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COMMUNICATION FROM THE COMMISSION

"INVENTING TOMORROW"
Europe's research at the service of its people

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"... apart from generating new knowledge, we would like science to contribute to general well-being and social balance. We want to see scientific progress and innovation making a major contribution to Europe's future ..."

European Research Ministers, 1996

The purpose of this document is to open a debate with the participation of Parliament, Council and all those concerned by or interested in European research. The aim is to decide together the guidelines which will serve as the basis for a detailed proposal for the Fifth Framework Programme of research and technological development, which will determine Union action in this area as we move into the next millennium.

SUMMARY

INTRODUCTION

The world is changing ever more rapidly. Never before has there been such a mix of trends, ideas and aspirations, feeding on each other and contradicting each other at the same time. This is borne out by three statistics, all of which were difficult to imagine even a few years ago. In 1996 there are now 18 million unemployed in Europe, 1.3 million declared cases of AIDS throughout the world and 50 million Internet users.

Everything seems possible. We now have a global economy. Ideas, like capital, travel around the earth as fast as fibre optics and satellites permit. Every day, shares for an equivalent of US$2 000 billion are traded throughout the world. Increasingly, the value of products lies in their intangible characteristics. Unemployment on the other hand is a very tangible problem.

Meanwhile, work continues on the institutional framework for Europe with the opening of the Intergovernmental Conference which will determine the future of the continent for many years to come. Research policy will have to play its part as a force for integration and for shaping the future.

On a day-to-day basis, in a European society which is torn between moving ahead and marking time, each individual is at the same time a citizen, a consumer of products and services and a source of ideas and patterns of behaviour. Locked into a society which depends ever more directly on the acquisition of knowledge, individuals sometimes wonder about the impact of scientific progress on their lifestyle and values.

There is no denying that the world has become increasingly complex. In order to understand it better and to feel more at home in it, individuals require more knowledge. However, the answers to many of the major problems now facing society - growth and unemployment, and also health, the environment and mobility - have to be sought in science and technology.

This is the purpose behind European research. It is not an end in itself but a means of meeting common objectives. It is now time to change direction slightly in order to put it in its new context. Hitherto research has been based largely on technical achievement. The aim now is to make research more efficient and increasingly directed towards meeting basic social and economic needs by bringing about the changes which each individual citizen desires.

I. WHAT DO WE NEED FROM EUROPEAN RESEARCH AT THE BEGINNING OF THE 21ST CENTURY?

Europe needs research and research needs Europe.

With the globalization of economies and trade, the only way to solve many of our problems will be by bringing to bear the critical mass of Europe's own resources and knowhow. Europe provides the framework for national and local research activities and Europe is the level at which meetings of minds and cross-fertilization of ideas takes place.

Article 130f of the Union Treaty establishes an original instrument, the **framework programme** and sets out some general objectives for research in Europe:

(i) to strengthen the scientific and technological bases of Community industry;
(ii) to encourage it to become more internationally competitive;
(iii) to support other Community policies.

Four types of activity are envisaged:

(i) research, technological development and demonstration programmes;
(ii) international scientific cooperation;
(iii) dissemination and optimization of results;
(iv) training and mobility of researchers.

These four activities are the basis around which the fourth framework programme is organized. They correspond to areas where action at European level has proved fully justified.

Now that it has established its identity, European research has a value of its own. The sum is greater than the parts: joint projects, which are the principal way in which it operates, are an investment with a strong multiplying effect in both economic and social terms.

It is worth noting that in a recent opinion poll on "*Europeans, science and technology*", the citizens of the Member States supported research at European level "... *for reasons of efficiency* ..." (64% of those polled thought that "... *it is as efficient as or more efficient than national research* ..."), and considered that "...

it will increase in importance ..." (79% "*... to the same extent or greater than at present ...*") and that "*... it corresponds with national interests ...*" (69%).

I.1 General parameters

Before defining the objectives of the new framework programmes, it is essential to consider three parameters which are all connected in different ways with **added value**, which is the guiding principle of Community action:

- first of all, the **time-scale** set for achievement of results makes it necessary to re-consider the time it takes for research to find its way onto the market and into daily life. For example, 78% of the revenue of the computer industry comes from products which have been on the market for two years or less. The research activities undertaken by companies in the year 2000 will be aimed at the markets in the years 2003 to 2007 or thereabouts. Community research must at the same time prepare for the distant future and take account of shorter marketing lead times.

- Second, research should be undertaken at **European level** only if it is better done at that level than in the Member States or their regions. The framework programme accounts for only a fraction of the research carried out in Europe and is not designed to replace national research programmes. On the contrary, research at European level has to rely on sound national and regional structures, which make it easier for effective cooperation to take place.

  The idea is to **coordinate research in Europe** more effectively by ensuring the compatibility, complementarity and general coherence of the activities undertaken by the Union, the Member States and in other European or international cooperation frameworks.

- Finally, as with all public policies, the Union's research must comply with the principle of **budgetary efficiency**, since this will be a permanent feature of the planned move towards economic and monetary union. There will therefore have to be a precise estimate of the critical masses of resources which will have to be deployed and the results expected in each area of activity, where as a logical consequence topics will have to be chosen more selectively. More than ever before, European research will have to make a point of being as **cost-effective** as possible.

The total budgetary allocation will have to be decided by negotiation between government ministers and members of Parliament. To recall, European research investment in 1995 amounted to 1.9% of GDP, compared with 2.45% in the USA and 2.95% in Japan, where research spending has been increasing by 3% a year over the last seven years. Comparison with the major competitors of the Union indicates that private investment in research in Europe needs to rise.

The level of research is a sure guide to the confidence of a country or region in its own future. **Europe must "invent tomorrow".**

I.2 Challenges and opportunities (cf. annex)

Various studies and forecasts have been prepared (the Commission's "*Scientific Indicators*", the UK's "*Technology Foresight*", France's "*Key Technologies*", OECD studies, etc.) which identify the challenges and opportunities which Europe will encounter as we move into the next millennium, and also the key scientific and technical areas. As examples can be cited:

- ***The problems facing society in the Union and the challenge of sustainable development***: e.g. the problems connected with the need for mobility (the negative costs of traffic jams, accidents, environmental damage and human health are estimated at ECU 250 billion a year), the ageing population and the increasing cost of health care (the percentage of the population over 75 is expected to increase by about 40% between now and the year 2010).

  The concept of "eco-efficiency" - *producing more and better with less, whilst respecting the environment* - points the way towards reducing the burdens of waste and pollution, while at the same time providing the opportunity for businesses to make considerable savings.

- ***Market opportunities and job creation in Europe***. Many areas of technology are expected to show rapid growth: examples are the goods and services connected with environmental protection technologies, an area where certain European countries are a long way ahead (the European water market will grow to ECU 30 billion in the year 2000); the biotechnologies market, which in 1996 is estimated to be worth less than ECU 10 billion but is expected to grow to between ECU 40 billion and ECU 80 billion by the year 2000. At world level, there is a disturbing correlation between the loss of market shares in advanced technology areas by European industry, the rise in unemployment and the declining competitiveness of European countries.

These trends are not irreversible. Various studies show that, for example, the rapid and widespread introduction of advanced communications throughout the Union will add 3.5% to GDP growth between now and 2010, leading directly and indirectly to the creation of six million new jobs. More generally, conditions need to be created which at the same time encourage the development of high value-added activities, and support employment-intensive growth.

- ***The challenge of the globalization of knowledge and Europe's place in the world.*** Two thirds of world advances in science and technology take place outside the Union. Europe currently has 4.7 scientists and engineers per 1000 inhabitants compared with 7.4 in the USA and 8 in Japan. A new development is that together the total number of scientists and researchers in China, India and Indonesia is now the same as in the Union.

  Three needs arise from these considerations:

  (i) on issues of global importance (like climatic change and the emergence of new infectious diseases), knowledge, investment costs and risk should be shared;
  (ii) in areas where Europe does not have expertise, it should be able to draw on skills available elsewhere or have access to different environments;
  (iii) Europe should bring its influence to bear as widely as possible (e.g. by defining world standards) in order ultimately to capture markets.

- ***The European innovation "paradox".*** The Green Paper on innovation highlights a mismatch between Europe's scientific and technological potential and its record on innovation. For example, the total number of patents registered by Japan under the European patents system is higher than the number applied for by any single European country. In addition, it costs US$ 120 000 to file and maintain a patent in 8 Member States compared with US$ 13 000 in the USA.

  SMEs are a very important source of innovation. In addition to a small number of high-tech SMEs (e.g. in the areas of software and biotechnology) there is a much larger number of conventional SMEs which should be allowed access to research work and results.

1.3 Main objectives

Scientific and technical progress should pave the way for the opening up of new areas, whether they relate to knowledge, ideas, products, processes or services, in order to improve the quality of life for individuals and to help bring about the

harmonious development of employment, the economy and social cohesion in Europe. It should also contribute to sustainable development and growth.

If this new political will is to be incorporated into the framework programmes of the future, within the guidelines laid down by the Treaty, while supporting the aims of Community policies, various requirements will have to be met.

- It is essential to **satisfy the expectations of our citizens** for improved quality of life, work and environment, by making systems, products and services easy and safe to use within a perspective of sustainable growth. If science and technology are to be accepted and adopted by our citizens, research must be more comprehensible, more visible, and more accessible even though modern science is becoming increasingly complex.

- Research must have a **positive impact on employment and competitiveness**, by being based on "... *non-material investment in human capital and R&D, innovation* ...", as was emphasized at the Florence European Summit in June 1996.

  Some economists consider that technological change and the level of educational attainment account for 80% of growth. The generation of new ideas, which is a virtually unlimited resource, is an increasingly important factor here and makes it possible to transcend physical limitations. Recent studies[1] have shown that in the G7 countries an increase in research spending of US $100 will increase GDP by an average of US $123. The way to encourage the emergence of an innovatory tertiary sector, which will create jobs, is to have high performance industries and services based on high research intensity.

- The **frontiers of knowledge must be pushed back** in a number of key areas. This will require more than ever respecting the **principle of excellence**. Working together the best research teams in Europe have recently succeeded, by networking and by pooling their equipment, in sequencing the yeast genome, which is a world first and prepares the way for many medical and industrial applications. Europe must be a reference and focal point for world science.

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[1] *International R&D spillovers*. European Economic Review, vol. 39, No 5, May 1995.

- A more determined effort must be made to create a **favourable climate for research and innovation in Europe**. The framework programme must help the Member States to adapt their research and innovation systems and make them more coherent.

  Efforts must continue at **strengthening partnership** links throughout Europe between scientists, industry, universities and consumers so as to share out the risks, investment costs and benefits of research and to help create a real European scientific area and single market. In this respect it is encouraging to note that in some industrial programmes two thirds of the partnerships established for a given project carry on after it has been completed.

List of criteria

On the basis of these objectives it is possible to draw up a **list of criteria**. Now that a measure of maturity has been achieved, the fifth framework programme should provide the opportunity for choosing topics more **selectively**, by concentrating on those areas where Community research can play a decisive role. Each topic should be selected according to an optimal combination of criteria under the following three headings.

(i) "**Basic principles**", in particular:

- the **value added** at European level, with reference to the principle of subsidiarity and the resources available;

- the concepts of **public and social acceptability**, which ensure that research is meaningful to European citizens.

(ii) "**Major concerns**", like those repeatedly proposed at European summit meetings, in particular:

- tackling **unemployment**, through the possibilities of creating new jobs, or through a high level of employment in the areas selected for research;

- **competitiveness**, by concentrating on Europe's real assets (for example its knowhow, and its production and exploitation capacity), on the basis of the priorities identified by industry and market development prospects;

- helping to establish the **information society**;

- promoting a model for **sustainable development** by improving living conditions and reducing environmental damage;

- **preparing for the accession** of new Member States from **Central and Eastern Europe** and the **Euro-Mediterranean** partnership.

(iii) Support for **Community policies**, in particular through:

- helping to develop policies for **agriculture** and **fisheries**;

- defining the tools and systems needed for **transport**;

- knock-on effects on the European regions (**cohesion** policy);

- expanding knowledge and developing new techniques for **health** protection;

- developing and refining new **energy** technologies;

- involving **SMEs** more in research and innovation.

II. MOVING FROM THE FOURTH TO THE FIFTH FRAMEWORK PROGRAMME

The vast input already received for the next framework programme makes it clear that merely continuing the fourth framework programme would not be appropriate.

The priority would seem to be to consolidate our research efforts. Secondly, although it is worth persevering with certain projects and tried and tested principles and procedures,[2] it is essential to incorporate new topics and new ways of organising research. Attempts to shift the balance must be viewed in the light of the initial findings arising from analysis of the fourth framework programme.

11.1 Progress with the fourth framework programme

The fourth framework programme has been running for 18 months and is proving extremely attractive. In 1995 more than 20 000 proposals were received, resulting in 3 000 projects involving more than 10 000 participants.

It can be observed that the size of projects is tending to increase, including on average more participants from a larger number of Member States, the rate of renewal of participants is increasing (37% on average of which 40% are SMEs). One area of concern is the continual increase in the number of proposals not accepted: on average only 1 in 6 has received funding.

These preliminary figures clearly indicate a need for better targeting of calls for proposals and for more concentrated efforts as a way of reducing the dispersal of resources and the administrative burden. A detailed evaluation of projects will accompany the formal proposal for a fifth framework programme.

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[2] Most contributions received from Member States and other bodies with an interest in the future of Community research emphasize the positive aspects of the framework programmes, particularly in the fields of industrial research, establishing networks of researchers and encouraging researcher mobility.

Over time, apart from various "success stories" (*eg sequencing of the yeast genome, parallel computers, telecoms standards, first demonstrations of nuclear fusion)* it can be said that 100 000 partnership links have been established across Europe, which often lead to commercial relationships.

II.2 Shifting the balance to improve the impact on society and the economy

The new general policy guidelines to put research at the service of the people can best be achieved by improving the bases of European competitiveness within a perspective of sustainable development. This can be done by, at the same time, providing better support for the production of new ideas, taking more account of the realities of demand and reinforcing links with organizations which can help to exploit the results.

Supporting basic research

Reduction in the period of time which elapses between "discovery" in the laboratory and putting products "on the market", as well as the wider range of inputs required for the development of complex systems, tends to eliminate the old distinction between basic research and industrial and applied research. It is now difficult to catalogue the discovery of a new computer algorithm or a breakthrough in the sequencing of genomes, since the time between the discovery of new knowledge and its application may be extremely short.

Consequently it is essential to maintain a research context which is open to new ideas, for work on basic questions which may possibly generate new fields of activity.

Bringing research more into line with the real market

Discussions of the framework programme have always touched on the distance between research and the market and the difference between "academic" and "industrial" research. This is how the idea of "precompetitive" research came about, although its boundaries have become rather vague and in practice it is largely ignored by the major competitors in Europe.

Competition, whether intellectual, industrial or economic, is one of the basic driving forces behind research. However, three observations should be taken into account when preparing the framework programme. First, research should now be viewed within its world context; second, the spiralling costs of research and development are now beyond the means of individual operators or even individual states, which means that risks and investment costs have to be systematically shared out; third, it is important to consider how results can be exploited.

Experience shows that we should be moving from research aimed purely at technological achievement to research aimed at satisfying consumers by providing high quality goods and services which are produced in an acceptable manner at low cost and which are at the same time highly diversified and personalized and rapidly available.

The need to involve users much more in project design, which is beneficial in terms of meeting real needs, presupposes that much greater attention should be given to demonstration and prestandardization activities. This will require varying the level of support given, with appropriate transparency, whilst complying with international rules on research aid and the Community framework for state aid for research.

Doing more to exploit results

In previous framework programmes, not enough has always been done to exploit results. Additional efforts are required in order to extend the relationships between partners and networks so that results are better exploited and to ensure that risks are funded by calling on a wider range of sources of finance, including financial institutions and risk capital organizations.

The rules on intellectual property are closely linked with the question of partnership and exploitation. They will have to be changed to take account of technological progress, to provide more incentive for the exploitation of results and to ensure that European interests are pursued at world level.

III. *PRELIMINARY PROPOSAL FOR THE STRUCTURE OF THE FIFTH FRAMEWORK PROGRAMME*[3]

Given the framework and list of criteria set out above, an initial outline can be drawn of the structure and content of the future framework programme and of ways of implementing it.

III.1 Content

Without prejudice to the final structure, the number of subjects has been deliberately limited and the following three priorities can be identified along with three horizontal activities.

III.1.1 Priority topics (research at the service of the people)

The focus is on the targeting of activities and the impact the research will have on people's lives.

- **Unlocking the resources of the living world and the ecosystem**: The life sciences and the environment are literally vital to people's lives and have an especially critical impact on health. Europe must realize the full potential of its scientific and technical assets in these areas, which are also promising in terms of the growth of markets and the creation of jobs.

  This topic will in particular cover the acquisition and utilization of knowledge about fundamental mechanisms affecting human life, especially in the fields of health and food. Emphasis will be placed in particular on the acquisition of fundamental knowledge, the prevention of disease, (research on the brain and newly developing infectious diseases) and the quality, safety and renewable nature of bioproduction, while complying with ethical rules.

  For the environment, the development of environmental regulations, tax incentives and wider adherence to the principle of responsible behaviour call for a greater understanding of the interplay between environmental factors and the introduction of advanced forms of technology in order to safeguard natural resources, reduce the use made of them and tackle the problems of pollution and waste.

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[3] By extension, this discussion also covers the EURATOM framework programme.

This highly interdisciplinary research could in particular include in-depth study of matters relating to global environmental change, the basic cycles, natural hazards and European ecosystems.

- **Creating a user-friendly information society:** Europe has made a name for itself by developing the concept of an "*information society*", linking together technical, economic and industrial considerations and the social dimension. The very numerous applications to which it lends itself in virtually all areas of activity underline its enormous potential for increasing the competitiveness of industry and satisfying the demands of the individual.

  The anticipated technological and industrial convergence between computers, telecommunications and the media is now rapidly coming about through the use of digital systems and multimedia. The non-material aspects of this development, in particular the "content" of software, are especially important. The aim now is to identify the research needed for an information society.

  This research could aim at the development of technology, infrastructure, services and applications that are interoperable at world level. It will provide the foundations for very many jobs in tomorrow's world and will contribute toward the decentralization and personalization of activities in a more competitive and innovative framework.

  The identification of and experimentation with these new concepts and tools will give people easier access to information and education throughout their lives, help people to share the cultural heritage and preserve linguistic diversity.

- **Promoting competitive and sustainable growth:** This topic covers a range of priorities which are the result in particular of various Community policies. They have a major impact on the competitiveness of the Union in view of the considerable number of jobs involved and their common feature is that they lead to a reorganization of production systems in the interests of sustainable growth.

  Conventional forms of industrial manufacturing as well as the design and production of new products and materials will, for example, have to integrate the notions of product "life cycle", lower costs, the development of standards, and, more generally, "externalities", all of which have too often been disregarded in the past. Services and intangible activities, techniques for the design, production and management of complex systems and ergonomic considerations, all of which are becoming increasingly important in the economy, could also be developed.

In the energy domain, priority could be given to the development and demonstration of safe, acceptable energy systems which comply with standards and environmental constraints and are competitive in terms of production costs and the global economy. Research might also cover the rational management of energy in everyday life (e.g. the "town and home of the future"), as well as the various options as regards the production and storage of energy with a view to the medium-term and long-term.

As regards the mobility of passengers and freight, research could be directed in particular at optimizing efficiency, safety, environmental impact and competitiveness as these are all necessary to promote the quality of products and services, to ensure their integration at the European level and to capture world markets. Particular attention could be paid to the question of intermodality, combining different transport modes.

In the agricultural sector, it is necessary to flesh out the concept of an "integrated rural development policy". All activities in rural areas, including forests, could be linked within an integrated approach, based on the need for competitiveness and sustainability and ensuring optimum land use in these areas. New instruments and systems to optimize and diversify production need to be developed, focusing on complete cycles and sequences, multifunctional management (production and ecological and social aspects) and links between activities, incorporating quality, health, environmental and socio-economic considerations at all levels.

Lastly, in the fisheries sector, a multidisclipinary approach could be adopted to shape the future of this industry and help to restore fish stocks to their normal levels.

III.1.2 Horizontal activities

These activities will include two components: one general component designed to meet common needs and provide general coordination, and the other component related to the list of priority topics above.

- **Improving human potential:** Greater effort is needed to improve the training and mobility of scientists, including those in industry, and to encourage them to seek scientific research posts in Europe. This would require the provision of compatible training courses and equitable treatment of visiting scientists throughout Europe, extending the communication and exchange networks between laboratories and companies and granting access to major facilities, the duplication of which should be avoided, while ensuring that new projects are better coordinated.

The promotion of a European identity by introducing a European science prize (as recently suggested by the European Parliament) and the qualification of "European scientist" could be pursued. Better links could also be sought with education and training policy mechanisms.

In a socio-economic context, action will be needed to identify social needs more clearly and to improve understanding of the social impact of research work, the changes taking place in European society and the diverse nature of its component parts and foundations, eg by increasing capacity for foresight and the study of various scenarios resulting from the introduction of technology at work and in the economy, education and culture. New organisational and developmental models which may help to reduce problems of exclusion and to achieve a breakthrough in the creation of new jobs might be analyzed together with the most promising experiments carried out in this area.

- **Innovation and participation of SMEs**: Access to all research and research results by a larger number of "conventional" SMEs and mid-sized firms could be facilitated through the introduction of a single, simplified framework and the development of technology transfer mechanisms.

  In parallel, following the guidelines laid down in the innovation action plan, more attention could also be given to the ways in which results are analyzed and used to the best possible effect and to the establishment of links with risk capital and financial engineering mechanisms, as seen in the success of the NASDAQ. An analysis could also be made of different ways of encouraging research.

- **Confirming the international role of European research:** The following guidelines could be implemented in line with the Union's political objectives (particularly its foreign policy objectives) and the principle of mutual interest and on the basis of bilateral or regional agreements, and decisions to start programmes and specific projects:

  - *the direct, improved involvement of certain outside participants in research programme projects.* Particular attention could be given to the Central and East European countries in order to help with their rapid accession to the Union, and to encourage them to become fully involved in research. At the same time, for mutual benefit, greater participation of the industrialized countries, the emerging economies and possibly the countries of the Mediterranean could be envisaged.

- *the introduction of schemes to improve cooperation at European level* and *to make the European research area more attractive* to scientists from countries with which the Union has beneficial links;

- *the definition of specific international scientific cooperation projects*, along with the appropriate resources, either on specific topics or relating to specific countries or regions such as the Mediterranean, the CIS and the developing countries, to support external policy objectives, involving industry and European centres of excellence.

III.2 Implementation

With each framework programme, the question arises of the "dispersion" of projects and resources. There is also the problem of incorporating novel ideas that arise during the course of the programme and the difficulty of winding up activities, each of which is of interest, de facto, to a particular group of people.

The time has come to be more **selective** about topics and to ensure a greater **concentration** of resources. For it to succeed, this approach must be accompanied by greater **effectiveness** in implementation while complying strictly with the **principle of transparency**, especially in the project selection process. The Commission will also work to ensure the **avoidance of fragmentation** in Community research.

Increasing flexibility in research work and the decision-making process

The procedures set up over the years for the framework programme need to be slimmed down, while retaining the defining principles of equality of treatment and access and of transparency.

There is much room for improvement in the institutional support arrangements. At the Intergovernmental Conference, the Commission will, for example, advocate a **simplified decision-making procedure** for implementation of research policy and specific programmes and for their adoption by a qualified majority. Matters could also be simplified by **reducing** considerably **the number of programmes** and the **number of committees**.

It needs to be possible to supplement and adjust work programmes at regular intervals in line with scientific and technical changes and policy

developments. In the event of an emergency, as recently with the problem of "mad cow disease", there needs to be an arrangement for the rapid regrouping of several areas of action around a single target, for bringing together the resources needed and, where appropriate, for redirecting effort.

Ensuring more efficient management

A slight improvement would seem to be possible where management techniques are concerned. The Commission has called for ideas about possible ways of **simplifying** internal management procedures and the procedures governing external contractual relations.

A stated aim is to **shorten the deadlines** and reduce administrative costs, e.g. when selecting proposals and concluding contracts, and when making payments, a matter of particular importance for small firms and researchers in receipt of grants.

The **calls for proposals** must be published on a regular basis, be compatible with the working patterns of industry, research centres and universities, and meet the requirements of sound management. Where the procedures governing the **selection** of proposals are concerned, it would seem to be necessary to explain the selection criteria more clearly.

Lastly, the need is being felt for some kind of **monitoring** tool with which to measure, in real time and on the basis of objectives, indicators and high quality statistics, the state of progress and performance of the framework programme, **and a forum** (e.g. on the Internet) **for ongoing dialogue** with participants in the Fifth Framework Programme and other interested parties.

Extending the range of instruments and means of coordination

The approach so far, which has very largely consisted of juxtaposing a large number of projects (50/50 partnership for a project generally of a modest size), should be replaced by a wider range of modalities and financial instruments more appropriate to the various objectives, whereby it is possible to establish closer links between Community activities and national activities or between national activities on certain topics.

In order to be able to respond rapidly to the considerable pressure to allow spontaneous proposals, to include emerging interdisciplinary research topics (e.g. neurosciences) and to allow for the unexpected, there needs to be some leeway, albeit strictly controlled in terms of decision-making;

The following instruments in particular are envisaged:

- a small number of **horizontal programmes** with a strong focus on generic technologies applicable to many areas, capable of giving rise to and sustaining more targeted research topics not necessarily always specified initially;

- ***"task forces"***. This approach is that of targeted research, open to all comers, on unifying topics. Task force activities are a new concept introduced by the Commission on an experimental basis with the fourth framework programme;

  This type of research is based on the idea of placing advances in knowledge and technologies at the service of central societal and industrial objectives, thus meeting the three objectives of transparency, selectiveness and concentration. In practice, the task forces are primarily coordination instruments for formulating and monitoring the implementation of a limited number of new short-term activities, for which priorities must be identified in close consultation with industry, consumers and governments.

- **instruments for encouraging cooperation between Member States**. To be truly significant, European research must not confine itself to work carried out together solely within the specific programmes. Depending on the genuine desires of the Member States, the Commission is willing to promote this approach on specific topics, making use of the possibilities afforded by Articles 130k (supplementary programmes), 130l (participation in projects undertaken by certain Member States) or 130n (participation in joint undertakings) of the Treaty.

Where these first three instruments are concerned, COST could be used, as it was to begin with, as a breeding ground for ideas, while links with EUREKA could be improved in order to direct the results of Community research towards the market. This would necessitate closer interaction between the framework programme and these two forums for cooperation whose strategy is currently under review.

In addition, there is a need for more exchange of information and better **coordination** between Community and national research policies and investments.[4] Greater consistency would entail a competitive advantage and a financial saving, enabling the Union and the Member States to focus more effectively on their respective objectives.

- to ensure that the framework programme is better equipped to provide effective support for other Community policies, there is a need for a significant improvement in the **mechanisms for liaising and interfacing with the instruments of the other policies** so as to make these instruments "interoperable"[5] with research and to make the Community activities more effective.

  International cooperation[6] and the Structural Funds are chiefly concerned. In the latter case, the aim is to encourage the Member States to devote a larger proportion of structural resources to research in order to foster the rapid development of their potential for scientific excellence and confirm the catching-up process that has begun[7].

- the **Joint Research Centre**: the role and tasks of public laboratories are being carefully examined in all the major industrialized countries. The laboratories that go to make up the JRC should, similarly, be used for clear and ambitious tasks, striving for excellence and focusing on a few aspects in line with new needs emanating from industry and the market. It is necessary in particular:

  - to make available independent and impartial expertise to meet the needs of Community policies and contribute towards the scientific basis for Union policy decisions;

  - to ensure closer links between the institutes and the national and international laboratories.

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4 See Article 130h of the Union Treaty: "*The Community and the Member States shall coordinate their research and technological development activities so as to ensure that national policies and Community policy are mutually consistent.*"

5 Experience with the task force approach has shown how difficult it is to involve different programmes (e.g. research and education programmes) in a joint call for proposals exercise.

6 Where international scientific cooperation is concerned, improvements are already in sight with programmes such as TACIS, PHARE and MEDA being opened up more widely in order to allow the participation in Community research projects of entities from the countries concerned.

7 A communication on the relationships between research and the structural funds is currently being prepared by the Commission.

The JRC needs to be given the organizational flexibility it requires to be in a better position to cooperate with industry and users within a properly adapted legal framework. The emphasis will be on utilizing the know-how and expertise of the institutes' researchers and facilities, which in many areas are unique in Europe, transfers of technologies, and industrial joint ventures.

CONCLUSIONS

The preparations for the fifth framework programme are taking place in a period of rapid and far-reaching change. The critical problem of employment, the increasing globalization of the economy, and the movements in progress in the building of Europe (Intergovernmental Conference, economic and monetary union, enlargement) introduce many additional factors in this exercise.

We therefore need to examine under a new light the rationale for European research. If it is to continue to exist, its tasks must be more transparent and visible, it must be carried out more simply, and its results must be more effective.

A first set of guidelines can be drawn. While maintaining the continuity of certain recognized achievements, new balances must be established and the content of research topics renewed in the light of the challenges and opportunities of the horizon 2000+.

Basically, it is a question of moving on from research focusing solely on technological performance towards research focusing on the citizen and the response to economic and social needs.

In order to succeed, a strong political will based on consensus is needed. The Commission invites discussions and reactions to these first guidelines. Subsequently, it will be submitting detailed proposals to the Parliament and Council.

Fact, figures and trends

1. Europe's position in world research
2. The European paradox
3. European research within the international technological scene
4. American and Japanese research efforts
5. SMEs, research and employment
6. Visions of the future and priorities
7. Society's needs and market prospects: some examples

    Sustainable development and the environment

    Biotechnologies

    Health

    The information society

1. Europe's position in world research

The share of GDP devoted to research, expenditure by industry on research, expenditure on research per inhabitant, the total number of researchers and of researchers in companies in proportion to the active population as a whole are all lower in the European Union than their equivalents in the United States of America and Japan.

	EU 15	USA	JAPAN
Total R&D expenditure (million ecu) 1994	121,802	142,047	104,069
Total R&D expenditure as a % of GDP 1995	1.91	2.45	2.95
Total R&D expenditure per inhabitant (ecu) 1994	329	545	833
% of total R&D expenditure financed by the State 1993	39.6	39.2	19.7
% of total R&D expenditure financed by industry 1993	53.5	58.7	73.4
Number of researchers 1993	774,071	962,700	526,501
Number of researchers per thousand active persons 1993	4.7	7.4	8.0
Number of researchers in companies 1993	376,000	765,000	367,000
Number of researchers in companies per thousand active persons 1993	2	6	6

Source: European Commission DG XII, from data supplied by OECD

Observing the major indicators (expenditure on research, the number of researchers) for other regions of the world reveals that the nations of the Triad are no longer the only players on the international scientific and technological stage. New powers are emerging and progressively hoisting themselves up to the level of the most advanced countries.

Main indicators for some areas of the world

	Gross Domestic Expenditure on R&D ($ billions)	*GERD/Gross Domestic Product %*	*R&D scientists & engineers (000s)*	*R&D scientists per thousandpopulation*
Central & Eastern European Countries	2.89	1.5	285.5	2.2
Israël	1.24	1.9	20.1	3.8
Latin America	3.93	0.4	158.5	0.3
NICs	10.73	1.3	136.7	1.5
China	22.24	0.7	391.1	0.3
India	7.1	0.8	106.0	0.1

Source: European Commission DG XII (1994) European Report on S&T Indicators; UNESCO; OST estimates and treatment, 1995 *UNESCO, World Science Report*

2. The European paradox

World share of publications in %

	1981	1993
EU 15	29	32
USA	37	36
JAPAN	7	8
OTHERCOUNTRIES	27	24
WORLD - Total	100	100

Europe remains a major scientific power: about one-third of the world's scientific publications originate in the European Union and Europe's share of this total has even increased in the last few years. An analysis of the patents registered in the United States and in Europe reveals, however, that European technological performance is, overall, weaker than that of its competitors: this is the "European paradox".

World share in % terms of registered patents

	In the USA		In Europe	
	1990	1993	1990	1993
EU 15	23	18	46	46
USA	45	50	26	29
JAPAN	25	24	21	18
OTHERCOUNTRIES	7	8	7	7
WORLD - Total	100	100	100	100

Source: European Commission DG XII, OECD, EUROSTAT

If we break down the shares of European and American patents worldwide by field, what clearly emerges is the predominance of Japan in advanced technologies, the importance of traditional sectors in Europe and the substantial presence of American industry in all sectors.

The positions of the Triad by technological area, measured in patents, 1993

	European patents world share (%)			US patents world share (%)		
EUROPE	European Union	USA	Japon	European Union	USA	Japon
Electroncis/ electricity	34.2	30.0	31.8	11.5	46.7	35.4
Instruments/optics	37.8	32.4	23.4	14.9	50.8	28.0
Chemistry/pharmaceuticals	40.3	33.7	20.0	28.2	51.0	19.7
Industrial processes	50.1	25.6	16.6	22.3	50.5	19.3
Mechanical engineering/transport	58.5	19.2	15.5	23.6	45.4	22.5
Consumer goods	64.0	16.9	8.0	19.1	50.1	12.5
All fields	45.4	27.3	20.9	18.6	48.7	26.0

Source: USPTO data; OST and CHI-Reasearch treatments, 1995. *UNESCO World Science Report*

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3. European research within the international technological scene

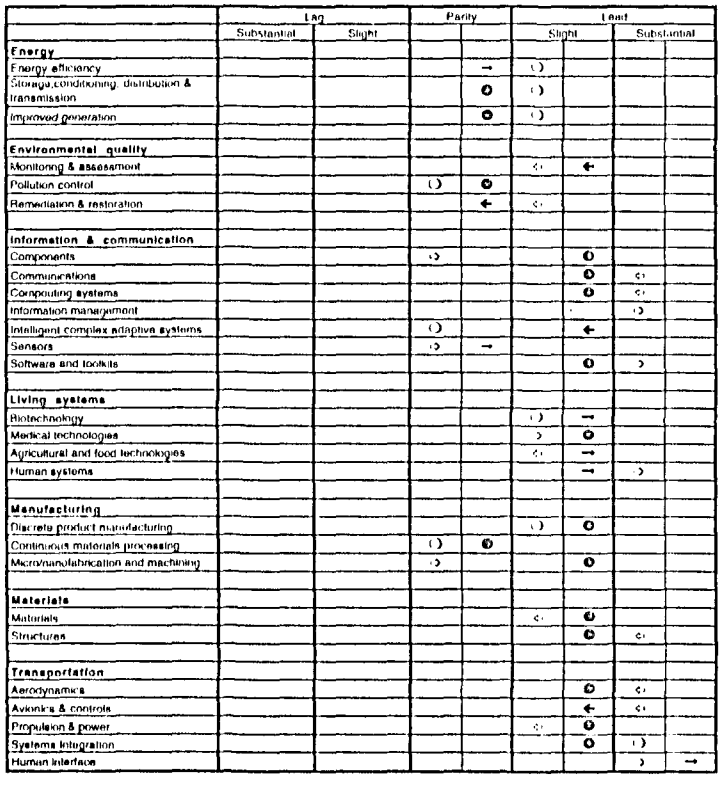
A decline in the balance of trade between the Union and the rest of the world for high-level R&D goods indicates that European technological competitiveness is being eroded: in the last ten years, the deficit has increased ten-fold.

Trade balance in thousand million dollars

	1982			1991		
Industrial sectors, of which:	*European Union*	*USA*	*Japan*	*European Union*	*USA*	*Japan*
High-level R&D	-2.21	13.48	15.98	-23.64	12.48	52.36
Medium-level R&D	69.93	6.23	54.92	87.79	-23.44	133.34
Low-level R&D	35.75	-18.01	24.07	5.54	-43.05	-9.21

Source: Chelem CEPII; OST traitement OST, S&T Indicators 1996

US Technology Position Relative to Japan & Europe



A comparison of the American, European and Japanese positions in a series of "critical technologies" shows that, despite the erosion of its position in some sectors, the USA continues to dominate the international technological scene.

US Technology Position Relative to:			
	Improved	Declined	Maintained
Japan	›	‹›	( )
Europe	→	←	o
1990-94 Trend			

Source: National Critical Technologies Review Groups *Science Engineering Indicators 1996*

4. American and Japanese research efforts

United States of America

Although there was a nominal increase between 1990 and 1996 in the American federal budget for research, in fact it declined slightly in real terms. The origin of this fall was a reduction in military R&D funding.

On the other hand, civilian research expenditure has increased in real terms by $3.4 billion in the last five years. The relative shares of the health, space, energy and basic research sectors in the federal budget increased. For 1997, despite budgetary restrictions, the Clinton/Gore Government proposed a budget increase of 1.6%.

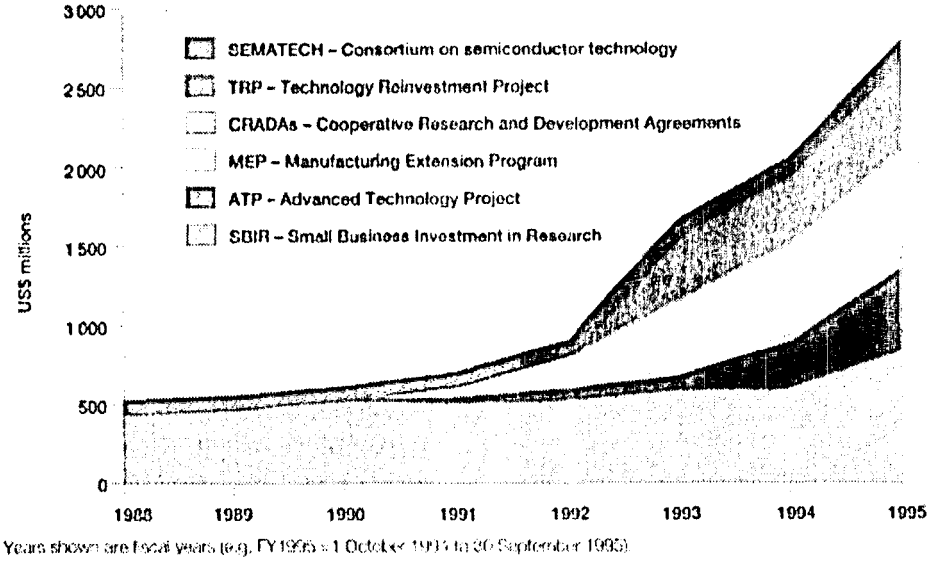
Evaluation of priorities of American federal R&D funding (R&D budget appropriations by socio-economic objective)

	1990	*1995*	*1996*
Total value (in $ million)	*63 781*	*70 309*	*70 503*
Defence	62.6	54.8	53.3
Health	13.0	16.2	16.7
Space research and technology	9.0	11.2	11.2
Science	3.8	4.0	4.3
Energy	4.3	4.1	4.4
Natural resources and environment	2.2	2.9	3.1
Transport	1.6	2.7	2.8
Agriculture	1.5	1.7	1.7
Other	2.0	2.4	2.5
Percentage total	100.0	100.0	100.0

Source: National Science Foundation

Between 1991 and 1995, funding for American research programmes based on partnerships with the private sector grew considerably in number.

Selected Federal Partnership with Industry



Years shown are fiscal years (e.g. FY 1995 = 1 October 1994 to 30 September 1995).

Source: Department of Commerce data, 1995

UNESCO, World Science Report

Japan

While occupying a leading position in the application of technology, but behind the United States and Europe in basic research Japan has begun to make massive investments in science and human resources for research purposes. At the same time, its level of industrial research remains high.

Increases in the Japanese public research budget in 1996:

Total public research budget: + 6.9%

Bodies:

- Ministry of Science (MONBUSHO):	+ 7.2%
- Ministry of International Trade and Industry (MITI):	+ 5.3%
- Science and Technology Agency (STA):	+7.2%
- Industrial Research and Technology Agency:	+7.4%

Programmes :

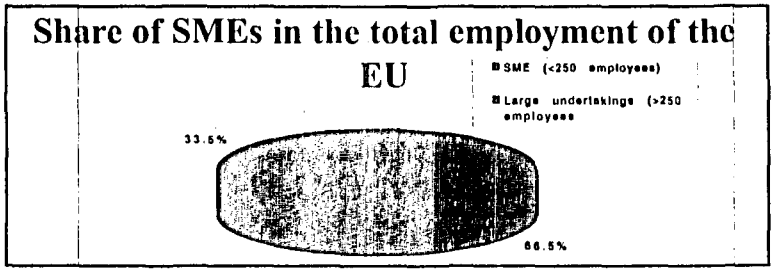
- Post-doctoral fellowships:	+ 33.5%
- Programme for centres of excellence:	+ 23.8%
- Research aid grants:	+ 10.2%
- "Industrial Science and Technology" programme:	+ 6.3%

Areas (examples):

- Strategic basic research:	+ 100%
- Space:	+ 5.2%
- Nuclear energy:	+ 7.2%

5. SMEs, research and employment

SMEs are the largest source of employment in the European Union. In addition, small and very small undertakings produce the most innovations. Analysis reveals that the sectors with the greatest growth in research investment are also those where most jobs are being created.



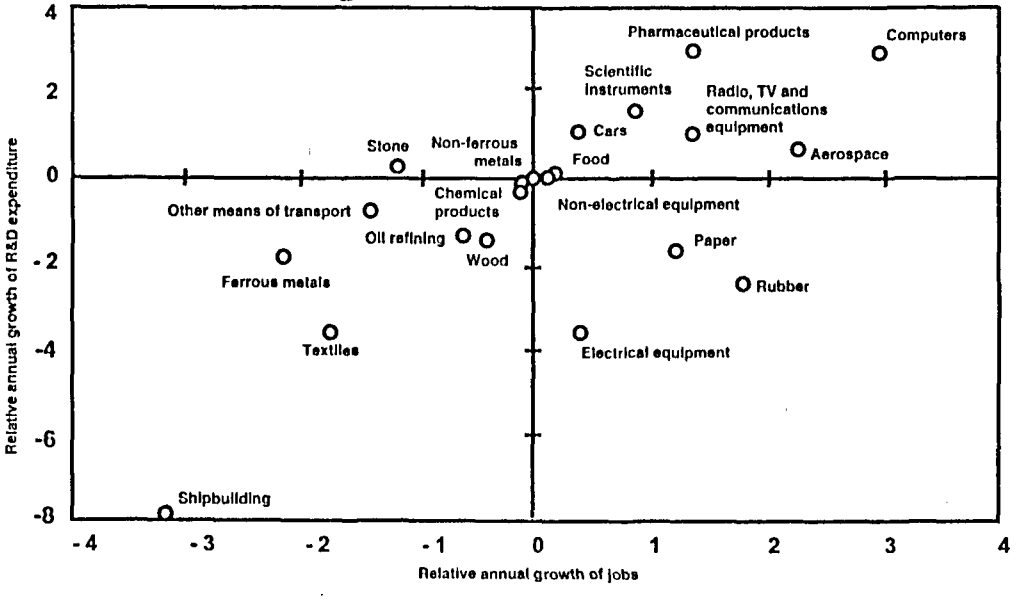
Source: European Commission Eurostat, SME Project database, 1995.

Percentage breakdown of innovations according to categories of salaried employees (Ireland, Italy, Netherlands, United Kingdom)

Size category	Ireland	Italy	Netherlands	UK
1-19	61.0	14.4	35.0	22.4
20-49	21.0	21.3	18.4	14.7
50-99	9.0	27.2	10.9	26.7
100-499	8.0	14.1	21.1	15.6
500-999	1.0	5.5	14.6	7.6
1000 and over		17.5		13.0
Total	100.0	100.0	100.0	100.0

Source: European SME Observatory, 1995.

R&D expenditure and growth in jobs, 1973-1990
Average percentage growth rates per industry in relation to total industrial growth for the 13 OECD countries



Source: OECD STAN Database

6. Visions of the future and priorities

For the last thirty years, Japan and the United States have regularly carried out "foresight exercises" (studies for scientific and technological future planning). Operations of this type have recently been launched in Europe (particularly in the United Kingdom, France, Germany, Denmark, the Netherlands and Spain).

A comparison of their conclusions shows a high level of convergence in the priorities chosen when the subjects are merged at high and medium levels (optoelectronics and artificial intelligence; nanotechnologies and new and intelligent materials; biotechnologies, molecular biology and neurosciences; environmental technologies and clean energy production technologies, etc.).

In terms of economic and social objectives, two major themes emerge:

- **the information society;**
- **sustainable development.**

These conclusions also converge with those of "Project 2025" undertaken at the request of 18 major organizations and companies in the USA, United Kingdom and Germany. Based on a critical analysis of 1500 foresight exercises carried out since 1970, this project has resulted in the drawing up of a list of 83 "high probability" hypotheses for the year 2025. The major themes include: *integrated management of the environment and natural resources; integrated management of human health; the advent of the "electronic global village"; intelligent manufacturing.*

Source: OECD Science Technology Industry Review, No 17, Special issue on Government Technology Foresight Exercises: The competitive position of European science, technology and industry - an ESTA opinion in relation with the 5th Framework Programme; L'avenir hautement probable, 83 hypothèses sur l'année, 2025, Joseph Coates, Futuribles, April 1996.

7. Society's needs and market prospects: Some examples

Sustainable development and the environment

There can be no sustainable development without research playing its part. Among others, two of the major problems to be solved are water resources and the impact of transport on the environment. At European, as at world level, the environment represents a potentially important market.

Water: a rare resource

Water is becoming a rare resource in Europe and in the world. 65% of the water drawn from rivers, lakes and aquifers in the world is used by agriculture. 1 000 tonnes of water are needed to produce a tonne of wheat. An additional 27 million cubic metres are needed to feed the 90 million people being added to the world population every year.

20% of European surface waters are under threat. 60% of farmland presents a concentration of fertilizers and pesticides which is hazardous to the water quality in its vicinity. Between 15 and 30% of the water collected in Europe is lost in the course of its distribution.

Source: Commission staff working paper on Research-Industry Task Forces (SEC(96)568)/The state of the planet 1996.

Transport costs

In the space of 50 years, the world population has doubled while the number of private vehicles has increased tenfold and now amounts to about 500 million. At this rate there will be 1 000 million cars in the world by 2025 or 2030. In Europe alone the number of cars is expected to increase by 25% between 1992 and 2005.

Transport accounts for 30% of final energy requirements and is responsible for 25% of all CO_2 emissions. Road transport alone represents 80% of the CO_2 produced by transport. The total cost of problems other than health problems attributed to emissions from transport is estimated at between 0.3 and 0.4% of GDP.

Source: Commission staff working paper on Research-Industry Task Forces (SEC(96)568)/The Economist, 22 June 1996 "Living with the car": a survey.

The world environmental market
Estimates in $ '000 million

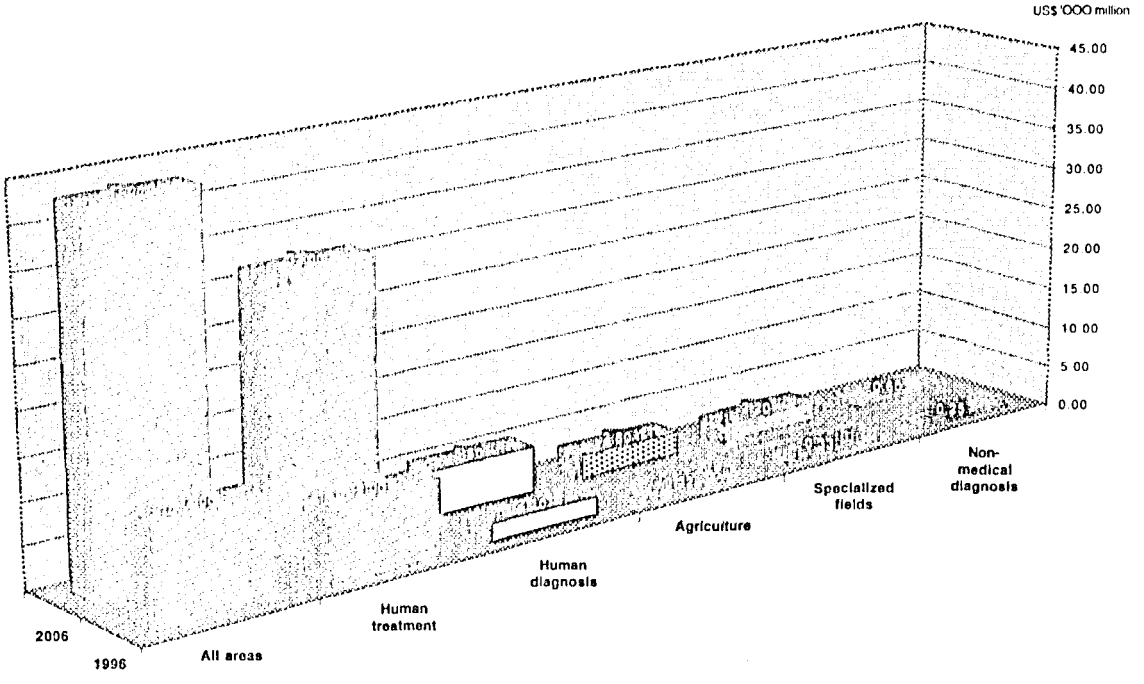
	OECD	*ECOTEC*	*ETDC*	*Environmental Business International*
Year	2000	2000	2000	1998
North America	125	147	217	199
Latin America	-	5	-	10
Western Europe	78	89	188	132
Eastern Europe/NIS	21	9	25	27
Asia & the Pacific	42	63	138	49
World total	300	320	580	426

Source: OECD (1992); ECOTEC (1994); ETDC (1994); OTA (1994).

Biotechnologies

The market for biotechnology-based products is one of the fastest growing in the world. In terms of the number of companies, jobs, turnover or research expenditure, American efforts in this area are currently much greater than their European counterparts.

Global Sales for Biotechnology-Based products
10 year Projection (1996-2006) - in 1996 $ Billions



Source: Consulting Resources Corp.

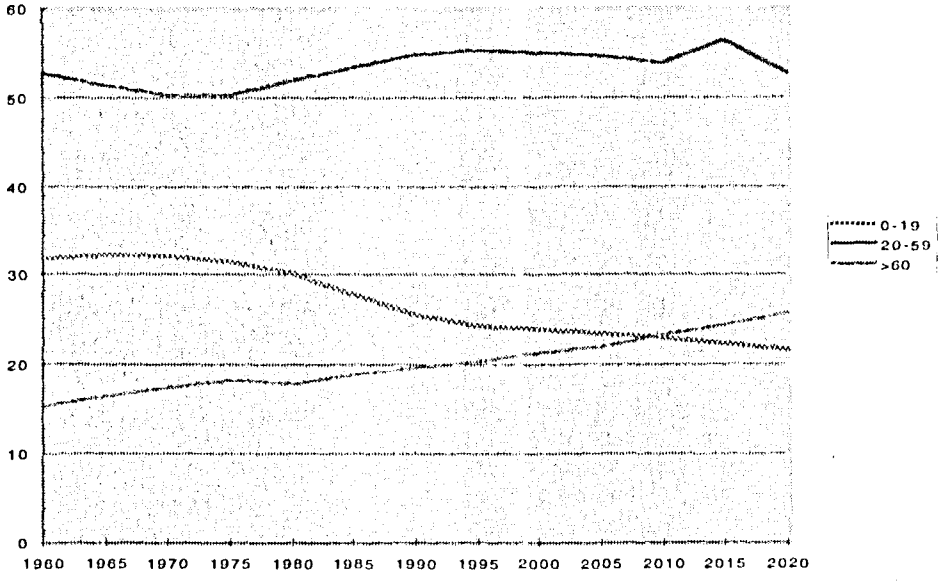
EU vs US BIOTECH SECTORS
(Ecu Millions)

	Europe	US
Financial		
Turnover	1 158	9.663
R&D Expenditure	605	5.859
Industry		
Number of Companies	584	1.308
Number of employees	17 200	108.000

Source: Ernest & Young BioBusiness

Europe's population is becoming older. By the year 2020, over a quarter of people will be more than 60 years old, while those under the age of 20 will constitute only just over one-fifth of the population. The consequences of this trend in medical and public health terms are important.

EU population by age group (%)



Source: Eurostat, Europe in figures

Throughout the world, infectious diseases affect hundreds of millions of people and kill tens of millions.

Populations Affected by Various Infectious Diseases, 1993

Disease	Deaths	Incidence
Acute Respiratory Infections	4.1 million	248 million
Diarrheal Diseases	3.0 million	1.8 billion
Tuberculosis	2.7 million	8.8 million
Malaria	2.0 million	300-500 million (prevalence)
Measles	1.2 million	45 million
Hepatitis B	1.0 million	2.2 million
HIV/AIDS	700000	2-3 million
Cholera	6800	380000
Polio	5500	110000

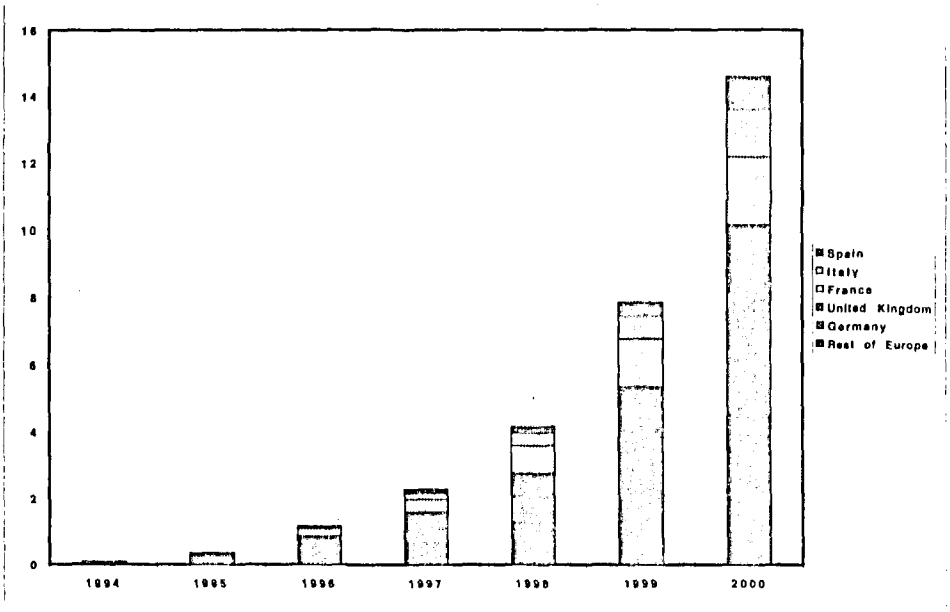
Source: WHO, 1995

State of the World 1996

The Information Society

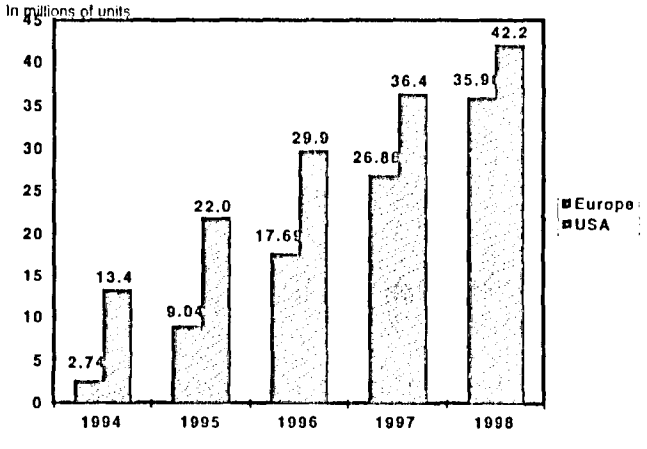
Europe has entered the information society. The number of connections by private individuals and firms to the Internet and the market for CD-Rom drives is increasing at a steady pace. American firms are currently producing most of the CD-Roms available

The Internet Market in Europe, 1994-2000
Number of Households with Internet Access (Millions)



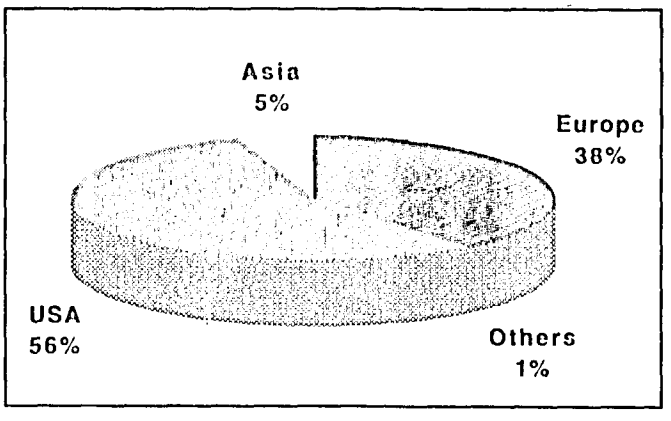
Source: European Information Technology Observatory EITO 1996

Homes equipped with CD-Rom drives



Source: Inteco 1994

World production of CD-Roms in 1995



Source: TPFL Publishing, Facts & Figures 95