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RESEARCH ON NANOSCIENCES AND NANOTECHNOLOGIES WITHIN THE EUROPEAN UNION'S 6TH FRAMEWORK PROGRAMME

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1. INTRODUCTION

The multi-annual Framework Programmes for Research and Technological Development of the European Community provide funding for research carried out at European level.

Nowadays, the European Commission (on behalf of the European Community) supports a significant portfolio of nanosciences and nano-technologies related projects. Already in the 4th Framework Programme (1994 – 1998), some 80 projects involving nanotechnology were funded. In the 5th Framework Programme, (1998 – 2002) the estimated funding level raised at about 45M €/year. The overall project portfolio is very wide in scope, encompassing for example nano-electronic devices, medical devices, giant magneto-resistance, carbon nanotubes, bio-sensors, molecular diagnostics, nanocomposite materials and atomic force microscopes.

In the case of the current 6th Framework Programme (2003–2006), nanosciences and nanotechnologies are a priority. The role played by the Union's initiatives is of paramount importance with respect to the total public funding in Europe. In broad terms, we can estimate the grand total for the European investment in nano-research being now of the order of almost 700M € per year.

The 6th Framework Programme has been tailored to help better structure European research and to cope with the strategic objectives set out by the EU Heads of State and Governments in Lisbon in 2000. This should enable Europe to become the most dynamic and competitive knowledge-based economy of the World within the next 10 years. The commitment is clear: a sustainable development.

The twofold transition towards knowledge-based society and sustainable development demands new paradigms of production and consumption. There is a need to move from resource-based approaches towards more knowledge-based ones, from quantity to quality, and from mass produced single-use products to new concepts of higher added value, eco-efficient and sustainable products, processes and services.

Materials sciences and nanotechnology allow us now to add value and «intelligence» to materials, components and systems. This will offer great benefits to society and boost the shift from production-oriented approach to a use-and-performance-driven industrial society. Novel activities, and the new generation of high-tech industries are showing up on the market. The shift from labour-intensive to brain-intensive operations modifies jobs and the skills required of engineers and the workforce.

To take the benefits from the opportunities afforded by nanotechnology, challenges must be met. There are challenges at a scientific and technical level: to increase our basic understanding of the nano-world; to create new materials, devices and processes; to establish new tools and techniques for industrial manufacture. There are also many

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challenges at a structural level: to maximise the efficiency of publicly funded pre-competitive research; to educate the next generation of students; to enhance the societal awareness and perception; to use standardisation for increased efficiency; and so on.

Top-quality research in very advanced and promising priority technological areas is vital to foster such a transformation of European industry and society. Nanosciences and nanotechnologies are one of these priority areas.

2. THE EUROPEAN UNION'S 6*th* FRAMEWORK PROGRAMME FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT

The 6th Framework Programme is formulated within the context of the European Commission's initiative on the European Research Area. This initiative addresses the perceived weaknesses of European research and seeks to improve co-ordination between the research programmes of the Member States, the Accession Countries, the Associated States and those implemented by the European Commission. It addresses key elements of European research, such as the scope and scale of projects, support for research to the benefit of small and medium-sized enterprises, the critical questions of scientific education, careers and mobility, and the relationship between scientific endeavour and society.

Annual or biannual workprogrammes are defined. To realise the research, the following instruments are used: Integrated Projects (IP), Networks of Excellence (NE), specific targeted research projects (STREP), co-ordination actions (CA), and specific support actions (SSA).

The majority of the funding in the 6th Framework Programme is in the form of grants to research projects. Research will be long term and highly challenging, but oriented towards industrial breakthrough applications. Special emphasis is given to education and training to create the required pool of multidisciplinary skilled personnel, without whom any substantial progress into the knowledge and exploitation at the "nano level" will be impossible, hence also the need to increase awareness for these new scientific and technological challenges.

In addition, it is expected that breakthrough research activities help fostering dialogue with society and generating enthusiasm for science. Whenever appropriate, ethical, societal, health, environmental IPR and regulatory issues, in particular metrology aspects, should be addressed.

With the 6th Framework Programme, Europe does not plan to go alone. We are ready to gather a critical mass whenever and wherever appropriate in order to achieve our goals more effectively and more rapidly. Indeed, another peculiarity of the 6th Framework Programme is its openness to international co-operation: researchers from virtually all countries of the world can participate. In particular, reinforced co-operation is enforced with those countries, which have a bilateral scientific/technical agreement incorporating nanotechnology, such as the USA, China and Russia.

In the 6th Framework Programme (www.cordis.lu/fp6) the main funding channels for research projects and networks are a series of eight Thematic Priority Areas, collectively constituting «Focusing and Integrating Community Research». Of further particular interest are also the parts «Structuring the European Research Area» (concerned specifically with human resources and mobility, research infrastructures and «Science and Society») as well as «Strengthening the Foundations of the European Research Area».

In order to establish and maintain a coherent approach to nanosciences and nanotechnologies, all of the relevant Thematic Priorities and Specific Programmes operate in co-ordination. In particular, a cross-programme section «nanotechnology» on the Cordis information service (www.cordis.lu/nanotechnology) has been created. Appropriate criteria are established in order to address concerns about overlaps and voids, so to serve at best the scientific community and industry.

Focusing and Integrating Community Research

Given the wide-ranging nature of nanotechnologies, it is likely that several thematic priority areas will provide funding for their application, including dedicated support for medium- and small-sized enterprises. Of particular relevance for the development of nanosciences and nanotechnologies is however the Thematic Priority Area 3 «Nanotechnologies and Nanosciences, Knowledge-based Multifunctional Materials, and New Production Processes and Devices».

The Thematic Priority Area 3

The Thematic Priority Area 3 «Nanotechnologies and Nanosciences, Knowledge-based Multifunctional Materials and New Production Processes and Devices» will include a wide-ranging programme on nanosciences and nanotechnologies (including

nanobiotechnology) research and development activities. The Community public funding for nanotechnology under this programme may be estimated to mobilise total financial resources in the range of one billion € over the four-year period of the 6th Framework Programme. Two global objectives are defined: first, to stimulate the introduction of innovative nanotechnologies in existing industrial sectors; and second, to stimulate breakthroughs, which can lead to entirely new materials, new devices, new products and new industries. The overall approach is an integrative one, where long-term and medium-term aspects of given scientific/technological developments may be pursued as elements within a project. The programme covers essentially all nano-material types and related device and process developments. It includes long term research, research into techniques and instruments, nano-structured structural and functional materials, and related application development.

The primary objective of the Thematic Priority Area 3 is to promote real industrial breakthroughs, based on scientific and technical excellence. This requires changes in emphasis in Community research activities from short to longer term and in innovation, which must move from incremental to breakthrough strategies. The transformation of industry towards high-added value organisations necessitates real integrated approaches, either «vertical», combining materials sciences, nanotechnologies and production technologies, as well as other technologies based e.g. on information technologies or biotechnologies, or «horizontal», combining multi-sectoral interests.

Other Related Thematic Priority Areas

As said above, nanotechnology applications will be investigated under other Thematic Priority Areas, such as those dealing with life sciences, information society technologies, aeronautics and space and energy. In particular, within the Thematic Priority Area 2 «Information Society Technologies», nanotechnology relevant activities contribute mainly to three areas, namely «Micro, Nano and Opto-electronics», «Micro and Nano Technologies, Microsystems and Displays» and «e-health». In the first case the objective is to reduce cost, increase the performance and improve reconfigurability, scalability and self-adjusting capabilities of electronic components and systems-on-a-chip. In the second case, the aim is to bring improved intelligence and functionality in "everything", exploiting the possibility of networking. The third case will directly contribute to the improvement of quality of life of European citizens through better diagnosis systems and data treament after networking. This may occur in a distributed fashion or localised for improved miniaturisation and portability. Research may also address introducing or upgrading sensing, actuating operations and improving the interaction of every potential item with their surrounding and with the individuals, building upon research in micro-, nano, micro-nano-systems and large integration technologies for increased quality of life.

Structuring the European Research Area

Different activities of "Structuring the ERA" are relevant to nanotechnologies and nanosciences. Within "Human Resources and Mobility" and under the common "Marie Curie" label (MC), host-driven actions such as "MC Research Training Networks" or "MC Host Fellowships", will provide support to organisations hosting European and third-country researchers for transnational training and mobility of researchers. All fields are covered including nanotechnologies and nanosciences. In addition, individual-driven actions such as "MC Intra-European Fellowships" will also be supported. Within the Research Infrastructures activity, different schemes of support is implemented such as, for example, "Transnational Access". Where relevant, this activity, which by its nature and means of implementation is applicable to all fields of research and technology, can be implemented in association with the thematic priorities. Moreover, dedicated initiatives related to the societal and ethical implications of nanotechnology are launched within the "Science and Society" activities. The above mentioned www.cordis.lu/fp6 website can provide detailed information.

Strengthening the Foundations of the European Research Area

There are efforts to encourage co-ordination activities, using a bottom-up approach, also in the field of nanosciences and nanotechnologies. The objective of the co-ordination at European level is to enhance the complementarity and synergy between Community actions undertaken under the Framework Programme and those of other European research co-operation organisations, for example within the framework of the European Co-operation in the field of Scientific and Technical Research (COST). COST is a long-standing bottom-up mechanism that facilitates co-ordination and exchange between nationally funded scientists and research teams in a variety of areas related to nanosciences and nanotechnologies, like physics, chemistry,

materials, biotechnology, medicine and health. Reinforced co-ordination among the activities of the European Science Foundation, COST and the Framework Programme is sought in areas of common interest.

3. CHALLENGES TO BE MET WITH AN INTEGRATED APPROACH

An integrated approach should cover consumption patterns so that the complete industrial cycle conforms to the societal requirement for sustainability. Particular attention is given to the strong presence and interaction of innovative enterprises, universities and research organisations in research actions. Europe wide networks and projects are required that give research organisations access to new technologies, therefore stimulating implementation of new approaches in most industrial sectors, in particular SME intensive sectors. A key issue will be to integrate competitiveness, innovation and sustainability into consistent RTD activities. The integration of education and skills development with research activities will play an important role in increasing European knowledge, in particular in nanosciences and new technologies and opening opportunities for industrial applications.

Industry will be one of the major beneficiaries of nanotechnology, approaching it firstly in a rather «top-down» direction. Universities and research centres, on the other hand, are also engaged in exploring «bottom-up», self-organising, self-assembling routes. Both ways need huge investment in terms of people, research, infrastructures and financial resources. The more we generate knowledge and understanding at the nanoscale, the quicker we will be able to use these in industrial production.

In 2010 or 2015, if future forecasts are to be believed, we can expect nanostructured materials and products to generate income of the order of magnitude of one trillion of € (or $): from electronics to telecommunications, from materials science to biotechnology. To achieve this we necessarily need a new generation of some 2 or 3 million engineers, technicians and operators able to innovate and work in the new nanotechnology-based industries. Who is already thinking about educating all these newly skilled people?

It is difficult to foresee the necessary time for implementing this new technological approach. Apart for a new scientific/technical culture, more entrepreneurship, long term capital, responsible behaviour and clear «rules of the game» are required for entering the «nanoworld». Metrology, pre-normative and pre-standardisation issues, and industrial property rights are some examples.

There are many barriers, risks and challenges. A large critical mass is required in terms of both human and material resources. This implies a new way of co-operation being more open, reinforced, transparent and verifiable.

More knowledge means more power. More power demands more responsibility. The potential offered by control at the nano-level must be matched by an appropriate analysis and control of the possible risks. The education of the new players should be underpinned by a sound ethical consciousness and by responsible attitude. The discussion on the ethical and social aspects of nanotechnology is part of a large dialogue with the public. It may result in regulations that take into account societal values and demands. Launching broad discussions on this matter is, therefore, also a means to guarantee that new products have a market, since they will be built following citizens' requests and expectations.

Sound, science-based information is due. Transparency is necessary: What are we doing? How do we intend to use the results? Social acceptance and the trust of the general public will depend crucially on this. Appropriate «rules of the game» are also needed, on the one hand to secure industrial property rights and the return on the money invested in research and development, and on the other hand to avoid the creation of «technological grey zones» where dangerous technologies and applications could be developed.

With the research efforts and resources invested, we can expect that nanosciences and nanotechnologies will progress well. This implies the possibility of a «nano-divide» with many countries in the world that risk to be left out. There is, therefore, also an ethical priority to grant everybody interested a way of access to knowledge, since a new «knowledge apartheid» could lead to unacceptable differences in the social-economic development among different regions of the planet.

4. CONCLUDING REMARKS

The European Commission aims at creating a favourable ground for the development of nanosciences and nanotechnologies research. This will be pursued through a focus on pre-competitive but application oriented research, through vertical integration in projects of significant size that comprises both academic and industrial partners, and through a focus on the multi-disciplinary aspects.

Public funds devoted to research in Europe come from the Member States and from the European Union (via the Research Framework Programmes). Research funded by the Union, although less in quantity, plays a pilot role and acts as catalyst of a much larger critical mass.

The final aim is not to develop nanotechnology *per se*, but to give impetus to the research in nanosciences and nanotechnologies to serve citizens' needs and demands, to sustain industrial competitiveness with an approach to sustainable development, and to contribute to other Union's policies.

These pages do not represent any commitment on behalf of the European Commission. Please refer to official documents or see http://europa.eu.int/comm/research/fp6/index_en.html; http://www.cordis.lu/fp6; or http://www.cordis.lu/nanotechnology.