



## Strategic Agenda for EuroNanoMed

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# Index

Executive Summary .....	3
Introduction.....	4
What is nanotechnology and nanomedicine?.....	4
Why is nanomedicine a strategic research priority for Europe?.....	4
The EuroNanoMed initiative .....	5
Why an ERA-NET in nanomedicine? .....	5
Organisation of EuroNanoMed.....	6
EuroNanoMed Strategies .....	8
Identification of Complementarities and Barriers to Joint Research Activities .....	10
Basic Characteristics of the National Funding Agencies.....	10
National Programmes in Nanomedicine.....	10
Evaluation Procedures for Research Project Proposals .....	12
Financing Models of Research and Development Projects .....	12
Reflections and Recommendations.....	13
Current Trends in Nanomedicine .....	15
Strategies for Research and Development Financing.....	15
State of the Nanomedicine Industry .....	16
Clinical Nanomedicine .....	17
Emerging Legal, Ethical and Safety Issues.....	18
Global State of Nanomedicine.....	21
North America.....	21
Asia Pacific .....	24
Conclusions.....	28
Figures .....	29
Tables.....	33
References .....	39

## Executive Summary

There is a global unmet need to cure and prevent diseases for which we currently lack efficient treatments, and which causes suffering and a shortened life expectancy. The ageing population, the high expectations for improved life quality and the changing life style of European citizens also call for improved, more efficient and affordable health care. Nanomedicine, the application of nanotechnology in health care, offers numerous promising possibilities to significantly improve medical diagnosis and therapy, ultimately leading to a higher life quality. Furthermore, nanomedicine is an important strategic issue for the sustainable competitiveness of Europe. The global competition in the field is very strong and the strategic importance of nanomedicine is being increasingly recognised by industry and governments around the world. Co-ordinated efforts at the European level are thus crucial to stay competitive.

The EuroNanoMed ERA-NET initiative comprises 24 partners from 18 countries or regions. EuroNanoMed aims at fostering the competitiveness of European nanomedicine players through the support of trans-national collaborative and multidisciplinary research and technology development projects with participants from academia, industry and clinical/public health communities.

## Introduction

### *What is nanotechnology and nanomedicine?*

The idea of building objects from individual atoms was introduced in a historic lecture by Richard Feynman at the Californian Institute of Technology in 1959 [1]. The suggestion did not gain much attention until the mid-1970s, when Norio Taniguchi at the university of Tokyo used the term nanotechnology to refer to the ability to engineer materials precisely at the nanometer level [2]. At that time, the primary driving force for minimisation came from the electronics industry. Today, nanotechnology promises to transform most sectors of industry and society, and it is believed to have a particularly profound impact on health care and medicine [3].

Nanomedicine is the application of nanotechnology to the practice of medicine, and it is believed to be an essential tool to address a number of unmet clinical needs of today and in the future. The field takes advantage of the physical, chemical and biological properties of materials at the nanometer scale to be used for diagnosis, treatment and follow-up of diseases. Nanomedicine holds the promise to greatly improve the efficacy of pharmaceutical therapy, reduce side-effects and make drug-administration more convenient. Due to its much larger analytical capacity, nanomedicine will allow an earlier and more personalised treatment for many diseases, exploiting the understanding of diseases at the molecular level. Hence, nanomedicine will be an essential future tool to improve healthcare in all phases of the care process.

### *Why is nanomedicine a strategic research priority for Europe?*

Europe is facing strategic challenges in the field of health due to issues such as an ageing population, negative environmental effects on personal health and a demand for improved personal healthcare. Healthcare expenditures presently account for 10% of gross domestic product (GDP) in industrialised countries and are expected to grow at an average rate of 6% per year in the future [4]. Nanomedicine offers numerous promising possibilities to significantly improve medical diagnosis and therapy and the field thus has a large potential for developing public welfare and economic growth. Despite the fact that, for several reasons, the full promise of the field is not likely to arrive in the near future, there is a large industrial enthusiasm for nanomedicine. The industry is maturing rapidly, and the US National Science

Foundation has estimated that by 2015 half of the world's pharmaceutical industry products will be made with nanotechnology, and that the contribution of products incorporating nanotechnology to the global economy will be around \$1 trillion (cf. [5]). Furthermore, Europe has a responsibility towards the developing world to provide means to combat infectious diseases and other causes of mortality and poverty in the affected regions. Nanomedicine will have a profound impact on infectious diseases in several ways, offering, e.g., improved diagnostics and detection, targeted therapies and antibacterial surfaces [6]. Hence, Europe has an opportunity to make important contributions to global health by acting for the application of nanomedicine to fight the major diseases of the developing world.

Due to the complexity and the inherent multidisciplinary nature of the nanomedicine field, close cooperation between industry, research centres, academia, hospitals, regulatory bodies, funding agencies, patient organisations, investors and other stakeholders will be important to achieve progress. The European Technology Platform for Nanomedicine (ETP Nanomedicine), an initiative led by industry and set up together with the European Commission, aims at strengthening Europe's capacity to organise and to deliver innovation in the area of nanomedicine [7]. The ETP Nanomedicine aims at bridging the gap between research and product development, promoting the industrialisation of nanomedicines to bring real benefit to patients in the shortest possible time [8]. Three research priorities of the ETP Nanomedicine have been identified:

- Nanotechnology based diagnosis and imaging
- Drug delivery
- Regenerative Medicine

Figure 1 gives an overview of areas within each of these strategic research priorities.

## The EuroNanoMed initiative

### *Why an ERA-NET in nanomedicine?*

Nanomedicine is a rapidly emerging field with a large potential for developing public welfare and economic growth. To avoid that this young and very fast growing discipline suffers from fragmentation and a lack of coordination, funding organisations across Europe – together with the European Commission – have identified the need for a European initiative to coordinate

joint research efforts. The EuroNanoMed initiative is part of the ERA-net scheme, a structure that was launched in 2002 as part of the Sixth Framework Programme (FP6), and has continued in FP7. ERA-nets offer an opportunity for programme owners and programme managers to coordinate research activities at national and regional levels around a specific priority that has been defined in a bottom-up process. ERA-net is therefore a step towards the creation of a European Research Area (ERA).

EuroNanoMed targets the creation of a mechanism to support trans-national collaborative research and technology development projects between academic laboratories, companies – especially small and medium-size enterprises (SMEs) – and clinicians/public health setting, in the field of nanomedicine. EuroNanoMed achieves an effective critical mass: the participating national/regional programmes expect to dedicate significant budget to the calls, approximately 15–20% of the sum of their national/regional Nanomedicine budgets. The Long Term Vision of EuroNanoMed is the design of a European-wide integrated programme with a coordinated funding.

### *Organisation of EuroNanoMed*

The EuroNanoMed co-ordination activities and management functions are organised into five work packages. Below is a brief description of the primary objectives of each work package.

#### *Work package A (WPA): Systematic Mapping of the Ongoing Programmes and Strategic Agenda for Joint Activities*

The primary objective of this work package is to provide information and systematic benchmarking activities on partnering programmes, to identify complementarities and barriers to joint activities and to raise solutions to overcome the barriers. The main tasks of WPA include exchange of national information, definition of the strategic priorities for the two joint transnational calls for applications, development of a strategic agenda for the implementation of the EuroNanoMed activities, and design of a proposal for future activities beyond EuroNanoMed. The WPA therefore corresponds to analysis and conception tasks, implemented first in the early stage and then updated to keep the information pertinent during the EuroNanoMed initiative time frame.

*Work package B (WPB): Establishment of the Framework for the EuroNanoMed Joint Trans-National Calls*

The work package will provide the partners with a strong, commonly agreed framework and a joint funding scheme being consistent with national legal applicable rules. The main tasks of WPB include benchmarking of the joint trans-national calls used in other ERA-NETs, designing the agreed framework and procedures for the two joint trans-national calls for applications, and analysis of the feedback from the first joint trans-national call, to be used as input for the planned second call.

*Work package C (WPC): Implementation of the EuroNanoMed Trans-National Calls for Proposals*

The objective of this work package is to implement two successive common joint trans-national calls for project proposals, based on the process, procedures and documents defined in WPB. Through a step-by-step coordination with two successive joint calls, the consortium will ensure the visibility of the integration process at policy maker's level as well as in the scientific community.

*Work package D (WPD): Non-Technological Innovation Barriers*

The main aim of this work package is to address non-technological innovation barriers for later industrial exploitation and market access as well as concerns about safety, ethical and social aspects of nanomedicine. Within a global European market directed at the European level (EMA) it is essential to address this issue at a European rather than at a national level. These activities will be carried out in close collaboration with work package A.

*Work package E (WPE): Management of EuroNanoMed and Support*

Work package E will establish a practical infrastructure that will manage all of the administrative, technical, communication and economic aspects of the ERA-NET and initiate strategic activities. The main tasks of WPE include the establishment of an external advisory board, the preparation of annual workshops and progress reports, communication of the main results and lessons learned to the relevant audience, and the development of a sustainable network of influential national government representatives with policy responsibility for biotechnology involvement in European industrial competitiveness.

### *EuroNanoMed Strategies*

European countries are investing substantial resources into the development of a nanotechnology industry. Even if there is a consensus on the vast potential of nanomedicine for developing public welfare and economic growth, there is evidence that the field has rather special needs for bringing up this potential. Especially two issues are important to address from a European point-of-view:

- The maturity of the economic players within the nanomedicine field and the capability to move effectively innovation from knowledge to industrial, clinical and public health applications. Industrial players need therefore to collaborate closer with academia and clinicians. In this respect the flexibility of the ERA-NET scheme is an asset.
- The ability in the harsh global competition to have companies networking in multidisciplinary small teams with academia and with the clinician communities, and to increase their efforts towards preclinical and clinical validations. This will shorten the delay for patients to benefit from the innovations and increase the competitiveness of European actors.

Different European countries have taken somewhat different approaches in their national programmes to support nanomedicine. A bottleneck in many countries is the fact that there are simply too few players in the field to achieve a critical mass. Besides, nanomedicine is often not the main focus of the national calls, and projects from many different fields will thus have to compete. Hence, there is a strong need to create a mechanism to support trans-national collaborative nanomedicine research projects between academic labs, companies, and clinicians/public health, thereby achieving a critical mass taking benefit from complementarities between the European countries.

EuroNanoMed offers a major opportunity for European enterprises and the research and clinicians communities to take benefit from the flexible coordination of several existing national funding programmes to enlarge their possibilities for partnerships, to fruitful cross-border partnerships. A similar multidisciplinary translational approach in the field with an international focus as the one developed in EuroNanoMed does not yet exist. The initiative aims at bringing together the academic, the clinical/public health and the industrial research teams to develop innovative diagnostic and therapeutic solutions for the patient, thereby enhancing the competitiveness of the European health industry.

EuroNanoMed will develop coordinated European-wide programmes based on two joint trans-national calls. Identifying complementarities and barriers to joint research activities and raising solutions to overcome the barriers are important strategic issues for the success of a trans-national program like EuroNanoMed.

The first call is based on the following three areas in nanomedicine: diagnostics, targeted delivery and regenerative medicine, thus keeping a broad scope not to restrict the innovative potential of the nanomedicine community in Europe. The call requires collaborative proposals from at least three countries and at least two of the following categories; academy, industry and clinic/health care. The scope of the second call will build on analyses and lessons learned from the first call and advice from nanomedicine experts. An analysis of the evolving field of nanomedicine in the form of a workshop will be arranged, to ensure that the scope of the EuroNanoMed calls are kept in line with the academic, industrial, health, and clinical needs. In addition, a dialogue between EuroNanoMed, the EC and the European Technology Platform is a strategic task included to define complementary thematic priorities.

Nanomedicine, which brings an array of novel technologies to the market and the patient, also raises concerns about ethical, legal and safety aspects (ELSA). Delivery of essential contributions to achieve a safe and responsible implementation of Nanomedicine requires that EuroNanoMed contributes to the identification and analysis of nanomedicine ELSA. For example, EuroNanoMed will organise a workshop on non-technological innovation with the main objective to enable a dialogue between producers of medical devices and imaging agents as well as regulatory agencies, to define common interests and to establish a fruitful co-operation to find rapid and practicable solutions to regulatory problems.

In conclusion EuroNanoMed will use a step by step approach based on 2 common joint trans-national calls for collaborative RTD projects, implementing progressively the opening of the national programmes to support trans-national RTD partnerships between academics, companies, and clinicians in the Nanomedicine area. The Long Term Vision for EuroNanoMed is the concept of a European-wide fully integrated programme with coordinated funding. EuroNanoMed is a first step to meet this goal within the ERA landscape.

## Identification of Complementarities and Barriers to Joint Research Activities

An important step to identify complementarities and barriers to joint research activities was a survey performed among the EuroNanoMed partners on national research or research and development programmes supporting projects on nanomedicine. In total, 19 organisations from 18 partner countries participated. The results of the survey are summarised below and in Appendix I. Note that for some questions an answer was not provided by all agencies, and hence the total number of responding organisations was less than the total number of participants.

### *Basic Characteristics of the National Funding Agencies*

The results of the conducted survey revealed a high divergence among the EuroNanoMed partners regarding the role of the funding agencies. The majority of the partners, 11 out of 18 responding organisations, are Research and Research and Development programme owners, whereas the remaining 7 organisations perform a role of managing agency. Some partners carry these two roles simultaneously. Based on a comparison of the strategic priorities, the funding agencies may be categorised into:

- Institutions supporting research and development activities in mainly the health area.
- Institutions focusing on basic research.
- Institutions supporting mostly applied research, often connected with innovativeness and technology transfer.

The main tool for achieving strategic priorities depends highly on the profile of the funding agency, but in most cases it takes the form of thematic programmes and projects within the framework of a more general strategy. Table I presents an overview of the strategic priorities of the EuroNanoMed partners.

### *National Programmes in Nanomedicine*

Most of the countries participating in EuroNanoMed have already developed national programmes to support research or research and development in nanomedicine although some

of these programmes were not directed specifically to nanomedicine, but to nanosciences or related topics. Only four of the investigated countries did not have a funding scheme specially dedicated to supporting research on nanomedicine. The lack of a specific nanomedicine program, however, does not mean that nanomedicine research is not supported. Instead, funding of nanomedicine projects is part of the open calls by these organisations. Detailed information on each participating country is provided in table 2. Within research programmes dedicated to nanomedicine, a group of specific thematic lines could be recognised:

- drug development and drug delivery – indicated 5 times
- implants and nanodevices – indicated 4 times
- diagnostics – indicated 4 times
- regenerative medicine – indicated 3 times
- imaging – indicated 3 times
- nanomaterials – indicated 3 times

Note that the research priorities of ETP Nanomedicine (regenerative medicine, drug delivery and diagnostics) are all included. It is important to stress, however, that respondents of the survey have indicated areas on different level of detail. When the type of research performed within the national programmes is considered, it is clear that the most often financed nanomedicine projects focus on technological development. 8 out of 19 surveyed organizations pointed out clinical and basic research as the most frequently supported activities. Projects focused on clinical trial phases 1 and 2 were definitely less frequent.

It is worth noticing that an unspecified profile of funded projects was rare among the surveyed agencies – only 5 of them declared such an approach in research programmes (see figure 2a).

Regarding entities eligible for funding within the EuroNanoMed partners' national programmes, the great majority (17 out of 19) are able to provide funds for academia and research institutes in nanomedicine projects. Twelve out of nineteen partners are able to fund clinical teams, eleven can fund small- and medium-sized enterprises, and ten are able to give funding to larger companies (for details on each funding agency, see table 4). The level of funding varies (see table 4); many agencies are able to cover the full cost of projects performed by academia and research institutes, and the financial support is stronger to small-

and medium-sized enterprises than to larger companies, which is in line with the EU state regulations.

### *Evaluation Procedures for Research Project Proposals*

Evaluation of project proposals in the field of nanomedicine is a complex process, and a thorough assessment should entail the evaluation of several factors. The performed survey queried the EuroNanoMed partners whether the following factors were taken into account in the evaluation of nanomedicine project proposals: scientific value, technological aspects, opportunity and strategy, and viability of the project. The results are presented in table 4. Obviously, a scientific evaluation is performed by all respondents, whereas the least frequently used category of evaluation was “opportunity and strategy”. In the description of evaluation criteria, the EuroNanoMed partners also frequently highlighted the importance of scientific aspects, as well as the level of innovativeness, and proper budget, workplan and human resources (see table 5). The least mentioned criterion was “social value”. It thus appears that the evaluation criteria of most EuroNanoMed partners are more focused on the scientific value of a project than on the socio-economic traits.

### *Financing Models of Research and Development Projects*

Prefinancing is the most common type of financing form employed by the surveyed EuroNanoMed partners. However, in some cases the funding is partitioned and transferred depending on the results and/or expenses, presented in periodic reports. In some cases, additional conditions of funding occur. Pure “refunding” does not appear to be a common financing model. The most eligible costs of research projects are those for personnel (see figure 2b) followed by costs for infrastructure. The type of personnel most frequently eligible for financing are postdocs (eligible for 16 agencies) and research support manpower, e.g. technicians (eligible for 14 agencies). However, costs for other types of personnel are also allowed for most agencies, e.g. senior scientists, undergraduate students, and PhD students (eligible for 12, 12 and 14 agencies, respectively).

International cooperation between funding organisations is already taking place and the previous experience of the partners from ERA-nets and other EC collaborative efforts was next assessed. Figure 2c displays the number of surveyed partners with previous experience of research or research and development projects funded by one of the four models “virtual pot”, “virtual common pot”, “real common pot” or “other”. It is clear that the virtual pot model –

the financing system where no trans-national flow of funding occurs – is by far the most commonly applied financing system.

### *Reflections and Recommendations*

The EuroNanoMed consortium is composed of diverse organisations with respect to profiles, strategic goals, and legal status (owners or managers). Finding common areas of activities of the involved organizations is thus important for establishing effective frameworks of co-operation in line with national interests and legal regulations.

One of the most serious barriers to trans-national co-operation is the fact that only a few organisations are legally entitled to perform trans-national funding. Other limiting factors include:

- obligations of funding R&D activities and exploitation of the results on national level
- overlapping of national and transnational R&D activities
- obligations concerning participation of specific types of beneficiaries
- other specific requirements on the national level.

Based on the analysis of the results from the performed survey, the following reflections are made:

- Common areas and interest should be defined to facilitate mutual cooperation.
- Creating joint R&D programmes requires setting similar priorities that: a) stay in line with national interests (e.g. national R&D programmes) and legal regulations; b) stimulate the largest possible group of potential beneficiaries; c) define clear R&D areas; d) facilitate establishment of national R&D programmes in nanomedicine for nations where such do not yet exist.
- Defining clearly the role of the commercial sector in programmes supporting nanomedicine is a vital issue. Underlining more strongly the commercial aspects in the evaluation process is an important step toward stimulating business for higher involvement in R&D and therefore creating important added value.

- Setting unified rules of financial support (eligible costs, funds transfer) is very important for facilitating transnational R&D cooperation in the field – convergent rules for all beneficiaries.
- Diagnosed barriers hindering the potential applicants from participating in joint transnational calls are often due to specific national regulations, like lack of possibilities to finance specific entities and focusing on support R&D mostly on national level. Overcoming these problems require, in most of the cases, legislative changes on the national level. Therefore, co-ordinated lobbying for implementing relevant legal solutions, both internal (bottom-up) and external (top-down) is a necessary pace.

## Current Trends in Nanomedicine

The analysis presented below was performed mainly by consulting published strategy reports, foresight analyses etc, and by querying databases accessed through the Internet. The following sections present the results and main conclusions of the analysis.

### *Strategies for Research and Development Financing*

A couple of recurring trends were identified during the global outlook. One of the strongest was the realisation by several nations that well co-ordinated joint efforts involving multiple nations and/or funding agencies are required to stay competitive, owing to the inherent multidisciplinary nature of nanomedicine, as well as to the high expenses often associated with research projects in the field. Considering the fact that nanomedicine in many respects is still only in its infancy—and consequently will entail many “high-risk” projects—it is obvious that many nations have realised the importance of research in the field. The strategic relevance of nanomedicine is also reflected by the fact that several established as well as emerging research nations are allocating significant amounts of money to research and co-ordination efforts in the field. This is especially noteworthy in light of the recent financial crisis; the fact that medical costs are rising along with the increasing demand on novel medical procedures makes nanomedicine one of the most prominent sectors for investments [9]. In fact, it appears that the financial crisis has even enhanced the urge on many nations to abandon (or at least put less emphasis on) their conventional industrial strengths in favour of new, more innovative sectors that hold promise for the future industrial growth. In many research intensive nations, nanotechnology in general—and nanomedicine in particular—has been identified as one such promising sector [5, 10].

The exponential increase in MEDLINE-indexed publications related to nanotechnology or nanomedicine also witnesses the rapid emergence of the field (see figure 3). The fact that the sharpest rise in number of publications related to nanomedicine (from 12 to 208 between 2004 and 2006) occurred a few years later than the corresponding rise in publications related to nanotechnology (from 64 to 844 between 2000 and 2002) is probably due to the dependence of nanomedicine on advances within nanotechnology, although it might also reflect a mere change in semantics as the term nanomedicine became more established in the scientific community.

### *State of the Nanomedicine Industry*

There seems to be a general consensus among nanomedicine stakeholders that, for several reasons, the full promise of nanomedicine will not arrive in the near future. Nevertheless, the vast commercial potential of nanomedicine has spurred industrial enthusiasm for the field; the nanomedicine industry is maturing rapidly, and in April 2006 it was estimated that 130 nanotech-based drugs and delivery systems and 125 devices or diagnostic tests were being developed world-wide [11], a figure which is likely to have increased substantially. The Freedonia Group estimates that the demand for nanotechnology medical products in the US will grow by more than 17% annually to reach \$53 billion in 2011, with the greatest short-term impact in cancer and central nervous system disorders [12]. The US National Science Foundation (NSF) seems to be even more optimistic about nanotechnology, estimating that by 2015 half of the world's pharmaceutical industry products will be made with nanotechnology, and that the contribution of products incorporating nanotechnology to the global economy will be around \$1 trillion (cf. [5]). There is reason to regard these figures with caution, however, as the nanomedicine industry is still maturing. One major obstacle in the process of nanotechnology based drug development is e.g. the strict regulations associated with clinical trials. Nevertheless, there is no doubt that nanomedicine research is considered highly relevant to the pharmaceutical industry; many of the larger, established companies have experienced patent expirations in recent years [13] and considering the fact that new pharmaceuticals conventionally require up to 15 years of testing to get through the approval process [14], there is clearly a strong need for new technologies.

A comprehensive analysis of the nanotechnology industry was performed in 2006 by the research and advisory firm *Lux Research*, where clinical results, scientific papers, patent filings and the financial performance of hundreds of life science corporations were subject to analysis [15]. This study confirmed the general enthusiasm for nanomedicine among industry stakeholders, and the investigators predict the field to have a major impact on the pharmaceutical industry, albeit not as drastic as estimated by the NSF (according to the Lux report, an estimated 16 % of manufactured goods in health care and life science will incorporate nanotechnology by 2014). Importantly, the observations and interactions with the industry enabled the investigators to uncover useful strategies for the development and commercialisation of nanobiotechnology drugs, diagnostics and devices. The major goal, according to the investigators, should be to use nanotechnologies to address unmet medical

needs. Once an appropriate technique to address a specific condition has been identified, companies need to navigate the procedure of funding development, patenting their innovations, finding outside partners and designing a roadmap ensuring multiple ways to succeed [15]. The investigators also predict that nanomedicine will drive a new wave of innovative drugs, devices, and diagnostic tools, intensifying the competition among industrial players and ultimately changing the structure of the life science industries.

### *Clinical Nanomedicine*

The success of nanomedicine will ultimately depend on whether or not it is for the benefit of the public. This is especially true from a financial point-of-view. Private investments in nanomedicine, whether from large industry or from venture capitalists, will be one of the determining factors in bringing forward the budding technologies that public investment is initiating and move them closer to the clinical applications [14, 16]. According to the Visiongain report *Nanomedicine 2006–2011*, nanomedicine receives approximately 40% of its funding from private investments (cf. [17]). The ultimate goal is of course to take research from bench to bedside, a process usually referred to as *translational research*. The process of translational nanomedicine [18] will require extensive collaboration between e.g. biologists, chemists, physicians and engineers, and is expected to be both costly and time-consuming. However, several nations have realised that translational research is crucial for the integration of nanotechnology into health care, and considerable resources are consequently being allocated to the formation of research centres or network dedicated to the translational process. The establishment of a network of eight Nanomedicine Development Centers [19] by the NIH (US) in 2005 represents one such example. The NIH roadmap for medical research [20] was launched in 2004 to promote research programmes that are expected to have exceptionally high potential to transform the manner in which biomedical research is conducted, but are too expensive or too high-risk to be supported by the NIH institutes or centres. Nanomedicine was one of the focus areas, and the Nanomedicine Development Centers were established within the framework of the NIH roadmap.

A world-wide search for clinical trials related to nanotechnology was performed on June 22, 2009, by querying three different web-based registries: *ClinicalTrials.gov* [21], the *IFPMA clinical trials portal* [22], and the *NCI clinical trials portal* [23]. Queries were performed for

a collection of terms<sup>1</sup> associated with nano-based drugs in the *Intervention* field of a trial record (specifying the drugs, devices, procedures or vaccines used in a trial). This procedure yielded a similar number of trials from the three registries (65, 72 and 64, respectively). Although we did not check for overlap between the trial records obtained in the three queries, we expect this to be substantial and thus assume that the total number of unique trials found does not greatly exceed 72. Of the 65 nanomedicine related trials identified in the ClinicalTrials.gov registry, 62 were related to cancer treatment (64 trials were found in the NCI clinical trials portal, which is dedicated only to cancer trials), and it thus appears that the majority of drugs currently in trial are related to cancer. Also, the majority of the 65 trials were in phase I or phase II (17 and 47, respectively). There is reason to believe that the retrieved number of nanomedicine trials is a strong underestimate of the true number of trials, however. According to the European Foundation for Clinical Nanomedicine, there are currently at least 150 nano-based drugs on the market [24], and it is a difficult task to estimate the true number of ongoing trials for several reasons. For instance, it is frequently a strategic choice of an investigator to avoid using the word “nano” or other terms indicating novel devices or processes, as the usage of these in clinical trials will entail stricter safety regulations [25]. An inevitable consequence of these strict legislations on nanomedicine based pharmaceuticals is of course a delay in the desired “from bench to bedside” translation. It is also important to realise that the disruptive nature of nanomedicine—i.e. the ability to rapidly cause radical changes and render conventional technologies and processes obsolete— will eventually transform clinical practice and challenge the traditional patient-physician relationship [26]. This transition may be a rate-limiting step *per se*, as it will also require new expertise among traditional clinicians. Hence, the education aspect is another crucial factor in the transition to nanomedicine, and the importance of formal nanomedicine training has consistently been recognised as a key strategic issue in forward-look reports from around the world [5, 10, 27, 28].

### *Emerging Legal, Ethical and Safety Issues*

The great enthusiasm regarding the commercial potential of nanomedicine has resulted in a burst on patent applications pertaining to the field [29, 30]. From a legal perspective, even

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<sup>1</sup> Search terms used: “nanoparticle”, “nanocapsule”, “nanovector”, “nanotube”, “nanocantilever”, “nanoshell”, “nanowire”, “dendrimer”, and “quantum dot”

defining nanotechnology or nanomedicine is far from trivial. Nanoparticles are usually defined to be in the range of 1–100 nm, but in pharmaceutical applications the desired property may very well be achieved outside of this range. Besides, the current “patent land grab” in nanomedicine has resulted in a situation with many overlapping patents [29]. In the US, where the great majority of nanotechnology patents have been assigned, the Supreme Court recently decided on stricter patent legislation that are likely to have a negative impact on especially small research-intensive enterprises whose primary asset is the intellectual property [31]. Although the intent of these stricter rules is to reduce the number of poor-quality patents, it might have serious negative effects on the US nanomedicine industry.

There is no doubt that nanomedicine will face significant ethical challenges as it moves from proof-of-concept to clinical application. Issues frequently addressed include health, environment, privacy, terrorism, and society [32]. The mere fact that manipulations occur on the atomic scale in nanomedicine makes it easy to draw a parallel with atomic physics, and the potential devastating effects it may cause when used in the wrong hands. The interdisciplinary nature of nanomedicine—with physicians, biologists, chemists, engineers, etc. working side by side—is likely to give rise to a different set of core moral values in this field compared to conventional medicine, as ethical codes and frameworks differ between different professions. A *nanoethics group* was founded in 2003 to deal with issues related to the ethical and social implications of nanotechnology [33].

The safety aspects – understanding of the toxicity and environmental impact on engineered nanoscale materials – are currently being heavily addressed [34, 35]. Although humans have always been exposed to nanoparticles - especially in the past century due to the increase of pollutions following the industrial revolution - this exposure is likely to elevate as an effect of the increased use of nanotechnology in high-tech industries, as well as in pharmaceuticals. Ironically, the properties that make nanoparticles so attractive for medical applications (small size, chemical composition, structure, large surface areas and shape) at the same time contribute to their potential toxicity. The ability of nanoparticles to enter the body through the skin, lungs or intestinal tract [36], cross the blood-brain barrier, to have a potential to trigger immune responses, accumulate in tissues or enter cell nuclei and affect gene expression raises health concerns not usually associated with conventional pharmaceuticals. Recently a number of investigators have found nanoparticles responsible for toxicity in different organs [37-43]. It is therefore important to make an evaluation of risks and benefits for the use of

nanoparticles in any technological or medical developments. Assessing the safety of nanomaterials is particularly difficult though, owing to their great diversity in chemical structure [3].

Although disputes certainly exist about the seriousness of the abovementioned issues, very few people would argue against the claim that it is better to thoroughly assess all possible hazards and negative consequences *now*, when the majority of nanomedicine applications are still in the future. A thorough analysis of ELSA aspects with regard to nanomedicine is also crucial for the acceptance of these new technologies by the citizens of Europe.

## Global State of Nanomedicine

The following sections give a more detailed description of the current status of nanomedicine in countries or regions representing either already strong players or rapidly emerging research and development nations. A comprehensive assessment is well beyond the scope of this report, and the analysis presented here should be regarded as an attempt to indentify the major players – and competitors from a European perspective – in nanomedicine currently and in the near future. To this end, we have focused on the two geographical regions that are likely to be the main competitors to Europe: North America and Asia Pacific.

### *North America*

The Unites States and Canada both have very strong positions in all medical research areas. Whereas the USA is dominant in the vast majority of scientific fields (as demonstrated e.g. by the fact that almost 40% of all Nobel prizes have been awarded to US researchers), the Canadian government has particularly emphasised the importance of health research. The United States has by far the highest number of cited publications, as well as the highest number of patents, in the field of nanomedicine. However, serious concerns are currently being raised about the rapid Chinese emergence in the field [44] as well as the new, stricter US patent legislations [31].

### *USA*

President Barack Obama recently announced that he intends to make major investments in research and innovations – 3 per cent of the GDP – and furthermore emphasised the importance of using funds to encourage high-risk, high-risk research [45]. This, together with the fact that the importance of nanotechnology was specifically stressed by Obama already during the presidential election [46], indicates that nanomedicine is likely to receive increased funding in the near future. The recognition of nanotechnology as a crucial field for future research and development is not new though; it has been a prioritised area for several federal agencies for at least a decade.

The *National Nanotechnology Initiative* (NNI) was launched in 2000 to focus and co-ordinate nanotechnology research and development activities being funded by several federal agencies. As a programme, the NNI does not fund research, but rather informs and influences the

federal budget and planning processes through its member agencies. At present, the NNI involves 25 Federal agencies with a wide range of research and regulatory roles and responsibilities, 13 of which have separate budgets for nanotechnology research and development [47]. The 2010 budget provides \$1.64 billion, and the cumulative investment since the inception of the NNI is nearly \$12 billion [47]. A Strategic Plan describing the visions, goals, and priorities of the NNI was released in December 2007 [28]. Agencies playing a central role in the contribution to the application area most relevant to nanomedicine, “Medicine and Health”, include the *Department of Labor* (DOL), the *Environmental Protection Agency* (EPA), the *Food and Drug Administration* (FDA), and the *National Institutes of Health* (NIH) [28]. The health and safety issues of engineered nanomaterials were specifically addressed in a separate strategy published in February 2008 [34]. The US invests significantly more than any other country in research concerning the effects of nanotechnology on environment, health and safety [34]. The cumulative NNI investments in education and in research on ethical, legal and other societal dimensions of nanotechnology since 2005 is over \$220 million [48].

Other major US initiatives related more specifically to the medical applications of nanotechnology include the NIH *nanomedicine development centers*, and the NCI *cancer nanotechnology platform partnerships*.

The National Institutes of Health (NIH) launched a roadmap for medical research in 2004, with the objective “to address roadblocks and to transform the way biomedical research is conducted by overcoming specific hurdles or filling defined knowledge gaps” [20]. Nanomedicine was defined as one of the focus areas, and within the framework of the roadmap a national network of eight nanomedicine development centres was established, thus enabling a unique approach to translational biomedical research. The centers have been assigned a clear mission to first develop a deep understanding of a fundamental biological nanoscale molecular complex or system, and in parallel develop a research programme to apply the obtained knowledge to study specific medical problems [19].

The National Cancer Institute (NCI), part of the NIH, launched a cancer nanotechnology plan (CNPlan) in 2004 [49], addressing the need for nanotechnology in diagnosis, treatment and prevention of cancer. The plan emphasised that duplications of efforts conducted through the National Nanotechnology Initiative or the NIH Roadmap for Medical Research should be

avoided. Specific goals of the CNPlan included the development of five Centers of Cancer Nanotechnology Excellence, with integrated, milestone driven and product oriented projects[49]. The ultimate goal is to “eliminate suffering and death from cancer by 2015”.

The main target industries for nanotechnologies in the US belong to the biomedical/life science sector [50]. USA has been strongly dominant regarding the commercialisation of all nanotechnology, as demonstrated by the fact that the number of nanotechnology patents registered in the United States between 1976 and 2002 (56,828) by far exceeded the corresponding number in any other country [30]. However, concerns have been raised recently over the rapid emergence in the field of a number of previously unimportant players. Particularly China is demonstrating an enormous progress in the field, all the way through basic research to production and commercialisation [44].

### *Canada*

In Canada, health research has been a national priority for the last decade. The Canadian Institutes of Health Research (CIHR) is the major federal agency responsible for funding health research in Canada. The agency was founded in 2000 as a response to the global revolution in health research, and it aims specifically at translating new health knowledge into real world applications. Although “health research” has been very broadly defined [51], nanomedicine has been a priority of the CIHR ever since its inception. Thus, one of the four main CIHR initiatives launched in 2000 was the *Regenerative Medicine and Nanomedicine Initiative* (RMNI) [52]. The fundamental goal of this initiative is in line with the mission of the CIHR: to develop meaningful multi-disciplinary research approaches to regenerative medicine and nanomedicine.

The public and private funding of nanotechnology in Canada was approximately \$246 million in 2005, and global R&D investments totalled \$9.6 billion (cf. [53]). In 2007, the government of Canada announced a new science and technology strategy [54] describing the direction of government investment in science and technology for the coming years. One of the identified prioritized areas was regenerative medicine and nanomedicine, and this together with the recent investment from the government in a Centre of Excellence for Regenerative Medicine [55] indicates Canada’s ambition to be in the forefront of nanomedicine research and development.

## *Asia Pacific*

The economy is growing fast in a number of Asian nations, and nanotechnology is considered a high priority in the entire region [27]. Although the EU and the US have the highest number of nanotechnology publications, China and a number of other Asian countries are increasing their publication rates rapidly [56]. In 2004, the *Asia nano forum network* (ANF) was founded to promote excellence in research, development and economic uptake of nanotechnology in the Asia Pacific region. The network is currently supported by the following 14 economies in the region (listed here in alphabetical order): Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, New Zealand, Singapore, South Korea, Taiwan, Thailand, United Arab Emirates, and Vietnam.

## *China*

China has emerged rapidly as a strong research and development nation, and according to a recent study [57] the country is likely to soon pass the US in the critical ability to develop basic science and technology, turn the developments into products and services, and market them around the world. In 2006, there were over 50 universities, 20 institutions within the Chinese Academies of Sciences, and more than 100 companies active in nanotechnology research and development in China (cf. [5]). A comprehensive inventory of the state of Chinese nanotechnology development has recently been conducted by the Center for Nanotechnology in Society at the University of California at Santa Barbara (cf. [58]). According to this, the Chinese investments in nanotechnology from 2002–2007 was only about \$400 million. However, the Chinese government has expressed high ambitions in the field, and funding is thus likely to increase. The short term strategy is to integrate nanotechnology research with the traditional industries and develop products with competitive benefits and performance. To provide a platform for the commercialization process, China is establishing a nanotechnology industry base. The long term strategy is to strengthen basic science and enhance global competitiveness (cf. [5]).

According to a recent assessment of nanotechnology-related publications in international journals, China now leads the world in publications on nanotechnology [59], although in terms of quality-based citation measures the US still maintains a strongly dominant position, followed by the EU [56, 60]. Moreover, the US showed an even stronger dominance when bibliometric analyses were confined to a database with a significant number of biomedical

research publications (the SCI database), rather than to a database of mainly physical science research (the INSPEC database), indicating that the Chinese growth is not as strong for nanomedicine as for nanotechnology in general [60, 61]. On the other hand, when a query was made for publications in MEDLINE related to nanotechnology and nanomedicine, respectively, the rise in publications related to nanomedicine appeared some four years later than the rise in nanotechnology publications (Fig. 3), indicating an inherent time-lag between the two fields, which implies that China may very well advance strongly in nanomedicine in the near future.

Taken together, most indicators point towards a continued strong growth of Chinese research and development in general, and nanotechnology is certainly no exception [57].

### *Japan*

Japan has traditionally been a strong actor in the field of nanotechnology. Second to the US, the country has had the highest annual number of nanotechnology patents per year for the last decades [30]. However, relative to China and other rapidly emerging Asian economies, Japan is falling in general technological standing [57]. In a recent analysis of Japan's nanotechnology competitiveness, concerns were raised about the serious problems the country is likely to face in the future commercialisation process, although an examination of published research papers and patents concluded that the country currently has a strong competitive position [62]. Japan seems to have a strong desire to maintain its historically strong position in the field, and the fact that the nation is getting more proactive in the ANF network [27] probably reflects this desire, but it also indicates that the country has realised the importance of Asian partnership to stay competitive within the field.

### *Asian Tigers*

Singapore, South Korea, Hong Kong and Taiwan – the “Asian Tigers” – have similar to China experienced a rapid economic growth, and they also have outlined very ambitious strategies for research and development. An analysis of nanotechnology publications and citations performed for three of the four nations (Hong Kong excluded) concluded that the Asian Tigers have demonstrated an impressive upswing in representation, accounting for more than 10% of 2006 publications in the field [56]. In general, the conducted research appears to be more industry relevance driven.

In *Singapore*, the Biomedical Sciences (BMS) initiative was launched in June 2000 to develop the Biomedical Sciences cluster as one of the key pillars of the nation's economy. The first phase of development (2000–2005) focused on the establishment of a strong basic biomedical research, whereas the second phase (2006–2010) focuses on the translation of basic research discoveries into clinical research. In response to the increasing nanotechnology heat worldwide, the government funding agencies, including Ministry of Education (MOE), Agency for Science, Technology and Research (A-STAR) etc., have put more and more emphasis on nanoscience and nanotechnology research, and in a recent report by the Singapore Ministry of Trade and Industry (MTI), the importance of nanotechnology was repeatedly emphasized [63].

*South Korea* is advancing fast both economically and technologically, and the Korean government and industry are among the most aggressive in the Asia Pacific region in driving the country towards a strong global economic power. Recognising the importance of nanotechnology, the Korean government formulated a ten-year plan for promotion of nanotechnology in 2001. The funding for nanotechnology research and development in the ten-year period is about \$1.3 billion, two thirds from the government and one third from the industry. Three sub-fields were identified as prioritised: IT, Biotech, and Semiconductors and displays [64].

### *India*

India is yet another economy in the Asia Pacific region which has grown rapidly, and in 2008 the Indian economy was the fifth largest in the world by GDP counted on a purchased power parity basis [65]. Despite the steady economic growth, the country continues to struggle with major socio-economic problems, and more than 80% of the population lives below \$2 a day according to the United Nations [66]. Nanomedicine research offers an opportunity to address these issues, for example by the development of lower cost drugs. Basic research in today's India is of high standard, comparable to research in Europe and the US. However, applied research and technology transfer to the industry is a severe bottleneck [67], and by 2005 it was estimated that the country was behind the world by about six years in nanotechnology patenting [68]. Besides, the public awareness of nanotechnology is very low, which might create problems at the application stage. Nevertheless, the country is determined to be part of the nanotechnology revolution, and the area is a main priority of the Indian government [69].

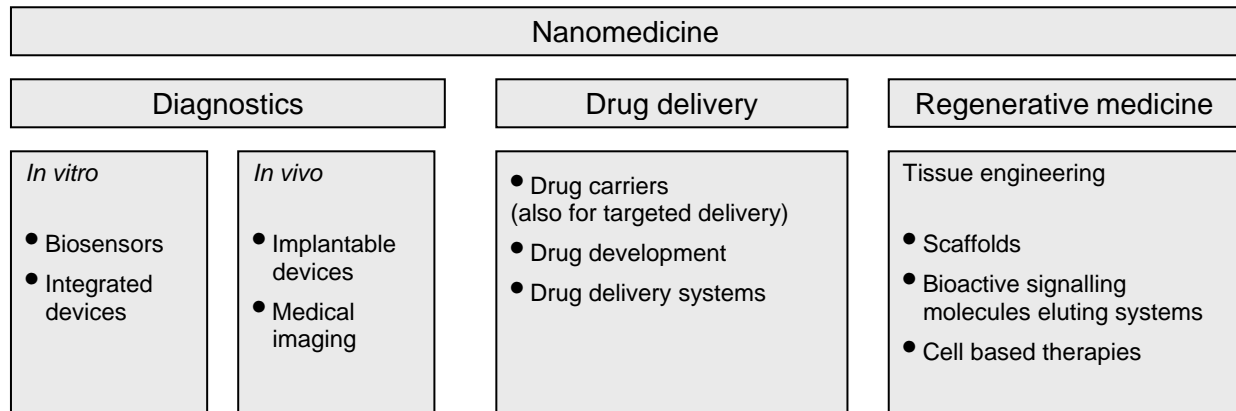
One important step towards the establishment of nanotechnology in India was the EuroIndiaNet project [70], initiated in April 2006 with the aim to foster long term collaborations between Indian and European nanotechnology stakeholders, including academia, industry and government. Nevertheless, recent assessments of nanotechnology-related publications indicate that India is not keeping pace with the rest of the world [60, 61], and it remains to be seen whether the country will eventually manage to fulfil the ambition of becoming a leading nation in the field.

## Conclusions

The emerging picture is that the field of nanomedicine is mobilising a number of established and emerging research nations for common action through the creation of strong consortia. The United States is currently the strongest actors in the field, especially regarding commercialisation aspects, and several US research agencies are coordinating action in order to retain this leading position. Nevertheless, global competition is growing, especially from the emerging Asian economies. The recently established Asia Nano Forum network comprises both currently strong actors in the field and a number of strongly growing economies with ambitious research strategies. This combination of established and emerging research nations is likely to be very fruitful and with more extensive collaborations the Asian Pacific region could very well be the main nanomedicine actor in the future. It is also important to realise that cooperation needs not necessarily be confined to a given geographical region, as demonstrated e.g. by a recent collaboration project between US and South Korean research teams to develop molecular imaging and nanotechnology tools for simultaneous diagnosis and treatment of cancer and chronic infectious diseases [71]. In other words, the establishment of a strong research environment not only increases global competitiveness, but also creates opportunities for fruitful collaborations with other leading research groups.

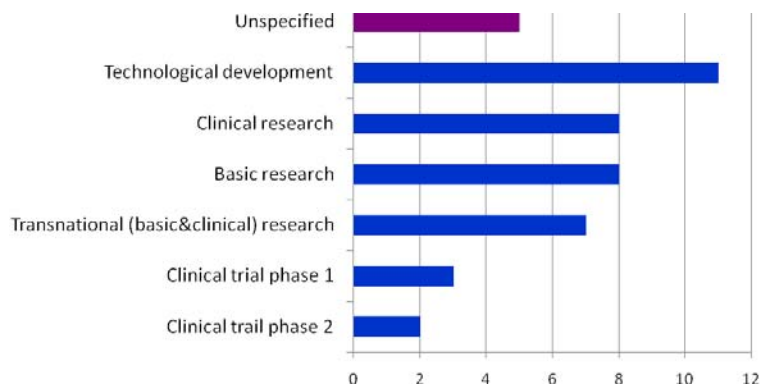
From a European perspective it will be an absolute necessity to join forces in order to stay competitive. Europe has already established key strengths in nanomedicine, and similar to the Asian countries we have the complementary advantages that will be required in this multi-disciplinary field. A recent report on world-wide nanotechnology strategies emphasised that well co-ordinated efforts at the Community level will be required for European countries to meet the increasing global competition [5]. The EuroNanoMed initiative is thus an important step in the establishment of a critical mass of strong European nanomedicine actors.

## Figures

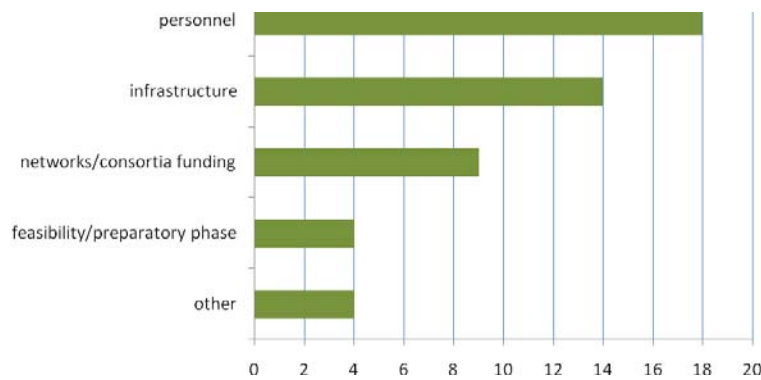


**Figure 1.** Examples on each of the three strategic research areas in the field of nanomedicine.

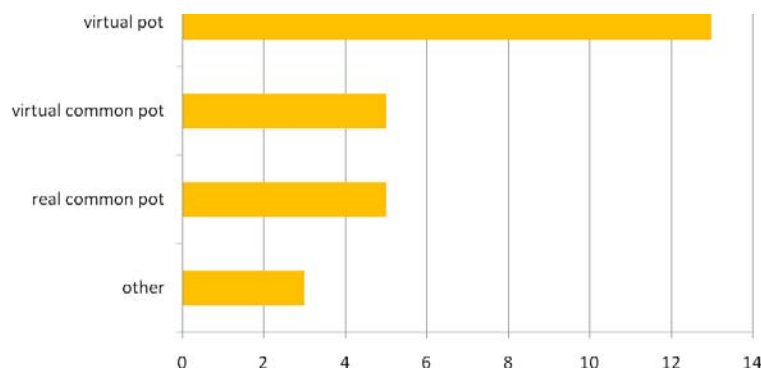
a)



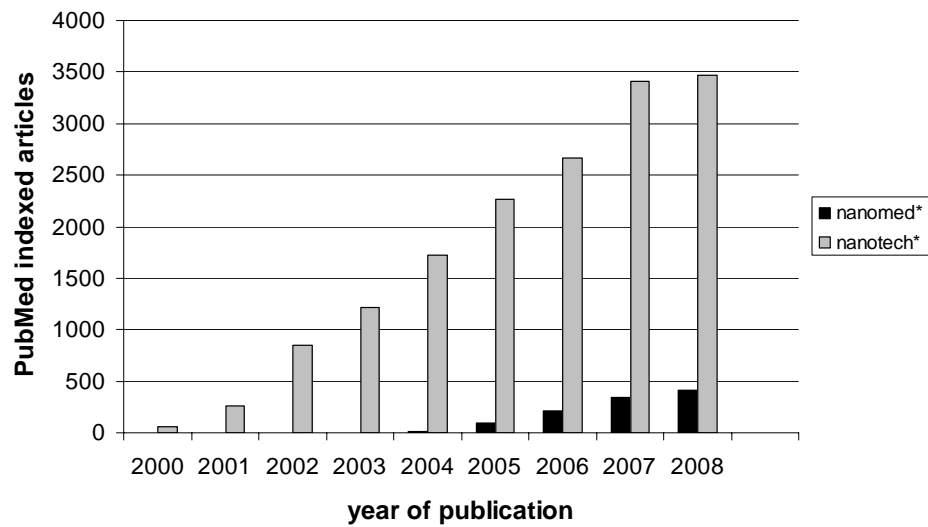
b)



c)



**Figure 2.** a) Main research activities funded by the national programmes of the EuroNanoMed partners. b) Eligible costs funded by EuroNanoMed partners within their internal funding scheme. c) Number of EuroNanoMed partners with previous experience of research projects funded by a given financing model. The number of partners are on the x-axis. The total number of partners participating in the survey was 19.



**Figure 3.** Number of MEDLINE-indexed publications between 2000 and 2008 where the abstract text contains a variation of either the word *nanotechnology* (grey bars; query search phrase “nanotech\*[All] AND 200x[Pdat]”, where ‘x’ was set to a digit between 0 and 8) or *nanomedicine* (black bars; query search phrase “nanomed\*[All] AND 200x[Pdat]”, where ‘x’ was set to a digit between 0 and 8).

## Tables

Institution Name, Country, EuroNanoMed Partner nr	Strategic Priorities
CEA (Atomic Energy Commission), <b>France, P1</b>	Technologies and technologies for health (within life science priorities of the CEA)
Industry, Trade and Tourism Department (ITT). Basque Government, <b>Basque country, P2</b>	Funding programmes GAITEK (development of new products) and INNOTEK (technological development and innovation projects) open horizontal calls every year where topics are not prioritised. Nevertheless, the Basque Science, Technology and Innovation Policy 2010 of the Basque Government set a specific effort in the development of 4 emerging sectors: biociences, nanosciences, alternative energies and ICT for intelligent transport.
Swiss National Science Foundation, <b>Switzerland, P4</b>	The Swiss National Science Foundation (SNSF) is Switzerland's leading provider of scientific research funding. With its federal mandate, it supports basic research in all disciplines. It also invests in applied research in various scientific fields.
VDI Technologiezentrum GmbH, <b>Germany, P6</b> (funding agency of the German Federal Ministry of Education and Research (BMBF), P5)	1. Strengthening of the innovative potential of companies. 2. Application of research and technologies for sustainable development. 3. Encourage efficient cooperation between science and economy. 4. Cross linking of R&D and education
INSTITUTO DE SALUD CARLOS III [INSTITUTE OF HEALTH CARLOS III], <b>Spain, P7</b>	1. Molecular and cell technologies applied to human health 2. Translational research 3. Promoting research in Public Health, Environmental health, safety and health at work, dependency and health services. 4. Promoting research in pharmaceutical drugs and development of pharmaceutical technologies. R&D and innovation of new drugs for treatment to most important diseases. 5. National public health system as platform for developing scientific and technical research with technical industries.
AGENCE NATIONALE DE LA RECHERCHE, <b>France, P8</b>	
Nemzeti Kutatási és Technológiai Hivatal/National Office for Research and Technology, <b>Hungary, P9</b>	Improving the efficiency of existing medicine, bringing them to market. Phase 1 and 2 clinical trials.
Chief Scientist Office, Ministry of Health (CSO-MOH), <b>Israel, P10</b>	Support high quality medical research in the state of Israel.
The Icelandic Centre for Research, <b>Iceland, P11</b>	Basic Science and Technological Development.
Latvian Academy of Sciences, <b>Latvia, P12</b>	Favouring research in basic and applied sciences, especially interdisciplinary research
SenterNovem, <b>the Netherlands, P13</b>	We promote sustainable development and innovation, both within the Netherlands and abroad. We aim to achieve tangible results that have a positive effect on the economy and on society as a whole. Our core competence is converting government policy into reality. On behalf of the Dutch government we implement policy regarding: Innovation Energy and Climate Change Environment and Spatial Planning
Narodowe Centrum Badan i Rozwoju, <b>Poland, P14</b>	Priority research areas include Health and Advanced technology for economy. The main priority is the application of R&D project results in the economy.
Fundação para a Ciência e a Tecnologia, <b>Portugal, P15</b>	FCT's mission is to continuously promote the advancement of scientific and technological knowledge in Portugal, exploring opportunities that become available in any scientific or technological domain to attain the highest international standards in the creation of knowledge, and to stimulate their diffusion and contribution to improve education, health, environment, and the quality of life and well-being of the general public.
National Centre for Programme Management, <b>Romania, P17</b>	CNMP leads and monitors two programmes which include also the health domain (CEEX: M1 – Biotech and the 4th Programme - "Partnerships in priority areas" of the PNCDI II).
Swedish Research Council, <b>Sweden, P18</b>	The Swedish Research Council is a government agency funding basic research of the highest scientific quality in all disciplines. The Swedish Research Council has a national responsibility to support and develop basic research and promote research innovation and research communication. The goal is for Sweden to be a leading nation in scientific research.
The Scientific and Technological Research Council of Turkey, <b>Turkey, P20</b>	There are no strategic priorities for our organization. Programmes are generic. The applications can be from all areas of R&D. Projects are evaluated according to their scientific sufficiency.
Lithuanian Science Council, <b>Lithuania, P21</b>	To deliver consultations for Government, Parliament in education, science and expanding scientific research, foundation for that, analyse science and education achievements
Veneto Region, <b>Italy, P22</b>	
Walloon Region – DGOER, <b>Belgium, P24</b>	Funding applied research (companies, research centres & Universities).

**Table 1.** Strategic priorities of the EuroNanoMed partners participating in the survey.

Institution Name	Partner No.	Country/Region	Programme to support R or R&D in nanomedicine	R or R&D NANOMEDICINE programme(s) in your organisation (funding body) or other funding bodies
CEA (Atomic Energy Commission)	1	France	Yes	C'nano Ile de France
Swiss National Science Foundation	4	Switzerland	Yes	Not specifically for nanomedicine.
INSTITUTO DE SALUD CARLOS III	7	Spain	Yes	1. Strategic Action for Health Research; 2. Fundamental Research Programme
AGENCE NATIONALE DE LA RECHERCHE	8	France	Yes	1. PNANO, Nanosciences, Nanotechnologies, Nanosystemes
Chief Scientist Office, Ministry of Health (CSO-MOH)	10	Israel	Yes	1. Fund through periodic calls (vs. programmes); 2. Funding available for all for fields of medical and biomedical research, including nanomedicine
The Icelandic Centre for Research	11	Iceland	Yes	1. Icelandic Research Fund; 2. Technology Development Fund; 3. Postgenomic Biomedicine, Nanoscience and Nanotechnology; 4. Strategic Research Programme for Centres of Excellence and Research Clusters
Latvian Academy of Sciences	12	Latvia	Yes	
SenterNovem	13	The Netherlands	Yes	1. Strength in Innovation, Chapter Life Sciences & Health
Fundação para a Ciência e a Tecnologia	15	Portugal	Yes	1. Scientific Research and Technological Development Projects in all Scientific Domains; 2. International Iberian Nanotechnology Laboratory (INL) supporting programme
The Scientific and Technological Research Council of Turkey	20	Turkey	Yes	1. The Support Programme for Scientific and Technological Research Projects (1001); 2. Short-Term R&D Funding Programme (1002)
Lithuanian Science Council	21	Lithuania	Yes	Steam cells Included in Government supported programs in Medicine
Veneto Region	22	Italy	Yes	
Industry, Trade and Tourism Department (ITT). Basque Government	2	Basque Country	No (Yes)	1. Programme for the development of new products GAITEK; 2. Programme for the development of technological development and innovation INNOTEK
VDI Technologiezentrum GmbH	6	Germany	Yes	1. "NanoforLife" - Nanotechnologies for Health Care "Bioactive Implants"; 2. "MoBiTech" - Technologies for Molecular Imaging; 3. "Biotransporter" - Targeted Delivery Systems
Nemzeti Kutatási és Technológiai Hivatal/National Office for Research and Technology	9	Hungary	No	1. NanoforLife; 2. "MoBiTech" Technology Initiative Molecular Imaging; 3. Bioaktive Implantate
Narodowe Centrum Badan i Rozwoju	14	Poland	No	
National Centre for Programme Management	17	Romania	No (Yes)	1. Life and Health – VIASAN; 2. National Plan for Research, Development and Innovation, 4th Programme- DC 4 Health; 3. CEEX Programme- "Research of Excellence"
Swedish Research Council	18	Sweden	No	
Walloon Region - DGOEER	24	Belgium/Wallonia	No	

**Table 2.** National programmes to support research or research and development in nanomedicine for EuroNanoMed partners participating in the survey.

Institution Name	EuroNanoMed Partner nr	Type of evaluation performed for R or R&D project proposals in nanomedicine			
		scientific	technological	opportunity and strategy	viability of the project
CEA (Atomic Energy Commission)	1	Yes	Yes	Yes	
Industry, Trade and Tourism Department (ITT). Basque Government	2	Yes	Yes	Yes	Yes
Swiss National Science Foundation	4	Yes			Yes
VDI Technologiezentrum GmbH	6	Yes	Yes	Yes	Yes
INSTITUTO DE SALUD CARLOS III [INSTITUTE OF HEALTH CARLOS III]	7	Yes	No	Yes	Yes
AGENCE NATIONALE DE LA RECHERCHE	8	Yes	Yes	Yes	Yes
Nemzeti Kutatási és Technológiai Hivatal/National Office for Research and Technology	9	Yes	Yes		Yes
Chief Scientist Office, Ministry of Health (CSO-MOH)	10	Yes	Yes	Yes	Yes
The Icelandic Centre for Research	11	Yes	Yes	Yes	Yes
Latvian Academy of Sciences	12	Yes	Yes	Yes	Yes
SenterNovem	13	Yes	Yes	Yes	Yes
Narodowe Centrum Badan i Rozwoju	14				
Fundação para a Ciência e a Tecnologia	15	Yes	Yes	No	No
National Centre for Programme Management	17	Yes	Yes		Yes
Swedish Research Council	18	Yes			
The Scientific and Technological Research Council of Turkey	20	Yes			
Lithuanian Science Council	21	Yes	No	No	No
Veneto Region	22	Yes	Yes	Yes	Yes
Walloon Region - DGOEER	24	Yes	Yes	Yes	Yes

**Table 3.** Evaluation criteria of the EuroNanoMed partners for nanomedicine related project proposals.

Institution Name	EuroNanoMed Partner nr	Entities eligible for funding (level of funding in %)			
		Large Companies	Small- and medium-sized enterprises	Academia and Research Institutes	Clinical Teams
CEA (Atomic Energy Commission)	1	No	No	No	No
Industry, Trade and Tourism Department (ITT). Basque Government	2	Yes (25–35 %)	Yes (40–45 %)	Yes	No
Swiss National Science Foundation	4			Yes	
VDI Technologiezentrum GmbH	6	Yes (50 %)	Yes (60–70 %)	Yes (100 %)	Yes
INSTITUTO DE SALUD CARLOS III [INSTITUTE OF HEALTH CARLOS III]	7	No	No	Yes (33 %)	Yes (66 %)
AGENCE NATIONALE DE LA RECHERCHE	8	Yes	Yes	Yes	Yes
Nemzeti Kutatási és Technológiai Hivatal/National Office for Research and Technology	9	Yes (65 %)	Yes (80 %)	Yes (100 %)	Yes (100 %)
Chief Scientist Office, Ministry of Health (CSO-MOH)	10	No	No	Yes	Yes
The Icelandic Centre for Research	11	Yes (50 %)	Yes (50 %)	Yes (80 %)	Yes (80 %)
Latvian Academy of Sciences	12	No	No	Yes (100 %)	No
SenterNovem	13	Yes	Yes	Yes	Yes
Narodowe Centrum Badan i Rozwoju	14			Yes	
Fundação para a Ciência e a Tecnologia	15	Yes (50 %)	Yes (50 %)	Yes (100 %)	Yes (100 %)
National Centre for Programme Management	17	Yes	Yes	Yes	Yes
Swedish Research Council	18	No	No	Yes	Yes
The Scientific and Technological Research Council of Turkey	20	No	No	Yes (100 %)	Yes (100 %)
Lithuanian Science Council	21	No	Yes (50 %)	Yes (75 %)	Yes (25 %)
Veneto Region	22	Yes (25 %)	Yes (45 %)		No
Walloon Region - DGOEER	24	Yes (60 %)	Yes (80 %)	Yes (100 %)	Yes (75%)

**Table 4.** Eligibility of each EuroNanoMed partner to fund large companies, small- and medium-sized companies, academia and research institutes, or clinical teams. The maximum possible financial support in per cent is given in parenthesis.

<b><u>Frequently used</u></b>
<i>Scientific aspects</i>
<i>Budget, work plan, human resources</i>
<i>Innovativeness level</i>
<b><u>Often used</u></b>
<i>Technological aspects</i>
<i>Quality of partnership</i>
<b><u>Sometimes used</u></b>
<i>Exploitation, commercialization strategy</i>
<i>Economical value</i>
<i>National, transnational, scientific added value</i>
<b><u>Rarely used</u></b>
<i>Social value</i>

**Table 5.** Frequency of occurrence of different criteria in the evaluation of project proposals by different EuroNanoMed partners. The results are based on qualitative elaborations of declarations from consortium partners.

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