Restructuring and Development of Biosciences in Finland

Memorandum for the Ministry of Education
Prepared by Working Group of Biocenter Finland

Summary

The purpose of the program described in this document is to restructure and develop the functions of the biocenters in Finland to advance biosciences, biomedicine and the relevant technology platforms at the national level as well as to promote collaboration among the partners and other stakeholders in this field. It aims at combining the local expertise into a nation-wide knowledge base, in order to facilitate restructuring and development of the Finnish bioscience in a coordinated fashion.

The operation of Biocenter Finland (host universities are the Universities of Helsinki, Kuopio, Oulu, Tampere, and Turku, and the Åbo Akademi University) will be developed with the main focus on technology platforms and other research services. Biocenter Finland will also promote international researcher training, research career development, and utilization of research results.

The governance of Biocenter Finland will consist of the Rectors' Council with the Rectors of the host universities, the Board, and the Director. Biocenter Finland will have a national Advisory Committee to facilitate collaboration of all interested stakeholders, including research institutes of other Ministries, university hospitals and relevant industries. Biocenter Finland will be open to new members, provided that research quality requirements are met.

Biocenter Finland will develop nation-wide technology platform services that will be selected on the basis of an international evaluation that will focus on the quality, scientific competence and the number scientists that the platforms are expected to serve. By these measures, overlapping and redundant investments will be avoided. The technology services are open not only for Biocenter Finland members but also for research groups in other universities, university hospitals, research institutes and industry.

The technology platform services to be developed by Biocenter Finland in collaboration with the Institute for Molecular Medicine Finland are bioinformatics; biological imaging; genome-wide methods; model organisms; proteomics and metabolomics; stem cells and biomaterials; structural biology and biophysics; translational research technologies; and viral gene transfer and cell therapy. In addition, attention will be paid on emerging technologies to prevent any undue delay in their implementation within the Finnish bioscience network.

The program also proposes new initiatives to be included in the Biocenter Finland activities, in order to support international researcher training, career development of the most-promising young principal investigators, recruitment of international expertise for key technology areas, and commercial exploitation of research results.

Biocenter Finland should serve as a useful model to restructure and develop other fields of science in a nation-wide fashion in Finland. This model could also serve as a European-wide example as to how to optimize the use of available resources within life science. The technology platforms to be developed by Biocenter Finland will improve the ability of the Finnish bioscience community to participate in and benefit from the upcoming pan-European research infrastructure initiatives. And finally, the Biocenter Finland program should help Finland recruit top international researcher talent in the globalized labor market.

Yhteenveto

Tässä muistiossa kuvatun ohjelman päämääränä on Suomen biokeskusten toiminnan rakenteellinen kehittäminen tavalla, joka edistää biotieteitä ja biolääketiedettä ja niitä tukevia teknologiapalveluja valtakunnallisella tasolla sekä parantaa yhteistyötä alan toimijoiden välillä. Ohjelma yhdistää paikallisen osaamisen kansalliseksi tieto- ja taitovarannoksi, jonka pohjalta suomalaista biotiedettä voidaan koordinoidusti kehittää.

Biokeskus Suomen isäntäyliopistot ovat Helsingin, Kuopion, Oulun, Tampereen ja Turun yliopisto sekä Åbo Akademi. Keskuksen toimintaa kehitettäessä paneudutaan ensisijaisesti keskitettyihin teknologiapalveluihin ja toimintaympäristöihin. Biokeskus Suomen edistää toiminnallaan myös kansainvälistä tutkijankoulutusta, tutkijoiden urakehitystä ja tutkimustulosten hyödyntämistä.

Biokeskus Suomen hallintoelimet ovat isäntäyliopistojen rehtorien neuvosto, johtoryhmä ja johtaja. Biokeskus Suomelle kutsutaan lisäksi kansallinen neuvottelukunta, jonka tehtävänä on helpottaa yhteistyötä kaikkien sidosryhmien välillä. Näitä ovat mm. sektoritutkimuslaitokset, yliopistosairaalat ja teollisuuden edustajat. Biokeskus Suomeen voidaan hyväksyä uusia, tutkimuksen laatuvaatimukset täyttäviä jäseniä.

Biokeskus Suomi kehittää valtakunnallisia biotieteiden teknologiapalveluja, joiden valinta perustuu kansainväliseen arviointiin. Arviointi keskittyy laatuun, tieteelliseen erinomaisuuteen ja palveluja hyödyntävien tutkijoiden määrään. Näin vältetään päällekkäiset ja turhat investoinnit. Teknologiapalveluja voivat käyttää Biokeskus Suomen jäsenten lisäksi muiden yliopistojen, yliopistosairaaloiden, tutkimuslaitosten ja teollisuuden tutkimusryhmät.

Biokeskus Suomi kehittää yhteistyössä Suomen molekyylilääketieteen instituutin kanssa biotieteiden keskitettyjä teknologiapalveluja erityisesti seuraavilla alueilla: bioinformatiikka, biologinen kuvantaminen, genominlaajuiset menetelmät, malliorganismit, proteomiikka ja metabolomiikka, kantasolut ja biomateriaalit, rakennebiologia ja biofysiikka, translationaalisen tutkimuksen teknologiat sekä virusvälitteinen geeninsiirto ja soluterapia. Erityistä huomiota kiinnitetään uusiin teknologioihin niiden saamiseksi ilman viiveitä maamme biotieteellisen tukijayhteisön käyttöön.

Ohjelmassa ehdotetaan Biokeskus Suomelle myös uusia toimintoja, joilla pyritään edistämään kansainvälistä tutkijankoulutusta, lahjakkaiden nuorten ryhmänjohtajien urakehitystä, kansainvälisten asiantuntijoiden rekrytointia teknologian avainalueille sekä tutkimustulosten kaupallista hyödyntämistä.

Biokeskus Suomi on erinomainen malli maamme muiden tieteenalojen rakenteelliselle kehittämiselle, ja se voisi myös olla esimerkki optimoitaessa muiden Euroopan maiden biotieteiden alan resurssien käyttöä. Biokeskus Suomen kehittämät teknologiapalvelut parantavat maamme biotieteen tutkijayhteisön mahdollisuuksia hyötyä tulevista Euroopan laajuisista tutkimusinfrastruktuurihankkeista. Ohjelma edistää myös Biokeskus Suomen mahdollisuuksia rekrytoida kansainvälisiä huippututkijoita globaaleilta työmarkkinoilta.

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1 Introduction

The Finnish Universities will face major changes in their current operations within the next few years. The most important change will be caused by the reformed University Law that will include a number of important amendments in the ways by which the institutions of higher education are capable of using their financial and other resources. Likewise, the governance of the Universities is subject to changes that are expected to provide the Universities with more administrative freedom. The Government of Finland and the Ministry of Education (MinEdu) anticipate that the institutions of higher education will use the opportunities provided by the new law to set forth clear priorities for restructuring and development of their strengths in research and education. In parallel with the reform in the University Law, the Ministry of Education aims at structural changes and development among the Finnish institutions of higher education, evaluation of the national infrastructure policy, as well as establishment of strategies for national innovation policy and international recruitment. These issues have been considered during the preparation of this document.

In its memorandum of August 24, 2007, concerning the structural changes and development of research and education in biosciences, MinEdu stated that ”In the efforts to restructure the institutions of higher education, the biosciences field provides the sole example with

regard to organizing an entire field of science at the national level. The MinEdu has supported two initiatives in this field; the establishment and financial support of Biocenter Finland, and the founding of the Institute for Molecular Medicine Finland. To develop biosciences in a well-planned fashion, funding of this discipline should be continued after the end of the National Biotechnology Program in 2009." In the same memorandum, the MinEdu stated that, "in collaboration with the biocenters in Finland, it is ready to prepare and fund a national program developing and restructuring the biosciences from 2010 onwards, providing that a number of preconditions will be met". The outline of the new program is presented here, and it spells out the ways by which Biocenter Finland together with the Institute of Molecular Medicine Finland aims at meeting the preconditions set forth by the Ministry of Education.

The National Molecular Biology and Biotechnology Program of the MinEdu commenced in Finland in 1987, but it will be terminated by the end of 2009. This program has been essential for the Finnish bioscience to develop and assume its current status as an internationally renowned field of science in Finland. The program has been evaluated for a number of times by working groups of the MinEdu, and twice by international experts. The first evaluation in 1996 was coordinated by the European Molecular Biology Organization; the report was very supportive to the biocenter concept. The second evaluation took place in 2002, and its expert panel was chaired by Professor Fotis Kafatos (at the time Director General of the European Molecular Biology Laboratory, currently Chairman of the European Research Council) stated in the report entitled "Biotechnology in Finland: impact of public research funding and strategies for the future" that "The establishment of a network of Biocenters with earmarked funding has been an excellent initiative from the Ministry of Education; their continued development and funding remain essential". The panel stated that continuous support of infrastructure development is important for Finnish biosciences. The panel also recommended strongly that other Finnish ministries, in addition to the Ministry of Education, to take a more active part in funding the biotechnology field, including support to develop and maintain infrastructure. However, these recommendations of the panel have not been implemented.

The National Molecular Biology and Biotechnology Program of the MinEdu led to a number of important developments in Finland. First, the timing of its launch was vital, in that there had been important ground-breaking developments in molecular biological techniques in the preceding years, and Finland was clearly lagging behind in adopting these novel techniques. Second, the program led to establishment of the current six biocenters in Finland. Third, the biocenters have not only developed strong bioscience programs but also realized the importance of centralized technology platforms (core facility services), the funding of which was not otherwise included in the strategies (or budgets) of the host universities or faculties. Fourth, the biocenters have worked together in their efforts to keep up with technical and intellectual developments in the bioscience field, and assigned priorities to specific centers in development of technology platforms and services for shared use. Fifth, the biocenters formulated a joint strategy for the years 2006–2009 and initiated the founding of Biocenter Finland. And finally, with the focus on the quality of science using regular international research assessments, the biocenters have become the leading international research units in their home universities, both through high-quality science and well-working research environment.

Even though the National Molecular Biology and Biotechnology Program of the MinEdu has permitted the biocenters to prevent Finnish bioscience from lagging much behind of international developments, this field has nevertheless suffered from shortage of resources over the last several years. The main reason for this is that every few years, a new technology comes along that dramatically changes how fundamental questions in biology are addressed. By and large, the emergence of a new technology is neither planned in a top-down fashion nor predicted. The impact of the technology is perhaps not appreciated at first – when it is used only by those involved in its development – but becomes clear once the technology begins to spread to the broader scientific community. Well-known examples are, among others, the emergence of genetically-modified animal technologies, sophisticated protein chemistry and proteomics methods, high-throughput technologies, and DNA microarrays. Typical of each new technical development has been that once applied, it has enabled a substantial leap in the depth of our knowledge. Biocenters in Finland have been able to stay abreast with these developments, but only to a limited degree. And there are already emerging novel technologies, such as ultrahigh-throughput DNA sequencing, that are making the transition from development to widespread use. For the Finnish bioscience to maintain its internationally renowned status, it is mandatory that the scientists will have access to state-of-the-art technologies and concepts in a timely fashion. It is important to note that establishment of new technologies involves, in addition the requisite equipment, also significant human resources. It is conceivable that, at least in a few instances, international experts ought to be recruited, in order to expedite the transfer of new and emerging technologies to Finnish bioscience community.

In our neighboring countries, such as Sweden and Norway, extensive programs on infrastructure development as they relate to biosciences have commenced during the recent years with annual funding of up to 50 mill. €, either from public and private sources (*e.g.*, Wallenberg Foundation in Sweden) and/or from the government (*e.g.*, FUGE program in Norway). Ireland, another country with the population size of Finland, has launched through the Science Foundation Ireland an impressive program to develop her biotechnology, with funding of at least 50 mill. € per year. Estonia, a new European Union member state, has two programs to develop the research environments in the country: one for 2006–2009 with total funding of 28 mill. € and the other for 2010–2014, with total funding of 120 mill. €. It is estimated that approx. 50% of the funds will benefit biological and biomedical sciences in Estonia. The current high level of biotechnology research in Finland should not be put into a position, where it starts lagging behind due to shortage of available resources. Since Finland does not have charities or private persons supporting research through donations similar to those, for example, in the United States and United Kingdom, the main resources to support biosciences in Finland have to come from public sources.

The Board of Biocenter Finland appointed a working group on February 29, 2008, in response to an inquiry from the MinEdu, to prepare this document, outlining the new program that aims at developing and restructuring the biosciences in Finland. The working group comprised the following persons: Chief Executive Officer Pekka Mattila (Chair, Finzymes, Ltd.), Professor Olli A. Jänne (University of Helsinki), Professor Olli Kallioniemi (Institute for Molecular Medicine Finland), Professor Riitta Lahesmaa (Vice-Chair, University of Turku), Professor Taina Pihlajaniemi (University of Oulu), Professor Mart Saarma (University of Helsinki, Biocenter Finland), Professor Jukka Westermarck (University of Tampere), and Professor Seppo Ylä-Herttuala (University of Kuopio). Docent Tero Ahola (University of Helsinki, Biocenter Finland) served as the working group's executive secretary.

Counselor of Education Erja Heikkinen was the working group's liaison to the MinEdu.

The working document draft was read and commented on by Professors Ruedi Aebersold (Institute of Molecular Systems Biology, Swiss Federal Institute of Technology Zurich, Switzerland), Carl-Henrik Heldin (Ludwing Institute for Cancer Research, Biomedical Center, University of Uppsala, Sweden), Ole P. Ottersen (Center for Molecular Biology and Neuroscience, University of Oslo, Norway) and Richard J. Roberts (New England Biolabs, Ipswich, Massachusetts, USA). The external experts felt that the plan was important, ambitious and innovative, and their constructive recommendations to improve the program have been taken into account in the preparation of the final document.

This document describing the Biocenter Finland program for restructuring and development of biosciences in Finland in 2010–2012 was approved by the Board of Biocenter Finland on November 28, 2008.

2 Biocenter Finland – a Nation-wide Collaboration Network

2.1 Background

The National Molecular Biology and Biotechnology Program of the Ministry of Education permitted the establishment of biocenters at the Universities of Helsinki, Kuopio, Oulu, Tampere and Turku. At the University of Helsinki, Institute of Biotechnology and Biocentrum Helsinki are the biocenters carrying out the Ministry's special funding program. The biocenter in Kuopio is A. I. Virtanen Institute for Molecular Sciences, an independent institute with the status of a university faculty. Biocenter Oulu is an umbrella organization with research groups from several faculties. The biocenter in the University of Tampere is the Institute of Medical Technology, an independent research and education institute. The biocenter in Turku is BioCity Turku, a joint venture of research groups from the University of Turku and Åbo Akademi University. Turku Center for Biotechnology is a shared institute of these two universities and a part of BioCity Turku.

The biocenters form a national cluster with complementary research and expertise profiles. No two biocenters are alike in terms of size, scientific orientation, organization or mode of operation. However, they all share the same goals: shaping the profiles of individual biocenters and the division of duties among them, and enhancing the ability to collaborate as members of the consortium. The biocenters have played a pioneering role in introducing and maintaining many research-related modes of operation in Finland, such as regular external evaluation of the quality of their research. Biocenters also represent a key source of innovation for small and medium-size enterprises, and their well-developed technology platforms and multidisciplinary training programs bear great significance for product development in industry. In addition, the well-functioning research environments that the biocenters have created at their home universities are very fertile grounds for establishment and support of new start-up or spin-off companies.

The biocenters set forth a common national strategy in December 2005. This strategy, covering the years 2006–2009, aims at creating a consortium of Finnish biocenters that would rank among Europe's leading research environments in the field of biotechnology. The goal is to merge functions of these centers of excellence despite their physical distance, thus cre-

ating a nation-wide consortium that allows efficient utilization of resources, technology platform and other services, and know-how. This mode of operation that is novel both nationally and internationally has already proven very successful.

The biocenters founded Biocenter Finland in August 2006. According to the founding charter, Biocenter Finland will enhance and coordinate national networking; promote international recruitment; develop prerequisites for high-quality research and product development in biotechnology; and promote commercial exploitation of research findings. Biocenter Finland coordinates and develops basic education and research training and aims at establishing effective connections with clinical investigators at university hospitals, biotech businesses, and polytechnics. The founding charter also states that the research activities of all Biocenter Finland members be regularly evaluated, and that its mode of operation will emphasize the importance of free competition and international evaluation of research accomplishments.

The Universities of Helsinki, Kuopio, Oulu, Tampere and Turku as well as Åbo Akademi University are known as the biocenter universities (*i.e.*, the host universities). The Rectors of these universities signed the founding contract of the Biokeskus Suomi–Biocenter Finland consortium in February 2007. The objectives discussed and approved in the constitutive meeting of Biocenter Finland are spelled out in this contract, as are the general provisions on the decision-making bodies of Biocenter Finland. The contract also states that, in addition to the founding members, other internationally acknowledged Finnish operators (*e.g.*, the Institute for Molecular Medicine Finland) can be accepted as new members.

2.2 Principles of Operation and Decision Making

The Ministry of Education has expressed keen interest in the development of Biocenter Finland, since this consortium represents a major strategic choice as to how research and training in a given discipline is organized in a nation-wide fashion. Biocenter Finland is a prime example of the will and ability of the host universities to restructure their activities. All Biocenter Finland decisions – including strategy, development and restructuring of research and research services, creation and support of researcher networks, distribution of funds, and appointment of personnel – are made through mutual agreement between the biocenters. Biocenter Finland should serve as a useful model for restructuring and development of other fields of science in a nation-wide fashion in Finland. This model could also serve as a European-wide example as to how to optimize the use of available resources within life science.

Biocenter Finland has prepared a directive to permit further restructuring and organizational development, as it must have a decision-making system that also allows all matters to be processed and settled conclusively, even though decisions through consensus are always the preferred choice. The biocenters and their host universities ought to be capable of influencing the decision making. The draft directive was submitted to the biocenter universities in late May 2008, and subsequently, a number of amendments and clarifications were inserted. The directive is to be ratified by an agreement of the Rectors of all biocenter universities. This agreement will clarify and complement the principles in the contract on Biocenter Finland, signed in February 2007.

According to the tentative directive, Biocenter Finland shall have the following executive bodies: (i) the Rectors' Council; (ii) the Governing Board; (iii) the Director, and (iv) the Advisory Committee. The quality and feasibility of the technology platforms to be funded by Biocenter Finland will be evaluated by an international expert committee.

The Rectors' Council comprises the Rectors of the host universities, and it is the supreme decision-making body of Biocenter Finland. It discusses matters of principle pertaining to Biocenter Finland activities; selects the coordinating university; appoints the Governing Board; appoints the Director; invites members to the Advisory Committee; approves new members of Biocenter Finland; and acknowledges resignations.

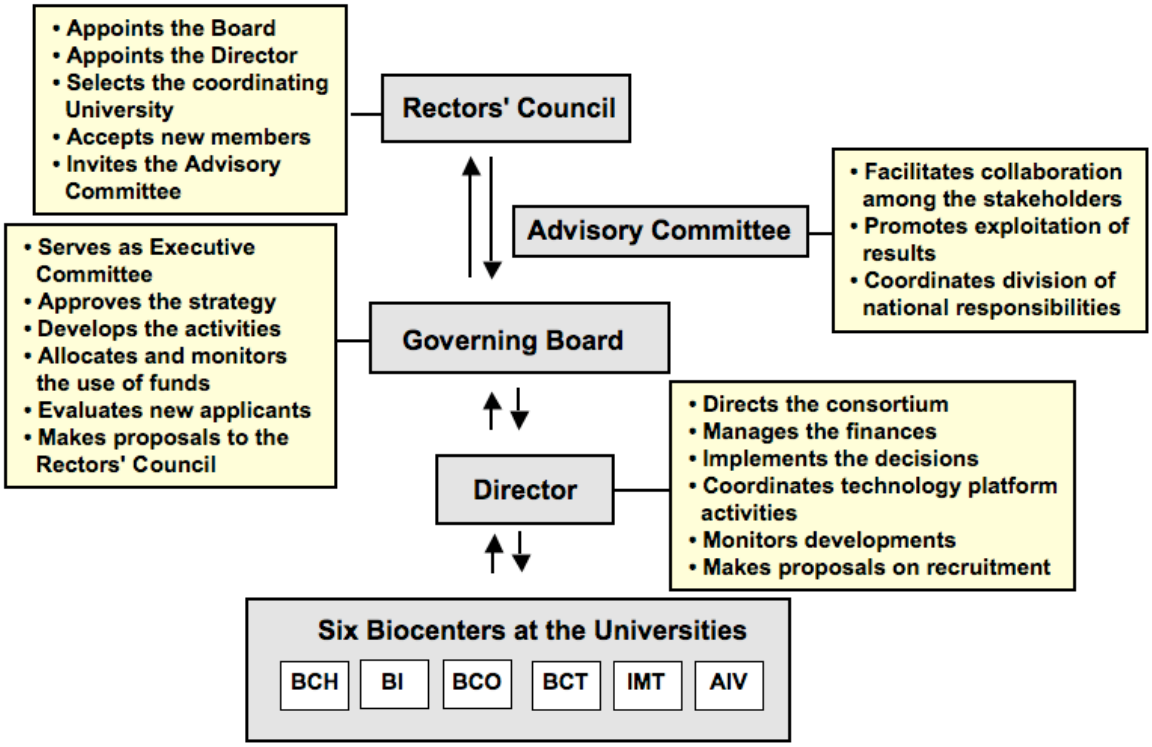

Figure. The executive parties and their principal responsibilities in the governance of Biocenter Finland. Abbreviations: BCH, Biocentrum Helsinki; BI, Institute of Biotechnology; BCO, Biocenter Oulu; BCT, BioCity Turku; IMT, Institute of Medical Technology, Tampere; and AIV; A. I. Virtanen Institute, Kuopio.

The coordinating university will house the administrative staff and handle financial issues of Biocenter Finland. Although Biocenter Finland administration is located in one university for a given time period, this arrangements will not influence Biocenter Finland's decision making that is based on full independence of the consortium.

The Governing Board shall comprise persons chosen by the host universities. The Board shall be appointed for a three-year period. In addition to members from the biocenter universities, the Board may also include external expert members. The Board develops and directs Biocenter Finland activities; approves the three-year strategy (starting from 2013, a four-year strategy); makes proposals and issues statements on matters pertaining to the finances, administrative and other activities; establishes the principles for the use and distribution of funds and other resources allocated to Biocenter Finland; makes proposals regard-

ing the recruitment of administrative staff for Biocenter Finland; and makes proposals to the Rectors' Council regarding the appointment of the Director of Biocenter Finland and the length of his/her term in office.

The Board makes proposals to the Rectors' Council pertaining to inclusion of new members to Biocenter Finland; handles resignations from Biocenter Finland membership; evaluates new applicants to Biocenter Finland; and organizes evaluations of activities and services prior to distribution of funds allocated to Biocenter Finland. In addition, the Board prepares annual reports on Biocenter Finland activities; monitors and supervises the use of resources; and makes decisions on important principal matters concerning Biocenter Finland, when such matters are not the responsibility of the Rectors' Council or the Director.

The Director of Biocenter Finland should be a Professor or otherwise highly-qualified scientist. She/he directs and develops the consortium; coordinates activities with different universities and biocenters; monitors general developments in the field; manages and develops the consortium's national and international networks; manages the consortium's finances; prepares matters for Board meetings; ensures implementation of the decisions made; makes proposals on recruitment and division of duties that are not the responsibility of another university official or administrative body; and resolves and takes care of other Biocenter Finland matters that have not been specifically assigned to someone else by law or ordinance. The Director shall be appointed for a fixed period of time that may vary from three to five years. This longer-term commitment of the Biocenter Finland leadership will undoubtedly strengthen the consortium.

The Advisory Committee shall consist of 10–15 members representing parties working in the field of life sciences, *i.e.*, universities, university hospitals, ministries and their sectorial research institutes, companies, polytechnics, sponsors, and users of bioscience research results. It shall have a chairperson appointed by the Rectors' Council. The Advisory Committee facilitates collaboration between biocenters and other parties conducting research in the fields of molecular biology and biotechnology; discusses the common national biotechnology strategy; creates operational models to improve the national technology development in biosciences; promotes the exploitation of bioscience research results; and coordinates the division of responsibilities among the operators in the field of bioscience.

2.3 Principles of Funds Allocation

The Governing Board principal task is to coordinate bioscience research, education and innovation activities in Finnish universities. Together, the Board and the Director shall determine the focal points of the development of activities, choose the partners and decide how the activities will be funded. The funds ought to be allocated on the basis of jointly determined strategic principles, with the goal of advancing Finnish bioscience to a high international level. The Board and the Director need to analyze the key trends on the national bioscience landscape, and the biocenter directors must be capable of profiling their centers and dividing tasks among themselves in such a fashion that it benefits all the parties involved. This requires not only mutual trust and cooperation but also strong leadership. It is also important for the future of Biocenter Finland that a close attention will be paid to pan-European programs and infrastructure initiatives (*e.g.*, ESFRI).

According to the tentative directive, the Board will be responsible for establishing the principles for allocation of funds and other resources among the Biocenter Finland members. Development and restructuring of research environments and technology platforms will be supported on the basis of the principles set forth by the Board. The principles and guidelines will, in turn, adhere to the recommendations of an evaluation by external (international) experts. To receive Biocenter Finland funding, all national technology platforms and other nation-wide services must meet the following operational principles: state-of-art technology platform; open access; transparency in pricing; approved cost recovery system; equal treatment and significant number of clients; and willingness to organize national training courses.

Close monitoring of developments at the forefront of science is essential in the rapidly changing bioscience research environment. A major task of Biocenter Finland is to launch new technologies, pay attention to emerging technologies, and recruit talented scientists to transfer these technologies to benefit biosciences in Finland. The Board will decide on new technology projects and recruitments of human resources to them, which must be based on the common strategy and serve a large user base. However, recruitment of individual research groups should still be carried out at the biocenter level, and potential product development should be performed in collaboration with companies and sponsors of applied research.

2.4 Administration of Biocenter Finland in 2010–2012

On the basis of discussions with the MinEdu in 2007, the biocenter universities have agreed to continue financing the activities of their biocenters from local funds for operational expenditure. In addition, Biocenter Finland has applied for project funding for 2007–2009, mostly for the maintenance and development of research services. This funding is anticipated to continue and expand in the framework of the new structural development program for biosciences.

The Board and Director of Biocenter Finland need human and other resources to carry out their administrative and other activities mentioned above. This proposal includes a separate budget for Biocenter Finland administration for the period of 2010–2012. The annual budget is 0.5 mill. €, and it includes the following items: (i) salaries of the staff (three persons); (ii) other expenses of the office (*e.g.*, travel and communication); (iii) Director's discretionary funds, (iv) expenses of the Board and Advisory Committee meetings; (v) evaluation expenses; and (vi) promotional expenses (*e.g.*, annual report).

3 Pan-European Initiatives for Research Infrastructures

European Strategy Forum for Research Infrastructures (ESFRI) is a strategic instrument formed by the European Union member states to develop scientific integration of Europe and to strengthen its international outreach. ESFRI published the first Roadmap for pan-European research infrastructures in 2006, which marked significant advances towards unity and international impact in research infrastructures of all fields of science. The Roadmap identifies new research infrastructures or major upgrades of existing ones that are of pan-European interest, corresponding to the long-term needs of the European research

communities. The infrastructure Roadmap will be periodically updated, and the first update is scheduled to become public at the end of 2008.

The rapid progress and expansion of life sciences are accompanied by major infrastructure requirements, which cannot be supported by single countries. Hence, there is clear need for increasing European and global co-operation in planning and building the infrastructures in life sciences. The ESFRI Roadmap presents an interconnected set of infrastructures required to support research in biological and medical sciences. The infrastructures required are often multi-sited in nature, and instead of one-time investments, these are characterized by continuous needs for new and upgraded equipment together with requisite experienced personnel. Moreover, life sciences are experiencing a paradigm shift, in that it is becoming an information science with an exponentially increasing amount of data collections and a need for computational approaches.

ESFRI has recommended that the following infrastructures are needed at pan-European level for biological and medical sciences:

- EATRIS (European Advanced Translational Research Infrastructure in Medicine)
- BBMRI (European Biobanking and Biomolecular Resources)
- INFRAFRONTIER (European Infrastructure for Phenotyping and Archiving of Model Mammalian Genomes)
- ECRIN-PPI (Infrastructures for Clinical Trials and Biotherapy)
- INSTRUCT (Integrated Structural Biology Infrastructure)
- ELIXIR (Upgrade of European Bioinformatics Infrastructure)

All of these pan-European infrastructure proposals have entered a preparatory phase, which encompasses planning for their construction, composition, and funding. Finland is participating in all six infrastructure processes; Biocenter Finland linking Finnish contribution to INFRAFRONTIER and INSTRUCT, FIMM linking Finnish contribution to EATRIS and BBMRI, the Center for Scientific Computing (CSC) linking Finnish contribution to ELIXIR, and A. I. Virtanen Institute, University of Kuopio (member of Biocenter Finland) linking Finnish contribution to ECRIN-PPI.

Active participation in the pan-European life science infrastructures will markedly strengthen the international connections and impact of Finnish life sciences. Participation in the preparatory phase makes it possible to influence the European planning in such a fashion that the needs of the Finnish scientists are included. However, the role and extent of Finnish participation in the upcoming construction and running phases varies depending on the infrastructure. The Finnish bioscience community will most likely need access to all above European infrastructures, which, in turn, may require investments in facilities and/or agreements user fees. In some cases, it is conceivable that important infrastructure nodes are located in Finland. Securing early technology transfer and training opportunities are also of high importance. Undoubtedly, Biocenter Finland needs to pay close attention to these developments.

The potential added value to Finland should be taken into account, when decisions pertaining to Finnish participation in the upcoming pan-European infrastructures will be made. The technology platforms of Biocenter Finland (described in section 5) will undoubtedly improve the readiness of the Finnish bioscience community to participate in and benefit from the upcoming pan-European research infrastructure initiatives. Nevertheless, the funds

and other investments required for such participation should not come from the budget of the program for the development and restructuring of national technology platform services in Finland to be described in section 5; rather, there should be a separate national plan with appropriate funds for the Finnish ESFRI participation.

4 Institute for Molecular Medicine Finland (FIMM) – Nordic EMBL Partnership in Molecular Medicine

The Institute for Molecular Medicine Finland (FIMM) was founded by the University of Helsinki in September, 2006. The University Senate approved its directive in December 2006, and the directive entered into effect in April, 2007. FIMM was launched as an international molecular medicine research institute, characterized by its partnership with the European Molecular Biology Laboratory (EMBL). FIMM recruits promising principal investigators and graduate students globally according to the EMBL model, and participates in pan-European infrastructure initiatives. At the national level, FIMM is a joint research institute of the University of Helsinki with three other founding members: National Public Health Institute (KTL), Hospital district of Helsinki and Uusimaa (HUS), and the VTT Technical Research Center of Finland. FIMM also operates a national molecular medicine network linking together top investigators from their partner institutes, such as biocenters and medical faculties in Finland. The scientific activities of FIMM will be supported by private foundations, its participating institutions, and potential other funding mechanisms, in addition to this Biocenter Finland program.

The FIMM Genome and Technology Center, formerly the Finnish Genome Center, represents a national research and service platform operated by a staff of 25 people. The Finnish Genome Center had originally a more limited service mission, but after the merge to FIMM, its role has been expanded, and it provides now services in genotyping, DNA sequencing, genetic data analysis, and bioinformatics. In 2008, the FIMM Genome and Technology Center has thus far produced 1.7 billion genotypes and carried out collaborative projects with 25 group leaders across the country and in European Union collaborations. DNA sequencing services has had in 2008 over 200 users and information technology (bioinformatics) services have ~900 registered users in Helsinki, elsewhere in Finland and across the world. With the Center being now operated as a part of FIMM, it is necessary to continue its national service operations, while at the same time expand operations from genetic services to other fields of molecular medicine.

The vision for the FIMM Genome and Technology Center will be to offer next-generation human DNA sequencing services nationally, including the requisite bioinformatics capabilities. The Center will also aim at expanding its service operations to high-throughput screening of siRNA, cDNA and compound libraries [link to EATRIS ESFRI effort], as well as biobanking and biomarker development [BBMRI ESFRI effort]. The support requested in this document to the FIMM Genome and Technology Center is meant to support its existing personnel and facilitate the launch of these new operations, while maintaining the existing nationally important genetic and bioinformatics services. Search for the new director for the FIMM Genome and Technology Center is underway, and she/he will be responsible for this transition of the Center towards the above goals, including a close collaboration with other Nordic sites of the EMBL partnership, the European ESFRI projects [BBMRI, EATRIS, ELIXIR] and Biocenter Finland activities. The resources to support the

functions of the FIMM Genome and Technology Center are potentially available from the funds for the development and restructuring of national technology platforms services, as described in section 5.

Collaboration of FIMM and Biocenter Finland. FIMM and Biocenter Finland are the two key organizations in the Finnish biosciences research. They have distinct profiles and play unique roles nationally and internationally. It is essential that FIMM and Biocenter Finland profile their functions and missions in such a fashion that overlapping and competing activities will be avoided. To achieve this goal, Biocenter Finland and FIMM have agreed to set up a formal collaboration to promote biotechnology research in Finland. They will collaborate in developing national research environments, and will have reciprocal observer status in each other's board meetings. Biocenter Finland and FIMM are also making a collaborative agreement to formalize their relationship.

5 Development and Restructuring of National Technology Platform Services in Finland

In Finland, the National Molecular Biology and Biotechnology Program that will close at the end of 2009 has been of great importance, as it has been a significant enabling vehicle for the biocenters to build research environments that are internationally well-known for the quality of science. A central part of this process has been the establishment of important technology platforms at the biocenters. In external evaluations that have been either nationwide (in years 1996 and 2002) or biocenter-specific (every 2–4 year in each center), these pioneering technology platform services have been considered as a real strength. In view of the rapid international developments, the importance of well-planned and sustained research technologies and service platforms is even increasing, and a fair number of the current ones in Finland require significant renovation and up-grading.

Biological and medical sciences have witnessed an unparalleled pace of technology development over the last two decades. Typically, application of these new technologies has permitted substantial leaps in the knowledge and produced ground-breaking results and concepts in the fields of biological and medical sciences. Over the last 20 years, at least half-dozen Nobel prizes have been awarded to scientists behind these technological innovations; the latest two prizes were in 2007 in Physiology or Medicine ("Introduction of specific gene modifications in mice by the use of embryonic stem cells") and in 2008 in Chemistry ("The discovery and development of the green fluorescent protein, GFP"). As a rule of thumb, the emergence of a new technology has neither been planned in a top-down fashion nor predicted. There are already emerging novel technologies on the horizon, and several of them are currently making the transition from development to widespread use. It is an important duty of the Biocenter Finland leadership to pay particular attention to emerging technologies, in order to avoid any undue delay in their transfer to Finland. As a rule, the Board of Biocenter Finland will consult scientists, research institutes, and universities prior to making decisions pertaining to funding of emerging technologies.

As mentioned above, biosciences are in many aspects approaching physical sciences, in that complex modes of data acquisition and computational data processing are required to deal with massive amount of information generated by research using, for example, genome-wide approaches, state-of-the-art biological imaging, proteomics, and structural biology.

The difficulties in keeping abreast with technology development constitute one of the greatest problems in Finnish biosciences research, and Finland is facing the danger of lagging even more behind her neighboring countries in support to competitive research environments. The foreseeable technology platform and other research services in biosciences necessitate strengthening local operations at each biocenter, prioritizing and dividing tasks with nation-wide services, and securing links to the international infrastructure efforts.

After being founded in 2006, Biocenter Finland started with the support of the MinEdu coordinating restructuring of the nationally important technology platforms in a number of areas. This process entailed division of tasks, avoidance of unnecessary overlaps, and assignment of priorities and responsibilities to different centers. This initial phase extends at the end of 2009. This document presents a detailed plan for restructuring and development of research environments in Finland in 2010–2012 within Biocenter Finland and in a well-coordinated collaboration with FIMM. Decisions regarding the funding of nation-wide platform services (core facility services) in the biosciences will take place on the basis of an international evaluation of the existing and/or new services and their proposed plans. Concomitantly, each biocenter will set priorities for their future goals and will determine the needs for sustaining high-level local research environment. Both current important platform services and new, yet to be established ones, are anticipated to receive support from Biocenter Finland.

General criteria and principles of operation for nation-wide platforms and other research services include, but are not limited to, the following:

- they are of national significance and too extensive for a single research group
- they support high-level research in the host institutes, and their services are open to universities at large, research institutes and companies
- they take into account and integrate with facilities in research institutes and other relevant players in the Finnish bioscience community
- they integrate with the pan-European and relevant Scandinavian initiatives
- they have open access policy and a cost recovery system with approved user fees
- they are based on division of tasks according to available resources and plans for building profile
- their continuation, further development and termination will be decided based on external evaluation, and
- a need for skilled staff should be taken into account to ensure efficient use of instrumentation and training of students and other users.

The sections below outline the most important technology platform services and describe their current status, concurrent international developments, division of tasks, and future needs and visions. The services are described in an alphabetical order (according to English language). The annual budget to support development and restructuring of national technology platform services is estimated to be 18.0 mill. €.

It should be emphasized that Biocenter Finland also aims at seeking additional funds from sources other than the MinEdu, for example, through participation to SHOKs (National Strategic Centers for Excellence in Well-being) and by partnership in European and other international networks as well as in pan-European research infrastructure initiatives. Likewise, it is anticipated that each biocenter will continue receiving funding from the host uni-

versity at the current level to support their on-going and future local functions. The supplementary funds – if successfully accrued – are not aimed at diminishing the funding request from the MinEdu, as the MinEdu funds for 2010–2012 will only cover the very basic needs of the Biocenter Finland activities. For the Finnish bioscience research to maintain its international competitiveness, Biocenter Finland assumes that the support from the MinEdu be not terminated after the initial three-year period.

5.1 Bioinformatics

Bioinformatics plays an increasingly important role in the everyday biological research. Computational biology and bioinformatics approaches are also crucial for making use of the genome-wide methods for systems biology, proteomics and metabolomics, structural biology and many other Biocenter Finland platform services. In view of this, it is clear that each biocenter has to have its own bioinformatics units and bioinformaticians who are capable of interacting with local bioscience personnel.

As a result of being actively developed both in the biological and technical universities, as well as at the IT Center for Science (CSC), Finland has high potential for bioinformatics with strong research groups. However, as a whole, the current efforts have remained local and scattered including many institutions outside the biocenter networks (such as technical universities, VTT Technical Research Center, and CSC). As a result, many of the activities in computational biology do not serve optimally the exponentially increasing needs of the large bioscience community. To address this issue, Biocenter Finland bioinformatics platform is meant to focus strongly on life science capabilities and applications, but it will also seek to link up with national and international information technology services and initiatives. Thus, a more coherent base for computational biology would underlie the bioinformatics research and services in the years to come. And as mentioned above, each biocenter needs to have a strong bioinformatics service unit to collaborate locally with the biologists, and to provide links to national developments.

Three complementary developments are envisioned: (i) A network of bioinformatics core facilities will be developed based on existing groups and strengths in the biocenters, with a strong link and supporting role for the other national infrastructure efforts. (ii) On top of this, a more expanded “national institute of bioinformatics without walls” will be launched (Finnish Bioinformatics Initiative). This network will expand beyond the core Biocenter Finland activities and involve also the technical universities, their information technology departments, VTT Technical Research Center, CSC and companies in the field. (iii) An internationally competitive focused medical bioinformatics service will be developed in collaboration between CSC, FIMM, and Helsinki Institute for Information Technology HIIT. HIIT is a joint facility between University of Helsinki and the Aalto University (formerly Helsinki University of Technology) and a leading site in Finland for algorithm development. CSC-FIMM-HIIT have initiated collaborative efforts to develop strong national expertise in medical bioinformatics. This program will initially focus on the significant challenge of dealing with large-scale genome sequence analysis, but will later incorporate other fields, such as integrative genomics, genetic epidemiology, chemical biology, and other fields with growing bioinformatics needs. This effort will also have strong links to the ELIXIR, EATRIS and BBMRI ESFRI projects as well as with the European Bioinformatics Institute-EMBL.

5.2 Biological Imaging

Imaging is a central tool in bioscience and biomedicine. Biocenter Finland aims to fill the huge gap existing in imaging expertise and facilities between the Finnish universities and the best centers in Europe, United States and Japan, raise the know-how, and acquire equipment in each center to the level allowing high-quality, internationally competitive research to be conducted.

Imaging can be divided to microscopic imaging of cells and tissues or their sections, and non-invasive imaging of animals or patients. The scope of Biocenter Finland is in developing services for basic research and hence, the non-invasive imaging of patients in hospitals is not discussed in this context. There is a need for developing imaging facilities in each biocenter, but the focus and scale depends on the research profile of the center. In addition, certain special methods should be centralized to a few centers or only to one center, which then serve(s) the entire scientific community in Finland. Through a joint effort, a working balance is built between nation-wide and local imaging services.

Microscopic imaging encompasses light microscopy and electron microscopy, and some new equipment combines the two methods. The most wide-spread imaging method is fluorescence microscopy of fixed or living cells and tissue sections. Equipment for live cell imaging is needed in each laboratory, whereas the instruments for high resolution imaging, such as total internal reflection fluorescence confocal microscopy or imaging of thick specimens, such as optical tomography devices, are not required by each biocenter. Small scale imaging of microplate-format analyses and requisite data handling are needed in each biocenter. In Turku and Helsinki, such facilities have been built, but they need to be further developed for high-content imaging and data processing in the context of automated, very large-scale genetic, RNAi and compound screens [see genome-wide methods (section 5.3) and translational research platforms (section 5.8)]. Two-photon confocal microscopes are used for thick specimens and even *in vivo* imaging of mice. They are expensive and their use requires special expertise, and hence, they should be concentrated to a few centers. In contrast, fast confocal microscopes and *in vivo* fluorescence devices for model organisms, such as zebra fish or mice, should be close to the researchers using these model organisms.

Biological electron microscopy entails transmission electron microscopy of cells and tissues, including cryo-immunoelectron microscopy and electron tomography, and structural electron microscopy of proteins, cellular organelles and virus particles. Transmission electron microscopy is mandatory in each biocenter and medical faculty, whereas the entire bioscience community may be served by the structural electron microscopy unit at the electron microscopy facility in Helsinki/Viikki, with expertise in cryo-electron microscopy, electron tomography and coordinated light-electron microscopy. Scanning electron microscopes (SEM) are used both in biosciences and material sciences, and they are usually available at microscopy centers of the universities.

In vivo bioimaging of experimental animals, including mice and rats, can be carried out by using ultrasound, luminescence and fluorescence imaging, X-ray imaging, magnetic resonance imaging or positron emission tomography (PET) imaging. The first three of these should be available at laboratories performing phenotyping of genetically-modified mice or rats, carrying out research using appropriately labeled or marked cells (see below) in several fields, such as cancer biology, developmental biology, matrix biology, neurobiology

and stem cell biology, or working with "reporter" animals. However, none of the biocenters in Finland has state-of-the-art equipment capable of non-invasive imaging at different wavelengths, with the possibility of recording radioactivity and skeletal structure at the same time. Magnetic and PET imaging should perhaps be centralized to one or two universities. The biomedical imaging unit of A. I. Virtanen Institute in Kuopio houses *in vivo* imaging facilities for small animals, including a national bio-NMR center for experimental MRI and small animal single photon emission computed tomography. There is a 4.7-tesla functional MRI equipment in Biomedicum Helsinki. A newly established experimental animal PET imaging unit is located at the National PET Center in Turku and the Turku Center for Disease Models. The internationally recognized MEG/fMRI center (Helsinki/Meilahti/Otaniemi) has its main emphasis in human imaging.

In addition to the use of imaging methods in biological research there is also product development going on at the biocenters, such as development of ultrahigh resolution stimulated emission depletion microscopy in Turku. In technical universities and engineering science faculties, there are large groups developing image analysis and mathematical algorithms for applications in machine vision and pattern recognition, and this expertise is relevant for biological imaging as well.

Modern imaging methods of cells and animals are highly dependent on fluorescent molecules, the green fluorescent protein, GFP, together with firefly luciferase (emitting bioluminescence) being the first and thus far most used proteins of its kind. There are now hundreds of derivatives of these molecules, and they can be tailored for specific research needs, including but not limited to studies on vesicle trafficking, blood circulation, cancer cell invasion and monitoring of the fate of stem cells in tissues. Creation of new probes requires collaboration between molecular biologists and organic chemists. In Finland, this type of research lags behind the international development, and Biocenter Finland will emphasize recruiting experts for the building of research environments for imaging living cells, tissues and model organism.

5.3 Genome-wide Methods

This research and service area entails (i) genetics and genomics, (ii) gene expression and gene regulation, and (iii) genome-scale biology and high-throughput screening. Other technologies that relate to systems biology are described in the bioinformatics and metabolomics/proteomics sections (sections 5.1 and 5.5, respectively).

(i) *Genetics and genomics.* This field has traditionally been a very strong area of expertise in Finland. Genome scans for genetic associations with complex diseases – *i.e.,* genome-wide association studies – are currently being accomplished at a rapid rate, resulting in the discovery of genes implicated in disease predisposition. The major national site for these services combined with the requisite bioinformatics expertise is at the FIMM Genome and Technology Center. This facility generates up to ~2 billion genotypes annually. The Finnish DNA Microarray Center in Turku and the new East-Finland Genome Center in Kuopio have also activities in this field.

A lot of the current genome scans will soon be replaced by genomic sequencing, with large international efforts already being underway. Genomic re-sequencing will require, on the other hand, establishment of methods by which defined regions of the genome can be iso-

lated prior to sequencing. These sequencing efforts will be supplemented with focused high-throughput genotyping of large patient materials. In all this work, there is a significant bioinformatics challenge, with a need for centralized expert facilities. From a medical point of view, pharmacogenomics is perhaps the most important one, and it will need the same platform services. Pharmacogenomics is, in turn, anticipated to impact relatively soon on future health care decisions, and it will aid efforts towards personalized medicine. FIMM will provide nation-wide service for human DNA sequencing (resequencing) in the future, with links to the patient cohorts of KTL and international BBMRI (Biobanking and Biomolecular Resources) ESFRI program. Ultrahigh-throughput DNA sequencing of other organisms is and will be primarily carried out by the Institute of Biotechnology in Viikki, but there is no technical reason why human DNA sequencing would not take place at this facility as well.

(ii) *Gene expression and regulation*. Gene expression profiling by microarray technology is currently carried out with commercial platforms (Illumina, Agilent, and Affymetrix) in the Finnish DNA Microarray Center (Turku) and Biocentrum Helsinki/Biomedicum Helsinki facilities. These facilities process thousands of samples per annum.

Many of the microarray-based services are expected to shift to next-generation DNA sequencing technologies, which provide many new opportunities for expression profiling of RNA, including alternatively-spliced RNA, micro-RNA and other non-coding RNAs (RNA-seq technology), and for studies on mechanisms of gene regulation, including transcription factor binding, and methylation and other epigenetics-related analyses (ChIP-seq technology). The first Ultrahigh-throughput parallel sequencing systems to carry out these analyses are currently located in Helsinki. For future functional genomics research, sequencing will perhaps be a major route for exploration of biological and medical samples. Since the number of applications exploiting this platform and related bioinformatics analysis methods is rapidly increasing and new technologies emerge it is important to increase the capacity of next-generation sequencing. It should be pointed out, however, that sequencing alone is not compatible with the very large number of samples to be analyzed. Therefore, microarray technology platforms will continue to have an important role in the foreseeable future.

(iii) *Genome-scale biology*. High-throughput center in Biomedicum Helsinki, the Systems Biology Initiative of Biocentrum Helsinki, and the BioCity Turku/VTT Medical Biotechnology Center in Turku operate high-throughput service facilities and maintain biological and chemical libraries. These technology platforms are supplemented by systems biology and high-content screening/imaging facilities at Biomedicum Helsinki and in Kuopio. In particular, the Systems Biology Initiative of Biocentrum Helsinki and Biomedicum Genomics aim at establishing a national resource that will provide human/mouse knock-down (for lentiviral shRNA, 16 000 genes) and human cDNA expression plasmids (18 500 full open reading frames) with flexibility to multiple experimental approaches.

It is envisioned that high-throughput biology continues to grow in importance, with RNA interference, cDNA and chemical biology screens being increasingly required. The same capabilities also support and link to translational drug discovery activities. To complement existing activities in Helsinki and Turku, FIMM will launch a fully automated 1534-plate compatible high-throughput system for chemical biology and drug discovery, as well as a unique cell microarray facility for RNAi screening. Taken together, these genome-scale re-

agents and services described above should keep Finnish scientists at the forefront in an area of significant future importance.

5.4 Model Organisms

Genetically-modified mice (GM) have become the most important organisms to understand the molecular basis of health and disease in man and to serve as suitable animal models for human disease. There is more than 95% similarity in protein-coding sequences of the genes between man and mice, and no other organism is as versatile with respect to the possibilities to manipulate the genome. There are a number of ways by which GM mice can be produced, such as a simple pronuclear injection to produce transgenic animals. Production of specifically gene-targeted mice usually entails the use on murine embryonic stem (ES) cells, in which system a gene of interest can be inactivated (knocked-out) or modified otherwise (knocked-in), for example, by insertion of a specific mutation. Present technology permits these modifications to be carried out in a time- and/or tissue-specific fashion (conditional knock-out/knock-in). Techniques are also currently available – and new ones are emerging –, in which viral vectors are used to perform knock-down of genes through production of short hairpin (sh)RNAs to inactivate mRNAs encoded by the gene of interest. When inactivation or knock-down of a specific gene is not the primary objective, various gene trap approaches have been devised and used by international or national consortia to produce GM mice. Some of these novel techniques, such as conditional gene targeting and shRNA-driven knock-down approaches, have been used by Finnish scientists only to a limited degree.

Large international projects are currently underway to systematically produce mutations in all genes in the mouse genome. To take full advantage of this huge research resource, Finland has to maintain and further develop its own research facilities for GM mice. In addition, there will be a continued need for generating more subtle mutations in the genome (*e.g.*, disease predisposing gene variants). All steps require specific equipment and laboratories, and well-trained personnel are of essential importance. Since the methods require handling and operations of living animals, laws on experimental animals as well as gene modified organisms regulate the set-up of facilities and education of personnel. Core facilities with permanent personnel are the only way to operate by the rules.

Archiving and shipping of valuable mouse lines are also tasks performed by core facilities. As part of the INFRAFRONTIER initiative, the European Mouse Mutant Archive EMMA will be expanded to contain new national nodes, including an EMMA node to be established in Oulu. This will secure constant updating of cryopreservation methods for embryos and germplasm. Important duties of core facilities are also education of researchers and following and being involved in development and set-up of new methods, such as generation of iPS (induced pluripotent stem) cells and high-throughput gene targeting. High-throughput genotyping services have been established at Biomedicum Helsinki for marker-assisted accelerated back-crossing, facilitating the rapid production of congenic knock-out or transgenic mouse strains. Moreover, mouse biobanks with murine tissue samples of different backgrounds and ages are also being planned.

More than 80 research groups in Finland use gene-targeted mouse models in their research, and this large user base is reflected in the need to support three transgene mouse facilities located in Helsinki, Oulu and Turku. A plan has been made to open up the current local

services for wider use, to deepen the special expertise on the basis of building individual profiles for services, and to generate a joint information center (accessible by the web) to enhance the possibilities of the large scientific community to access the services. With regard to generation of GM mice, the service units in Helsinki and Turku are largely directed to the local communities, whereas the Oulu facility will provide full service to the rest of Finland, *i.e.*, to scientists in institutes without their own service unit, and services for some specific tasks.

Whereas the generation of GM mice can be limited to 2–3 core facilities, it is not possible to centralize the mouse phenotyping facilities in Finland. Instead, a national Finnish mouse phenotyping network, which includes shared service in difference competence areas, will be built. This could be achieved partly as a Nordic effort, within the Nordic Infrastructure for Mouse Models network. Participating in INFRAFRONTIER is useful to secure access to standardized facilities for phenotyping of the mice, such as the German Mouse Clinic, and selected Finnish laboratories will have the possibility to provide in-depth analysis services as part of the pan-European initiative. And finally, up-to-date animal facilities with sufficient capacity to breed and maintain gene-targeted mouse lines are to be located in all Biocenter Finland host universities, as they are an essential part of a high-quality research environment.

Zebrafish is also a valuable model organism, and the cost for setting up a research and service facility is modest. The zebrafish user community in Finland is small, and the units established in Helsinki and Tampere can provide nation-wide services. The zebrafish platform will be coordinated by Tampere. Simple organisms such as the nematode *C. elegans* and the fruit fly *D. melanogaster* will also provide important information, for example, in large-scale genetic studies. Both of these model organisms require trained personnel rather than costly facilities. Laboratories in Helsinki and Tampere provide services and know-how for the use and maintenance of *D. melanogaster* lines, and several Finnish research groups are involved in the Nordic *C. elegans* network that is coordinated by Kuopio. The Viikki Plant Science Center will provide services in plant transgene technologies to other universities and research centers in Finland.

5.5 Proteomics and Metabolomics

Proteomics is the large-scale study of proteins, particularly their structures and functions. The proteome is the entire complement of proteins, including the modifications made to a particular set of proteins, produced by an organism or system. This will vary with time and distinct requirements, or stresses, that a cell or organism undergoes. Proteomics is an important technology in life sciences, ranging from basic cell biology in biomedical, clinical, food and environmental applications to more multidisciplinary approaches such as systems biology. It is a key technology in many academic projects, but essential for biotech industry as well. Identification of proteins in pathways, locations or at time-points, quantitative analysis, post-translational protein modifications, and protein-protein interactions are the most common inquiries. Typical of proteomics is the rapid technological development and expensive instrumentation. Compared to the best European centers, proteomics services are not well-developed in Finland. Nevertheless, current proteomics cores in Turku, Helsinki and Oulu have established an active nation-wide network, servicing basic research in national and international programs. There is, however, an urgent need to up-grade the exist-

ing facilities and thereby bring their instrumentation, technology and know-how to the cutting-edge level in Finland.

The areas of high priority include qualitative and quantitative protein analyses in cells, body fluids and tissues, analysis of protein modifications, and clarification of protein-protein complexes and interaction networks. Proteins labeled with stable isotopes or tagged with specific chemicals are often required in this context. These applications are central not only for basic biological questions but also for clinical applications such as biomarker discovery. The methods and platforms will be developed in collaboration with regional and international partners. Moreover, development and use of computational tools to visualize, interpret and manage large data sets is of high priority. This will be performed in collaboration with existing national bioinformatics facilities and institutes, including CSC. For the proteomics research in Finland to reach the state-of-the-art level, it is important to invest in new instrumentation, perform international recruitment and training to gain expertise in up-to-date methods and techniques.

Proteomics instrumentation has typically a fairly rapid turn-over rate, with marked technological advances taking place at 3–5-year intervals. Expensive instrumentation (*e.g.*, mass spectrometers with a high resolving power, a high mass accuracy, and a high dynamic range) appears to be needed in all three sites. However, a well-organized national coordination required to ensure that development of various applications takes place in a well-planned fashion. This will be achieved through division of tasks among the sites. National level proteomics screening, analysis and training should be coordinated from Turku, with network partners in Helsinki and Oulu. In Helsinki, services and responsibilities of the two proteomics and protein chemistry units at Biomedicum Helsinki and Institute of Biotechnology will be coordinated to form a high-quality service platform of local and national importance.

Metabolomics is the systematic study of the chemical fingerprints that specific cellular processes leave behind; in particular, the study of small-molecule metabolite profiles. The metabolome represents the collection of all metabolites in a biological organism, which are the end products of its gene expression. Thus, gene expression data (transcript analyses) and proteomic analyses do not necessarily tell the whole story of what might be happening in a cell, but metabolic profiling (metabolomics) can provide an instantaneous snapshot of the physiology of that cell.

Metabolomics is an increasingly important component of systems biology, and it is used in several fields of research in Finland, including biomedicine, diagnostics, drug development, nutritional and other intervention studies as well as in analysis and monitoring of bioprocesses in different organisms. The area of metabolomics in Finland is in the early stages of development. Similar to proteomics, the mass spectrometer-based instrumentation in metabolomics is expensive, even in small/moderate scale units. A state-of-the-art metabolomics facility with strong national and international collaboration, including industrial links, exists at VTT-Espoo. This activity will be formally linked to FIMM, with a plan to develop capabilities for metabolic profiling with the existing unique equipment. While focusing on biomedical and translational research, the VTT-Espoo facility will provide services nationally to Biocenter Finland also in other areas of life sciences. There are metabolomics initiatives in other biocenters as well, and establishment of a nation-wide metabolomics platform is the way to avoid unnecessary duplication of resources.

5.6 Stem Cells and Biomaterials

Basic research on stem cells is conducted in all biocenters of Biocenter Finland, and a nation-wide technology platform coordinating stem cell resources and training would be useful. Helsinki, Turku, Tampere and Kuopio have significant research activities related to human stem cell biology and the use of induced pluripotent stem (iPS) cells, whereas the focus in Oulu is primarily in mouse iPS and stem cells. Recent remarkable advances in the generation of iPS cells, *i.e.*, reprogramming of fully differentiated cells from adult organisms back to pluripotent stem cells by the use of limited number of transcription factors, represent perhaps the most important development towards the goals of regenerative medicine. Generation of iPS is now possible without the use of viral vectors that integrate in the recipient cell genome, and recent tantalizing results have shown that reprogramming of differentiated pancreatic exocrine cells in adult mice into cells that closely resemble insulin-producing β-cells is possible. These findings are of utmost importance to stem cells research and its applications, such as regenerative medicine and tissue engineering, and Biocenter Finland scientists need to stay abreast with these development. However, current activities on generation and use of iPS cells in Finland are in their early stages, but this work is envisioned to expand significantly over the next few years. As of now, it may suffice that scientists working on iPS cells of both human and murine origin will form a national network to share their technical and conceptual expertise and to train uninitiated scientists and students. It is conceivable, however, that the current activities on iPS cells in Finland will expand to such an extent that a centralized technology platform needs to be launched.

With regard to potential therapeutic use of human stem cells, Institute for Regenerative Medicine (Regea) in Tampere is the only research center in Finland harboring clean room space and quality assurance for GMP level production of stem cells, tissue products combining stem cell, biomaterials and other regulatory factors. It also has unique tissue bank activities that serve both research groups and university hospitals in Finland. It is anticipated that following the current phase of basic research related to derivation and functional characterization of human stem cell lines and the use of iPS cells, the next important phase will be the utilization of these cells for regenerative medicine and tissue engineering. As a consequence, research services for future stem cell efforts are in many aspects reminiscent of tissue technology approaches described above. The physical facilities of Regea will play an important role when stem cell activities will be coordinated in Biocenter Finland.

5.7 Structural Biology and Biophysics

Structural biology and biophysics describes how proteins and other macromolecules work at the level of individual atoms. The results from this type of studies are essential for understanding how biological systems indeed function. Structural information is also essential for design of new drugs. There are three major techniques for examining the structures of macromolecules – proteins, nucleic acids and their complexes – at the atomic level, namely X-ray crystallography (X-ray), nuclear magnetic resonance (NMR) and electron microscopy. Examining what happens – *i.e.*, getting a moving picture – requires NMR, fast biophysics, and mass spectroscopy.

There are structural biology groups at the Universities of Helsinki, Oulu, Turku, Jyväskylä and Joensuu, and a biophysics group at the University of Helsinki. In terms of technology

platforms, the Universities of Helsinki and Oulu have the largest investments, with smaller investments at Joensuu and Turku. X-ray requires both growing crystals and a source of X-rays. The largest-scale facility for growing crystals in very small (nanoliter) volumes is in Helsinki, whereas significant investments for producing X-rays are in Helsinki, Oulu, Joensuu and Turku. X-ray "data collection" takes place currently at dedicated facilities – synchrotrons – such as the European Synchrotron Radiation Facility ESRF. The other techniques mentioned above – NMR, electron microscopy, and biophysics – primarily exist only in Helsinki, though there are smaller-scale investments in NMR in Turku and Oulu. Up-to-date NMR work requires very powerful – superconducting – magnets, and the most powerful ones that are currently commercially available are around 1-GHz magnets. The NMR group in Helsinki is a national service center, and it has one 500-MHz, two 600-MHz and one 800-MHz machines, two of which have "cryoprobes" that also improve the quality of the data obtained. For electron microscopy, two cryocooled field emission microscopes have been in use. Finally, the biophysics units have unique instruments for laser-assisted time-resolved optical spectroscopy (one full visible spectrum per microsecond), and ultrafast freeze-quench technology for electron-spin resonance spectroscopy. These platforms are in demand by other groups in different parts of Finland and also internationally.

The next step forward in biomedical science requires the integration of structural knowledge at different resolution levels into specific cellular contexts. To accomplish this, a palette of techniques is needed, each appropriate to the required scales, with the gaps being bridged by molecular modeling. There is a need to image how structures change with time and how this, in turn, leads to changes in cell state. This requires merging the information from NMR, X-ray and electron microscopy with all other relevant information – such as mass spectroscopy, biophysics and cell biology techniques. Collectively, combination of these approaches will provide a dynamic picture of the cell from sub-nanometer to millimeter spatial resolution and time resolution from femtosecond to second.

The rapid advances in all aspects of structural biology technology over the last 15 years implies that, in order to stay abreast with the developments, Finland ought to be able to afford purchasing of new instrumentation, such as 300-kV transmission electron microscope and 950-MHz NMR equipment, and improve current structural biology platform services by other means as well. These measures are needed to answer important questions in human health and molecular medicine, such as those relating to cancer biology, aging, antibiotics design, etc. Improved structural information will also be essential for expedited development of a green economy; modified enzymes can replace energy-intensive, polluting, high-temperature chemical procedures with cleaner, low-temperature enzyme-driven ones – as in the Finnish pulp and paper industry.

FinStruct, a new model of the Structural Biology and Biophysics network of Biocenter Finland, has already been launched, and it comprises four core centers: Helsinki, Oulu, Turku/Åbo and Kuopio/Joensuu. Each will provide a different mix of techniques and training related to the biological focus of the groups present, as high-quality research is a prerequisite for high-quality platform service functions. Each partner has its own scientific program and will continue to develop cutting edge expertise in specific areas, and to serve that expertise to the other partners and to the stakeholders.

5.8 Translational Research Technologies

There is a significant need to link better the ever-increasing biological and biotechnological discoveries with public health, medical, and industrial applications and expectations. Likewise, it is a major challenge to merge the novel diagnostic and therapeutic capabilities to improve possibilities for personalized health care. Finland and the Nordic countries are well positioned to lead such developments. The choice of Nordic countries as the sites of the EMBL Molecular Medicine partnership is a testimony to this potential. To this end, FIMM will aim at coordinating the setup of new national translational research technology and service functions in Finland with two closely linked efforts. Together, these will form virtual "translational centers" that should have matching capabilities to those of major medical centers in the world.

(i) *Biobanking and biomarker development*. There are large population-based, epidemiologically-linked DNA archives and serum sample collections at the National Public Health Institute (KTL) that form the basis for the Finnish link to the BBMRI initiative. Many individual scientists/research groups and diagnostic laboratories across the country have also collections of biological samples. These are, however, neither currently well-organized nor made available to researchers. By contrast, the Tampere University Hospital operates the only hospital-linked biobank (Tampere Research Tissue Bank) in Finland, and it provides investigators with biological samples and corresponding clinical data. In many instances, analysis of the specimens and data sharing are facilitated by virtual microscopy established by scientists in Tampere. These developments have already taken place in the absence of national biobanking legislation. Once the new law is passed, expected to take place in 2009, the importance and impact of the biobanking efforts will increase substantially.

Centralized biobanks of national importance require new facilities that are, for the most part, currently lacking in Finland. Besides the efforts in Tampere, there are developments underway to set up centralized sample storage facilities and biobank operations at FIMM, together with KTL, University of Helsinki and Helsinki University Central Hospital. Biobanks will have privacy-protected access to archives and registries of patient data and a possibility to collect, archive and analyze these data by computerized data mining. The biological samples will also be made available in arrayed plates for downstream analyses by protein, DNA or other high-throughput techniques. In the case of tissues, specimens will be available as tissue microarrays (TMAs) that are being developed in Tampere, Helsinki, Oulu and other sites. With pertinent clinical and follow-up information, they will provide a good example for establishment of a powerful national network. Finally, without appropriate molecular profiling and biomarker discovery activity, biobanks will remain just "storage" facilities. Therefore, this resource should be used by clinical investigators at university hospitals and also linked to groups developing diagnostic activities, including companies in Finland.

(ii) *Finnish Advanced Translational Research Platform* will focus mainly on drug discovery and development. This program is linked to the EATRIS initiative. It will develop further several key activities in Finland, such as chemoinformatics and structural biology, (ultra)-high-throughout screening resources for small molecules (FIMM-Biocentrum Helsinki-VTT), as well as the use of model organisms for pre-clinical drug discovery and development. These efforts will explore proof-of-concept molecules with pharmaceutical potential or diagnostic importance to targets identified by the biomedical research community in

Finland. There is also an academic pharmacological research network and medicinal chemistry resource that could support the translational research platform. This platform is needed to bridge the gap between academic research and industrial interests, and Finnish pharmaceutical industry will be linked whenever possible. And finally, the two translational research platforms must be linked with each other to develop diagnostic and therapeutic means and to recognize, through pharmacogenomics and systems biology, improved possibilities towards personalized medicine and health care.

5.9 Viral Gene Transfer and Cell Therapy

Viral Gene Vector Laboratory in the A. I. Virtanen Institute (Kuopio) is one of the leading gene vector laboratories in the world and provides many gene transfer vector production, cell banking and manufacturing services required for basic biological research, identification of gene and RNAi functions, and translational research. This Laboratory has biosafety level 2 and 3 facilities that have been accredited by the Finnish National Agency for Medicinal Products and the European Medicines Evaluation Agency (EMEA) for the production of viral vectors for preclinical and clinical phase I/II/III studies. This license is unique in European Union, and it is the first granted outside big pharmaceutical companies. Two of the adenoviral gene therapy drugs produced in the Viral Gene Vector Laboratory have entered phase II and phase III large scale clinical studies in Europe and United States. This Laboratory has intense collaboration in European Union FP6 CliniGene Network of Excellence where it serves as a reference laboratory for adenoviral vectors for preclinical and clinical studies.

Viral Gene Vector Laboratory produces and makes available for all investigators the latest, validated adenoviral, lentiviral, retroviral, adeno-associated viral, and baculoviral vectors with cloning instructions and advice pertaining to all biosafety issues. It will produce high-quality small-scale and medium-scale lots of viral vectors for investigators. Large-scale production of clinical-grade GMP vectors will also be available. Likewise, vectors for the transduction of stem cells, iPS cells and progenitor cells will be provided. As mentioned in section 5.3 (Genome-wide methods), maintenance and production of lentiviral vector libraries for genome-wide knock-down purposes will be coordinated by the Biomedicum Genomics at Biomedicum Helsinki.

Viral Gene Vector Laboratory has produced vectors for cell therapy and developed them for short-term and persistent modification of stem cells, progenitor cells and iPS cells. This area clearly needs further development for better cell type-specific and conditionally-regulated vectors. Lentiviral siRNA and shRNA vectors will be developed for tissue-specific and conditionally-regulated approaches to generate transgenic and knock-down mice. This laboratory will also develop and optimize efficient *in vivo* gene transfer, cell delivery and cell grafting methods in rodents and large animals in the Kuopio Experimental Animal Center which has permissions to use biosafety level 2 and 3 vectors for *in vivo* work. Optimized methods will be made available for other laboratories in Finland.

Significance and structural development. This type of service unit is clearly needed and necessary to guarantee that the latest new gene transfer technology and validated vectors will be available for Finnish researchers. It significantly improves international competitiveness of Finnish research, and profiles A. I. Virtanen Institute in a research area where there is no significant overlap with other biocenters or research institutions.

6 New Initiatives

Three new initiatives will be described in this context, as they are anticipated to (i) render the already multinational biocenter research environments in Finland even more international in research training; (ii) support career development of the most-promising young principal investigators under the Biocenter Finland umbrella and bring expertise in novel technologies to Finland in some key technological areas; and (iii) facilitate commercial exploitation of research results among the Biocenter Finland investigators. The annual budget to support the new initiatives is proposed to be 2.0 mill. €.

6.1 International Graduate Student Start-up Program

Graduate students (Ph.D. students) have always played a very important role in biosciences – or in all life sciences for that matter – in Finland, as judged by the estimate that approx. 75% of all publications from Finland have belonged to someone's Ph.D. thesis. Recently, Finnish universities have established ambitious goals to significantly increase the number of foreign students. However, progress in this regard has been relatively modest. Even though the graduate student body within the Biocenter Finland research groups is already quite international, as compared to many other disciplines in Finland, a more systematic approach to promote international visibility of the biocenters and, by this means, recruit high-quality graduate students to Finland would be an important undertaking. To this end, Biocenter Finland aims at establishing a novel international graduate student start-up program.

In short, the start-up program's outline is as follows. Biocenter Finland will recruit annually 20 high-quality graduate students through an international campaign and interviewing process, and will provide start-up support for the first year to the selected 20 students. During this first year, the students will rotate in Biocenter Finland research groups (at different biocenters) and perform appropriate course work, after which each student will select a research group where she/he will start the thesis project. Biocenter Finland will appoint a group tutoring the students up until this phase. Upon his/her selection of research group and site of residence, the graduate student will be placed to a local biocenter graduate school that will assume the responsibility for the student's continuous funding and research training.

The start-up program of Biocenter Finland will by no means compete with current graduate schools in the biocenter campuses; rather, it will provide them access to pre-selected international graduate students and help their increasing efforts to recruit international scholars.

6.2 Personalized Support to Research Career Development in Biosciences

Development of Biocenter Finland and its member biocenters towards attractive places for international recruitment relies on two pillars: (i) the research environment comprising the physical facilities (the buildings) and the technology platforms and other research services, and (ii) the human resources – the scientists working at biocenters. Each biocenter has currently quite modern research laboratory facilities, and the plans of Biocenter Finland to restructure and renovate the technology platform services have been described in section 5 of this document.

It is of utmost importance for the Finnish biosciences to flourish that much more attention is paid to human resources; a career in bioscience research has to be an appealing choice for talented young students, and the local research community has to have more flexible means to retain top-quality young group leaders and recruit new ones. The reformed University Law will provide the biocenter host universities with more administrative freedom and give them the opportunity to set forth clear priorities for restructuring and development of their strengths in research and education. Even though each university will most likely aim at improving career development paths within the organizations and striving for establishment of a system emulating the tenure-track system in American universities, Biocenter Finland believes that additional measures are in order as well.

The greatest challenge in research career development in Finland is undoubtedly the transition from the first principal investigator (group leader) position (such as the five-year Academy Research Fellow position) to a position that requires financial commitment from the organization and permits a successful principal investigator to continue his/her work. One possibility to resolve this issue is, but only in part, that appointments to the Academy Research Fellow positions are made only under the conditions that the biocenter host university guarantees formally that there is a career development possibility for the recipient of the position, contingent on his/her performance during the Research Fellow period. Biocenter Finland proposes to address some of the possible up-coming problems by its program for personalized support to research career development in biosciences.

In a nutshell, the program is as follows. The Board of Biocenter Finland will identify – through regular external evaluations of individual biocenters or by other means – talented young principal investigators with excellent track records whose first five-year appointments are closing. Subsequently, Biocenter Finland will discuss with these individuals issues pertaining to their funding and wishes for future site of research. The Board will then engage in discussions with the appropriate organization for shared funding of the principal investigator's salary and offer, for example, to cover 20–50% of his/her salary for the next appointment period. Biocenter Finland assumes that by this means, it will be able to support career development (tenure-track) for 5–10 talented principal investigators in biosciences. Naturally, great attention will be paid to the candidates' evaluation to make sure that no bias with regard to their gender or site of research will take place.

It is also likely that a similar mechanism would be useful, when foreign experts or Finnish scientists living abroad will be recruited, for example, to bring expertise in novel technologies to Finland in some key areas such as proteomics. In these cases, sometimes a full coverage of the person's salary and a relevant start-up package for the first five years may be required.

6.3 Proof-of-Concept Funds for Commercial Exploitation of Research Findings

Exploitation of research results covers, in principle, all benefits that results from research. It can lead to financial gains, support to societal decision making, improvement in patient care, advances in general knowledge in a given field, or other comparable benefits. Thus, commercial exploitation of research findings is just one aspects of the exploitation.

Biocenter Finland recognizes that its activities in commercial exploitation of research results should be in concert with those of the host universities. Likewise, there is no need for

Biocenter Finland to assume a role in supporting commercialization of research results that is already the responsibility of other organizations such as TEKES. The governance of Finnish universities will have more administrative and financial freedom as soon as the new University Law has taken effect. This is likely to increase the activities of the universities in commercial exploitation of research results and other innovations, and novel strategic partners are needed.

Biocenter Finland believes that one of the most significant bottlenecks in the exploitation of innovations from academia is the lack of sufficient funds for proof-of-concept verification. This means that prior to any additional investment in commercial exploitation of research results, the innovations will be tested with appropriate strategic partners – for example, with a research-oriented small or medium size enterprise – to verify that it is indeed feasible to exploit the innovation and develop it towards a commercial product.

In order to bring scientific discoveries to commercial exploitation, it is important that sufficient intellectual property (IP) verifications will be made. These checks are always time- and money-consuming events, but if done properly, will eventually save costs. The outcome should be either a patentable discovery or a clear hindrance in the freedom-to-operate. Knowing this will then again direct the strategy to move forward. Similarly, before entering into extensive patent applications, it is useful if the market situation of the discoveries in question can be studied to some extent. These procedures could be carried out in close collaboration either with the strategic partners of Biocenter Finland or with the licensing bodies within the host universities.

7 Conclusions and Recommendations

The purpose of the recommendations in this document is to develop and restructure the functions of the biocenters in Finland, in order to advance biosciences, biomedicine and the relevant technology platforms at the national level as well as to promote collaboration among the partners in this field. It aims at combining the local expertise into a nation-wide knowledge base, in order to insure that restructuring and development of the Finnish bioscience will be conducted in a coordinated fashion.

Biocenter Finland is currently a collaboration network of six biocenters, which are located at six universities (University of Helsinki, University of Kuopio, University of Oulu, University of Tampere, University of Turku, and Åbo Akademi University). Biocenter Finland should continue to be open to new members (*e.g.*, the research institutes of other ministries), but only on the basis of evaluation of their research quality. The administration of Biocenter Finland should be sufficiently independent, in that its Board should be responsible for allocation of funds. Biocenter Finland should have a full-time Director responsible for the day-to-day administration activities. The Rectors' Council consisting of the member universities should decide matters of principle and appoint the Board and the Director. For the development of Biocenter Finland administration, an annual budget of 0.5 mill. € is proposed. In addition, Biocenter Finland should have a national Advisory Committee, whose task is to facilitate collaboration of all interested parties, including the sectorial research institutes, university hospitals, and relevant industries.

The Institute for Molecular Medicine Finland (FIMM) should be further developed as an international research center with the focus on human genetics, medical systems biology and translational research. FIMM will participate together with Biocenter Finland in developing and restructuring the technology platforms purported to serve the entire bioscience community in Finland.

The operation of Biocenter Finland should be developed with the main focus of being able to bring the research environments and technology services in Finland to a level compatible with international developments and those in the neighboring countries. For this purpose, annual funding of 18.0 mill. € needs to be allocated. Nation-wide and centralized technology platform services will reduce overlapping and redundant investments in different biocenters. Allocation of funds to the platform services will be based on international evaluation, which focuses on the quality, scientific competence, and the number scientists that the platform will serve. These services will have an open-access policy and can be utilized, based on approved user fees, by universities, research institutes and the industry.

Development of technology platform services is recommended in nine topic areas. These are the following: bioinformatics; biological imaging; genome-wide methods; model organisms, proteomics and metabolomics; structural biology and biophysics; stem cells and biomaterials; translational research technologies; and viral gene transfer and cell therapy.

Three new initiatives are described in this document, and they are anticipated to (i) render the already multinational biocenter research environments in Finland even more international in research training; (ii) support career development of the most-promising young Principal Investigators under the Biocenter Finland umbrella and bring expertise in novel technologies to Finland in some key technological areas.; and (iii) facilitate commercial exploitation of research results among the Biocenter Finland investigators. An annual budget of 2 mill. € is proposed for these new initiatives.

Biocenter Finland should serve as a useful model to restructure and develop other fields of science in a nation-wide fashion in Finland. It is also anticipated to serve as a European-wide example as to how to optimize the use of available resources within life science. The technology platforms to be developed by Biocenter Finland will improve the ability of the Finnish bioscience community to participate in and benefit from the upcoming pan-European research infrastructure initiatives. And finally, development of state-of-the-art technology platforms and research environments through the Biocenter Finland program should help Finland recruit top international talent in the globalized labor market.

7 Johtopäätökset ja suositukset

Tämän muistion suositusten päämääränä on kehittää rakenteellisesti Suomen biokeskusten toimintoja ja edistää siten kansallisesti biotieteitä, biolääketiedettä ja niitä tukevia teknologiapalveluja sekä alan toimijoiden välistä yhteistyötä. Esitetty ohjelma pyrkii yhdistämään paikallisen osaamisen kansalliseksi tieto- ja taitovarannoksi, jonka pohjalta suomalaista bioalaa voidaan kehittää suunnitelmallisella tavalla.

Biokeskus Suomi on tällä hetkellä kuuden biokeskuksen välinen yhteistyöverkosto. Keskukset kuuluvat kuuteen yliopistoon, jotka ovat Helsingin, Kuopion, Oulun, Tampereen ja Turun yliopisto sekä Åbo Akademi. Biokeskus Suomi on jatkossa valmis hyväksymään uusia jäseniä (esim. muiden ministeriöiden alaisia sektoritutkimuslaitoksia) sillä edellytyksellä, että niiden tutkimustyö on riittävän korkealaatuista. Keskuksen hallinnon on oltava riittävän itsenäinen, ja sen johtoryhmän vastattava varojen jakamisesta. Keskuksella tulee olla päätoiminen johtaja, joka toteuttaa ohjelman päämääriä ja vastaa käytännön hallintotehtävistä. Jäsenyliopistojen rehtorien neuvosto vastaa periaatekysymysten ratkaisemisesta sekä johtoryhmän ja johtajan nimittämisestä. Biokeskus Suomen hallinnon kehittämiseen esitetään 0,5 miljoonan euron vuotuista budjettia. Keskuksella on myös kansallinen neuvottelukunta, jonka tehtävänä on parantaa eri sidosryhmien välistä yhteistyötä. Sidosryhmiä ovat mm. sektoritutkimuslaitokset, yliopistosairaalat ja teollisuuden edustajat.

Suomen molekyylilääketieteen instituutista (FIMM) tulee kehittää ihmisen genetiikkaan, lääketieteelliseen systeemibiologiaan ja translationaaliseen tutkimukseen keskittyvä kansainvälinen tutkimuskeskus. FIMM osallistuu yhteistyössä Biokeskus Suomen kanssa koko Suomen bioalan tutkijoiden käyttöön tarkoitettujen teknologipalvelujen kehittämiseen ja uudistukseen.

Biokeskus Suomen toiminta tähtää siihen, että maamme tutkimuksen toimintaympäristöt ja keskitetyt teknologiapalvelut saatetaan kansainvälistä ja naapurimaiden tasoa vastaavalle tasolle. Tähän tarkoitukseen esitetään kohdennettavaksi 18 miljoonaa euroa vuodessa. Valtakunnallisilla ja keskitetyillä biotieteiden teknologiapalveluilla (keskus- tai ydinpalveluilla) vähennetään eri biokeskusten päällekkäisiä investointeja. Teknologiapalvelujen aloittamiseksi ja ylläpitämiseksi kohdennetaan varoja kansainvälisen arvioinnin perusteella, jossa keskitytään laatuun, tieteelliseen erinomaisuuteen ja kyseisestä palvelusta hyötyvien tutkijoiden määrään. Palvelut ovat yleisesti käytettäviä, ja mm. yliopistot, yliopistosairaalat, tutkimuslaitokset ja teollisuus voivat hyödyntää niitä sovittuja käyttömaksuja vastaan.

Keskitettyjen teknologiapalvelujen kehittämistä esitetään ensisijaisesti yhdeksälle alueelle, jotka ovat bioinformatiikka, biologinen kuvantaminen, genominlaajuiset menetelmät, malliorganismit, proteomiikka ja metabolomiikka, rakennebiologia ja biofysiikka, kantasolut ja biomateriaalit, translationaalisen tutkimuksen tekniikat sekä virusvälitteinen geeninsiirto ja soluterapia.

Biokeskus Suomen toimintaan esitetään liitettäväksi kolme uutta hanketta, joiden päämääränä on (i) tehdä Suomen biokeskusten toimintaympäristöistä entistäkin kansainvälisempiä tutkijankoulutuksen osalta, (ii) tukea lahjakkaiden nuorten ryhmänjohtajien urakehitystä Biokeskus Suomen puitteissa ja tuoda maahan avainalojen uusien tekniikoiden asiantuntemusta sekä (iii) edistää Biokeskus Suomen tutkimustulosten kaupallista hyödyntämistä. Näille uusille hankkeille ehdotetaan 2 miljoonan euron vuotuista budjettia.

Biokeskus Suomen uskotaan olevan hyödyllinen malli maamme muiden tieteenalojen rakenteelliselle kehittämiselle. Euroopassa tätä esimerkkiä voisi käyttää laajemminkin optimoitaessa biotieteiden alan resursseja. Biokeskus Suomen kehittämät teknologiapalvelut parantavat Suomen biotieteen tutkijayhteisön mahdollisuuksia hyötyä tulevista Euroopan laajuisista tutkimusinfrastruktuurihankkeista. Ohjelman toteutus edistää myös kansainvälisten huippututkijoiden rekrytointia Suomeen globaaleilta työmarkkinoilta.

Appendix 1

Budget requests for the program

(All figures are per annum)

Budget total 20.5 mill. €

Biocenter Finland administration 0.5 mill. €

- Salaries for Director, Coordinator, and support staff
- Evaluations, publications and advertising, travel and meeting expenses

Technology platforms 18.0 mill. €

- Purchase of new equipment: 6 mill. € (1 mill. € is reserved for emerging technologies)
- Running costs of technology platform services, including: salaries for staff, maintenance of equipment, space costs, training expenses for staff & students: 12.0 mill. €
- Running costs of a platform service are estimated to be 0.2–0.5 mill. €/year
- Allocation of funds (equipment purchase; running costs of platform services) will take place after international evaluation of the needs in different technology areas

bioinformatics
biological imaging
genome-wide methods
model organisms
proteomics and metabolomics
stem cells and biomaterials
structural biology and biophysics
translational research technologies
viral gene transfer and cell therapy

New initiatives 2 mill. €

- International graduate student start-up program
- Personalized support to research career development in biosciences
- Proof-of-concept funds for commercial exploitation of research findings