	27.2	0.0	27.2	27.2	27.0	27.0
<b>Total</b>	<b>244.0</b>	<b>36.6</b>	<b>280.6</b>	<b>298.1</b>	<b>37.6</b>	<b>335.7</b>	<b>319.8</b>	<b>38.1</b>	<b>357.9</b>	<b>361.9</b>	<b>353.8</b>	<b>349.7</b>

## Humanities

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	282.4	51.2	333.7	326.2	64.3	390.6	318.9	53.8	372.7	368.9	353.1	347.5
Ministry of Culture	56.4	0.0	56.4	57.0	0.0	57.0	62.8	0.0	62.8	62.5	63.4	62.3
<b>Total</b>	<b>338.9</b>	<b>51.2</b>	<b>390.1</b>	<b>383.3</b>	<b>64.3</b>	<b>447.6</b>	<b>381.7</b>	<b>53.8</b>	<b>435.5</b>	<b>431.4</b>	<b>416.6</b>	<b>409.8</b>

### R&D that cannot be distributed

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	2.7	43.8	46.5	2.8	63.2	65.9	3.0	27.8	30.8	26.1	34.2	35.8
Ministry of Education	0.0	10.7	10.7	0.9	0.9	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Ministry of Culture	79.0	2.5	81.5	99.6	8.5	108.1	106.1	4.4	110.5	110.9	108.8	108.9
Ministry of Energy	76.7	0.0	76.7	73.7	0.0	73.7	71.0	0.0	71.0	59.0	67.0	66.0
<b>Total</b>	<b>158.3</b>	<b>57.1</b>	<b>215.4</b>	<b>177.0</b>	<b>72.6</b>	<b>249.7</b>	<b>180.1</b>	<b>32.2</b>	<b>212.3</b>	<b>196.0</b>	<b>210.0</b>	<b>210.7</b>

### Post-graduate Research Training

Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
DKK million, 1991 level												
Ministry of Education	208.1	82.0	290.1	204.8	84.8	289.6	204.6	84.2	288.8	288.3	286.5	284.8
Ministry of Industry	0.0	31.9	31.9	0.0	20.5	20.5	0.0	20.0	20.0	20.0	20.0	20.0
Ministry of Energy	6.8	0.0	6.8	4.1	0.0	4.1	6.6	0.0	6.6	6.6	6.6	6.6
<b>Total</b>	<b>214.9</b>	<b>113.9</b>	<b>328.8</b>	<b>208.9</b>	<b>105.3</b>	<b>314.2</b>	<b>211.2</b>	<b>104.2</b>	<b>315.4</b>	<b>314.9</b>	<b>313.1</b>	<b>311.4</b>

### International Research Cooperation

Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
DKK million, 1991 level												
Ministry of Education	159.6	55.5	215.1	180.4	55.2	235.6	189.5	55.1	244.6	251.9	259.2	260.9
Ministry of Industry	0.0	24.4	24.4	0.0	32.8	32.8	0.0	36.0	36.0	45.0	50.0	53.0
Ministry of Traffic	0.9	0.0	0.9	2.4	0.0	2.4	2.0	0.0	2.0	1.7	1.4	1.0
<b>Total</b>	<b>160.5</b>	<b>79.9</b>	<b>240.4</b>	<b>182.8</b>	<b>88.0</b>	<b>270.7</b>	<b>191.5</b>	<b>91.1</b>	<b>282.6</b>	<b>298.6</b>	<b>310.6</b>	<b>314.9</b>

## Communication

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	2.4	16.9	19.3	2.3	7.6	9.8	2.3	0.0	2.3	2.3	2.3	2.2
Ministry of Culture	31.2	6.2	37.3	31.9	6.0	38.0	49.1	0.0	49.1	48.1	47.8	48.8
<b>Total</b>	<b>33.6</b>	<b>23.1</b>	<b>56.6</b>	<b>34.2</b>	<b>13.6</b>	<b>47.8</b>	<b>51.4</b>	<b>0.0</b>	<b>51.4</b>	<b>50.4</b>	<b>50.1</b>	<b>51.0</b>

## Materials Technology

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	0.0	36.5	36.5	0.0	52.2	52.2	0.0	52.3	52.3	52.3	52.3	0.0
Ministry of Industry	0.0	68.0	68.0	0.0	77.8	77.8	0.0	76.0	76.0	6.0	6.0	0.0
<b>Total</b>	<b>0.0</b>	<b>104.5</b>	<b>104.5</b>	<b>0.0</b>	<b>130.0</b>	<b>130.0</b>	<b>0.0</b>	<b>128.3</b>	<b>128.3</b>	<b>58.3</b>	<b>58.3</b>	<b>0.0</b>

## Food Technology

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	0.0	0.0	0.0	0.0	15.4	15.4	0.0	35.6	35.6	39.0	39.0	39.0
Ministry of Agriculture	0.0	61.8	61.8	0.0	96.9	96.9	0.0	151.8	151.8	146.0	135.0	137.4
Ministry of Fisheries	7.7	3.2	11.0	8.5	4.7	13.2	6.1	5.6	11.7	10.4	8.7	8.3
Ministry of Industry	0.0	0.0	0.0	0.0	49.2	49.2	0.0	64.0	64.0	32.0	16.0	0.0
<b>Total</b>	<b>7.7</b>	<b>65.1</b>	<b>72.8</b>	<b>8.5</b>	<b>166.1</b>	<b>174.6</b>	<b>6.1</b>	<b>257.0</b>	<b>263.1</b>	<b>227.4</b>	<b>198.7</b>	<b>184.7</b>

## Biotechnology

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Education	0.0	142.0	142.0	0.0	147.9	147.9	0.0	114.0	114.0	102.6	91.2	78.8
Ministry of Agriculture	0.0	10.0	10.0	0.0	8.9	8.9	0.0	9.8	9.8	7.0	4.4	4.0
<b>Total</b>	<b>0.0</b>	<b>152.0</b>	<b>152.0</b>	<b>0.0</b>	<b>156.8</b>	<b>156.8</b>	<b>0.0</b>	<b>123.8</b>	<b>123.8</b>	<b>109.6</b>	<b>95.6</b>	<b>82.8</b>

## The Environment

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Health	10.4	0.0	10.4	6.1	1.0	7.2	6.5	0.7	7.2	7.0	6.7	6.6
Ministry of Labour	0.0	8.7	8.7	0.0	20.7	20.7	0.0	21.7	21.7	21.8	21.6	21.6
Ministry of Education	0.0	3.1	3.1	0.0	3.1	3.1	0.0	2.7	2.7	2.7	0.0	0.0
Ministry of the Environment	16.8	70.0	86.8	18.4	64.9	83.4	2.0	58.9	60.9	60.9	33.5	32.5
Ministry of Agriculture	0.0	21.8	21.8	0.0	23.7	23.7	0.0	24.1	24.1	14.5	1.7	1.4
Ministry of Fisheries	11.9	1.3	13.1	11.7	1.0	12.7	10.0	0.0	10.0	9.7	9.7	9.4
Ministry of Traffic	5.7	0.0	5.7	1.6	0.0	1.6	1.4	0.0	1.4	1.2	1.0	1.0
Ministry of Energy	42.9	25.0	67.9	39.9	25.6	65.5	38.0	24.9	62.9	62.8	61.7	60.0
<b>Total</b>	<b>87.7</b>	<b>129.9</b>	<b>217.6</b>	<b>77.8</b>	<b>140.0</b>	<b>217.8</b>	<b>57.9</b>	<b>133.0</b>	<b>190.9</b>	<b>180.6</b>	<b>135.9</b>	<b>132.5</b>

## Energy

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Energy	44.8	178.4	223.2	44.0	174.6	218.6	43.0	184.5	227.5	211.5	210.5	195.5
<b>Total</b>	<b>44.8</b>	<b>178.4</b>	<b>223.2</b>	<b>44.0</b>	<b>174.6</b>	<b>218.6</b>	<b>43.0</b>	<b>184.5</b>	<b>227.5</b>	<b>211.5</b>	<b>210.5</b>	<b>195.5</b>

## Health

DKK million, 1991 level	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	0.0	22.0	22.0	0.0	15.2	15.2	0.0	16.5	16.5	18.0	18.0	20.0
Ministry of Health	77.5	7.1	84.6	76.1	5.5	81.6	75.6	7.3	82.9	82.0	82.0	82.3
<b>Total</b>	<b>77.5</b>	<b>29.1</b>	<b>106.6</b>	<b>76.1</b>	<b>20.7</b>	<b>96.8</b>	<b>75.6</b>	<b>23.8</b>	<b>99.4</b>	<b>100.0</b>	<b>101.0</b>	<b>102.3</b>

## Agriculture and Fisheries

DKK million, 1991 level	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	0.0	0.0	0.0	23.9	12.7	36.6	26.0	14.5	40.5	45.2	45.2	51.0
Ministry of Agriculture	228.3	118.1	346.4	200.5	105.9	306.4	182.1	120.1	302.2	275.2	319.5	316.6
Ministry of Fisheries	17.4	22.5	39.9	15.5	15.2	30.6	14.4	14.2	28.6	25.1	25.1	17.9
<b>Total</b>	<b>245.7</b>	<b>140.6</b>	<b>386.3</b>	<b>239.8</b>	<b>133.7</b>	<b>373.6</b>	<b>222.5</b>	<b>148.8</b>	<b>371.3</b>	<b>345.5</b>	<b>385.8</b>	<b>385.5</b>

## Industry and Trade

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Industry	0.0	515.5	515.5	0.0	245.8	245.8	0.0	180.0	180.0	170.0	170.0	170.0
<b>Total</b>	<b>0.0</b>	<b>515.5</b>	<b>515.5</b>	<b>0.0</b>	<b>245.8</b>	<b>245.8</b>	<b>0.0</b>	<b>180.0</b>	<b>180.0</b>	<b>170.0</b>	<b>170.0</b>	<b>170.0</b>

## Technological Infrastructure and Initiative Areas

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Industry	0.0	136.0	136.0	0.0	120.8	120.8	0.0	130.0	130.0	120.0	120.0	112.0
<b>Total</b>	<b>0.0</b>	<b>136.0</b>	<b>136.0</b>	<b>0.0</b>	<b>120.8</b>	<b>120.8</b>	<b>0.0</b>	<b>130.0</b>	<b>130.0</b>	<b>120.0</b>	<b>120.0</b>	<b>112.0</b>

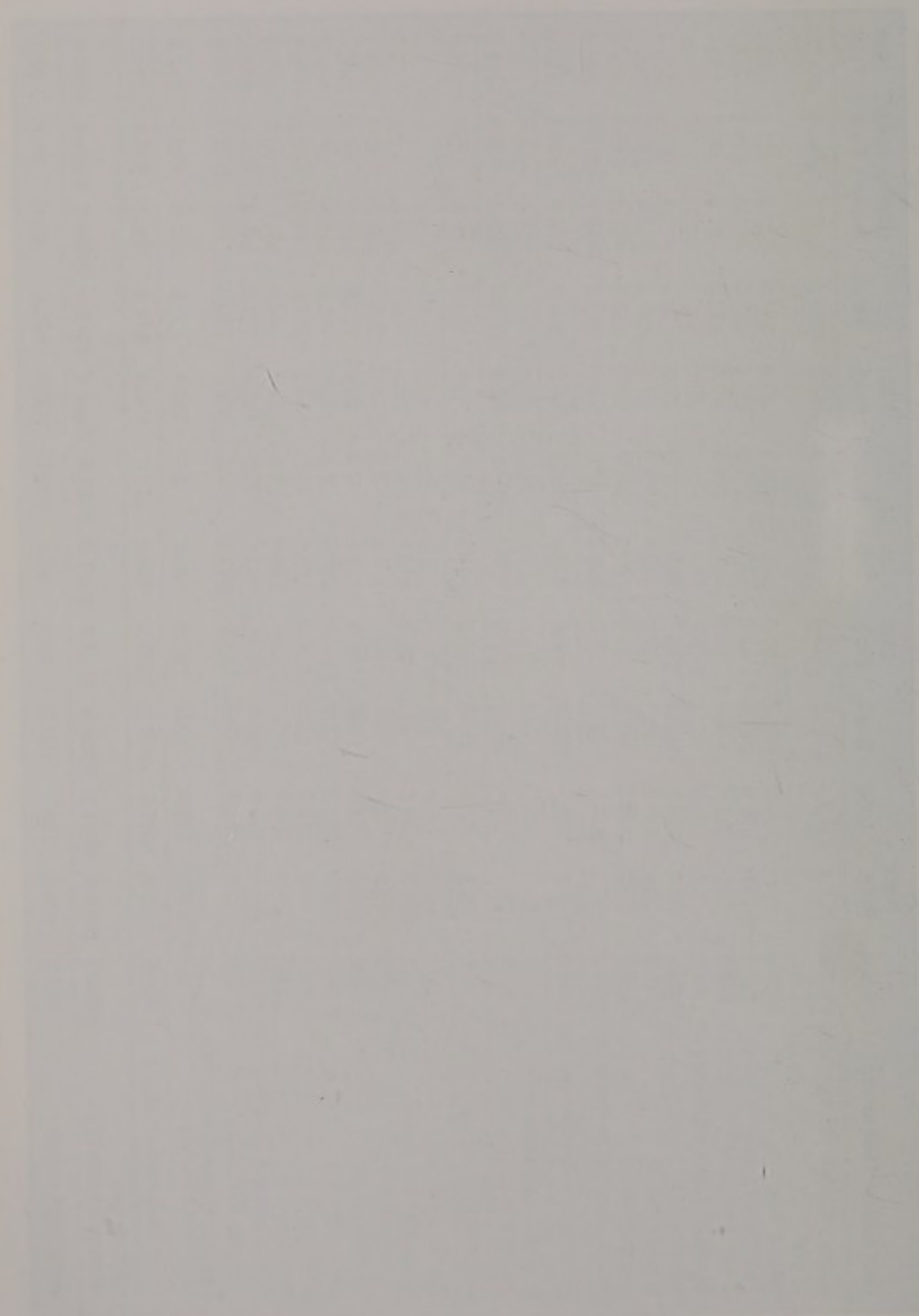
## Other R&D Appropriations

DKK million, 1991 level Ministries	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
Ministry of Foreign Affairs	25.7	4.1	29.7	2.8	0.0	2.8	4.2	0.0	4.2	5.0	0.0	5.0
Ministry of Economic Affairs	21.8	0.0	21.8	22.1	0.0	22.1	21.9	0.0	21.9	21.3	0.0	20.7
Ministry of Justice	5.1	0.0	5.1	4.2	0.0	4.2	3.9	0.0	3.9	3.8	0.0	3.7
Ministry of Defence	28.8	0.0	28.8	28.5	0.0	28.5	26.0	0.0	26.0	26.0	0.0	26.0
Ministry of Housing	60.9	11.8	72.7	57.3	20.5	77.8	53.4	15.7	69.1	64.7	0.0	60.9
Ministry of Social Affairs	18.3	34.2	52.5	16.7	39.0	55.7	16.2	18.9	35.1	29.8	0.0	29.0
Ministry of Labour	5.8	0.0	5.8	5.4	1.9	7.4	5.7	3.7	9.4	6.3	0.0	6.2
Ministry of Education	371.4	202.7	574.1	79.7	216.0	295.6	146.3	276.2	422.5	246.1	0.0	344.0
Ministry of Culture	23.3	29.1	52.4	33.1	22.2	55.3	32.3	5.0	37.3	33.3	0.0	32.3
Ministry of the Environment	40.3	8.1	48.4	42.4	8.2	50.6	89.9	30.4	120.3	113.1	0.0	107.2
Ministry of Industry	0.0	0.0	0.0	0.0	16.4	16.4	0.0	48.0	48.0	32.0	0.0	4.0
Ministry of Traffic	32.5	0.0	32.5	20.7	7.4	28.1	21.1	10.0	31.1	33.4	0.0	33.5
Ministry of Energy	114.2	43.8	158.0	113.3	41.0	154.2	106.8	39.0	145.8	144.2	0.0	103.5
<b>Total</b>	<b>748.0</b>	<b>333.8</b>	<b>1081.8</b>	<b>426.1</b>	<b>372.5</b>	<b>798.6</b>	<b>527.7</b>	<b>446.9</b>	<b>974.6</b>	<b>759.0</b>	<b>851.1</b>	<b>775.1</b>



## R&D Appropriations 1989-94

DKK million, 1991 level	1989		1990		1991		1992		1993		1994	
	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total	Basic	Prog.	Total
General scientific development of which:	1984.4	475.5	2459.9	2237.3	484.5	2721.8	2138.6	443.0	2581.6	2588.5	2495.9	2447.9
Natural science	438.3	96.1	534.3	495.7	95.3	591.1	408.3	99.6	507.9	512.1	480.3	470.3
Technical science	269.3	107.5	376.8	341.6	91.6	433.3	351.3	90.7	442.0	454.0	436.4	424.1
Medical science	436.0	75.0	511.0	418.4	76.9	495.3	378.5	77.8	456.3	461.8	442.8	429.6
Agricultural and veterinary science	99.7	52.0	151.8	123.2	46.1	169.3	118.9	50.8	169.7	171.3	156.1	153.7
Social science	244.0	36.6	280.6	298.1	37.6	335.7	319.8	38.1	357.9	361.9	353.8	349.7
Humanities	338.9	51.2	390.1	383.3	64.3	447.6	381.7	53.8	435.5	431.4	416.5	409.8
R&D that cannot be distributed	158.3	57.1	215.4	177.0	72.6	249.7	180.1	32.2	212.3	196.0	210.0	210.7
Post-graduate research training	214.9	113.9	328.8	208.9	105.3	314.2	211.2	104.2	315.4	314.9	313.1	311.4
International research cooperation	160.5	79.9	240.4	182.8	88.0	270.7	191.5	91.1	282.6	298.6	310.6	314.9
Communication	33.6	23.1	56.6	34.2	13.6	47.8	51.4	0.0	51.4	50.4	50.1	51.0
Selected areas:												
Materials technology	0.0	104.5	104.5	0.0	130.0	130.0	0.0	128.3	128.3	58.3	0.0	0.0
Food technology	7.7	65.1	72.8	8.5	166.1	174.6	6.1	257.0	263.1	227.4	198.7	184.7
Biotechnology	0.0	152.0	152.0	0.0	156.8	156.8	0.0	123.8	123.8	109.6	95.6	82.8
Environment	87.7	129.9	217.6	77.8	140.0	217.8	57.9	133.0	190.9	180.6	135.9	132.5
Energy	44.8	178.4	223.2	44.0	174.6	218.6	43.0	184.5	227.5	211.5	210.5	195.5
Health	77.5	29.1	106.6	76.1	20.7	96.8	75.6	23.8	99.4	100.0	101.1	102.3
Agriculture and fisheries	245.7	140.6	386.3	239.8	133.7	373.6	222.5	148.8	371.3	345.5	385.8	385.5
Industry and trade	0.0	515.5	515.5	0.0	245.8	245.8	0.0	180.0	180.0	170.0	170.0	170.0
Technological infrastructure and initiative areas	0.0	136.0	136.0	0.0	120.8	120.8	0.0	130.0	130.0	120.0	112.0	112.0
Other R&D appropriations	748.0	333.8	1081.8	426.1	372.5	798.6	527.7	446.9	974.6	759.0	891.1	775.1
<b>R&amp;D budget appropriations 1991</b>	<b>3604.9</b>	<b>2477.0</b>	<b>6081.9</b>	<b>3535.6</b>	<b>2352.3</b>	<b>5887.9</b>	<b>3525.5</b>	<b>2394.4</b>	<b>5919.9</b>	<b>5534.3</b>	<b>5430.4</b>	<b>5265.6</b>
Index 1991 = 100	102.3	103.5	102.7	100.3	98.2	99.5	100.0	100.0	100.0	93.4	91.7	89.0



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Danish research is to be boosted to make it internationally competitive.

The means to be employed are specialization, concentration, better post-graduate research training programmes and the introduction of »market principles« to the research system. Basic research is to receive special treatment with an annual grant of DKK 200 million from the Danish Fund for Basic Research.

These are some of the main points in the Research and Development Programme of the Danish Government 1991.

The programme sets out the Government's guidelines and strategy for research for 1991-94 and includes a status for 1990-91. The annexes describe global trends in the area of research and Danish research in the international context.

The Danish Ministry  
of Education and Research  
Department of Research

September 1991