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From Genes to Ethics Research for a New Millennium

FINAL REPORT OF THE LIFE 2000 RESEARCH PROGRAMME

ACADEMY OF FINLAND

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Final Report of the Life 2000 Research Programme

Mika Tirronen and Laura Walin (eds.)

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Julkaisun nimi	From Genes to Ethics - Research for a New Millennium. Final Report of the Life 2000 Research Programme.	
Tiivistelmä	Life 2000 oli suurin Suomessa koskaan käynnistetty bioalan perus- ja soveltavaa tutkimusta rahoittava tutkimusohjelma. Ohjelma toimi kolme vuotta vuosina 2000-2003, ja sen kokonaisbudjetti oli n. 14 miljoonaa euroa. Ohjelmaan kuului kaikkiaan 89 tutkimusryhmää 18 yliopistosta ja tutkimuslaitoksesta sekä yhdestä yrityksestä. Ohjelman rahoittajina toimivat Suomen Akatemia ja Tekes. Ohjelmassa oli kuusi painopistealuetta: neurotieteet, kehitysbiologia, funktionaalinen genomitutkimus, biofysiikka, bioinformatiikka ja biotieteisiin liittyvät eettiset, juridiset ja sosiokulttuuriset kysymykset. Tässä raportissa luodaan katsaus ohjelman toimintaan ja tuloksiin ja tarkastellaan ohjelmatoimintaa ja tiedotusta ohjelma-alueittain tutkijoiden, ohjelmakoordinaation ja muiden intressiryhmien näkökulmasta. Yksi tapa arvioida ohjelman vaikuttavuutta on tarkastella siinä toimineiden tutkimusryhmien tieteellisiä julkaisuja. Siinä valossa Life 2000 -ohjelma oli erittäin tuloksekas: ohjelmarahoituksen avulla tuotettiin yli 500 tieteellistä julkaisua kansainvälisissä SCI-julkaisusarjoissa. Keskimäärin 26% tutkimusryhmien tuottamista julkaisuista oli rahoitettu joko kokonaan tai osittain Life 2000 -rahalla. Tämä vastaa odotuksia, sillä suurin osa ryhmistä sai 10-30% rahoituksestaan Life 2000 -ohjelman kautta. Yksi ryhmä tuotti keskimäärin 7,5 Life 2000 -artikkelia (vaihteluväli 0-71). Yhden Life 2000 -artikkelin hinnaksi ohjelmarahoituksen kautta tarkasteltuna tulee keskimäärin 21 000 euroa. Tämän lisäksi 55 väitöskirjaa tuotettiin Life 2000 -ohjelman puitteissa. Tarkasteltaessa ohjelman merkitystä tutkijoiden näkökulmasta, 50% ryhmänjohtajista ilmoitti, että ohjelman kautta saatu rahoitus oli hyvin merkittävää kyseiselle tutkimusryhmälle. Jopa 77% ryhmänjohtajista arvioi, että he olivat saavuttaneet ohjelman kautta merkittävää tieteellistä yhteistyötä. Valtaosa, 95,1% ryhmänjohtajista, oli sitä mieltä, että ohjelma toi lisäarvoa myös muussa mielessä kuin lisäämällä tutkimusrahoitusta, kun 4,9% arvioi, että lisäarvoa ei tullut. Raportin lopuksi neljä ohjelmassa toiminutta tutkijaa arvioi oman tieteenalansa kehitystä ja haasteita uuden vuosituhannen kynnyksellä.	
Asiasanat	Life 2000, tutkimusohjelma, Suomen Akatemia, Tekes, neurotiede, kehitysbiologia, funktionaalinen genomitutkimus, biofysiikka, bioinformatiikka, bioetiikka, ELSA	
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Title	From Genes to Ethics - Research for a New Millennium. Final Report of the Life 2000 Research Programme.	
Abstract	The Research Programme on Biological Functions, Life 2000, was the largest research programme ever launched in Finland for purposes of funding both basic and applied research in the biosector. Running for three years from 2000 to 2003, it had a budget of 14 million euros and involved 89 research groups from 18 universities and research institutes and one company. Funding came from the Academy of Finland and the National Technology Agency Tekes. The programme areas covered neuroscience, developmental biology, functional genomics, biophysics, bioinformatics as well as ethical, legal and sociocultural issues related to bioresearch. This report reviews the programme's progress over these three years, looking separately at the different programme areas, the coordination function and information activities as well as the outcomes of the programme from the point of view of the researchers involved and other stakeholder groups. One way to assess the importance of the programme is to evaluate the scientific productivity of the projects involved. In this sense, the programme was highly succesful: more than 500 publications in international SCI series were produced partly or entirely by Life 2000 money. On average, 26% of the publications produced by the research teams during this period were funded from Life 2000 monies. This is more or less in line with expectations, bearing in mind that for most teams Life 2000 funding accounted for 10-30% of overall funding. One team produced on average 7,5 Life 2000 articles (range 0-71). The cost of one Life 2000 article to the programme would thus be around 21,000 euros. In addition to this, altogether 55 doctoral theses were produced within the framework of the programme. When assessing the importance of the programme from the scientist's point of view, as many as 50% of the group leaders indicated that the funding gained throught the programme was very essential for their research. No less than 77% of the research groups felt they had gained significant benefit from the programme through scientific cooperation. The vast majority, 95,1% of the group leaders, said that the programme was beneficial also in other ways than increasing their funding, while 4,9% said that there had been no value added. In the final part of the report, four experts who took part in the programme reflect upon the challenges that lie ahead in their respective fields in the new millennium.	
Key words	Life 2000, research programme, Academy of Finland, Tekes, neuroscience, developmental biology, functional genomics, biophysics, bioinformatics, bioethics, ELSA	
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Contents

1. Introduction

The Research Programme on Biological Functions, Life 2000, was the largest research programme ever launched in Finland for purposes of funding both basic and applied research in the biosector. Running for three years from 2000 to 2003, it had a budget of 14 million euros and involved no less than 89 research groups. Funding came from the Academy of Finland and the National Technology Agency Tekes. The subjects covered in the programme were also exceptionally far-ranging: there were six main areas of study, viz. neurosciences, developmental biology, functional genomics, biophysics, bioinformatics as well as ethical, legal and sociocultural issues related to bioresearch. The study of neurosciences, for instance, comprises several research traditions, including molecular neurobiology, brain imaging, neurophysiology, neuropharmacology and neuropsychology. The ethical, legal and sociocultural aspects of bioresearch also constitute a broad and heterogeneous field: a moral and philosophical examination of questions surround embryo research, for instance, will require completely different tools and concepts than a study of bioresearch funding policies or the commercialisation of new innovations.

Why, then, was such a large programme set up in the first place? Over the past 20 years biosciences have developed at a phenomenal rate and often in unpredictable directions. Two decades ago such methods as PCR, gene therapies, nuclear transplantation, the isolation of stem cells and DNA chips were still virtually unknown, and few would have foreseen the advances we have now witnessed. This kind of rapid technological change and development is extremely demanding on researchers: not only do they have to keep track of developments in their own field of study, but they must constantly be learning new methods and approaches. Proceeding from a study of the expression pattern of a single gene to a simultaneous analysis of the expression profile of thousands of genes requires not only new equipment and methods, but also a whole new approach, new concepts and new strategies

An effective response to the challenges of competition requires specialisation, but also a broad and open mind. A small research group rarely has the resources for this. The only solution is collaboration and cooperation. The developmental biologist does not necessarily have the expertise of a DNA chip specialist, so it is best to turn to the chip expert for help and advice. This strategy of linking together different lines of expertise serves to create a coherent chain of different of methods.

This was the leading idea behind the Life 2000 programme: it was thought that collaboration and cooperation might generate something that otherwise might not materialise. From the outset one of the programme's explicit and most prominent objectives was to encourage the creation of new kinds of research consortia.

The rapid development of biosciences has had a profound effect not only on research itself, but it has had far-reaching consequences in society more generally. The work of genome projects and all the talk about gene patents, gene testing and various kinds of biobanks has caused much public concern and anxiety. Who owns our genes? Advances in biomedicine have paved the way to completely new kinds of methods

and opportunities, and at once given rise to new concerns. Many question marks continue to hang over GMOs as well. In order to move forward and to benefit society in a balanced and safe way, bioresearch needs to have the support of adequate mechanisms of regulation; and decision-makers, for their part, need to have the support of sound research evidence on ethical, legal and sociocultural aspects (ELSA) of bioresearch. With this in mind, the Life 2000 research programme adopted the goal of linking together bioresearch and related ELSA research – for the first time ever in the programmes funded by the Academy of Finland and Tekes. This provided a new kind of vantage-point for the research programme and an interesting challenge not only for programme coordination but above all to the researchers involved.

It was against this backdrop that the Research Programme on Biological Functions set to work in autumn 2000. Three years on, the programme has now been completed and it is time to look at the results. To what extent were the goals and expectations met? This report reviews the programme's progress over these three years, looking separately at the different programme areas, the coordination function and information activities as well as the outcomes of the programme from the point of view of the researchers involved and other stakeholder groups. We also discuss the feedback received on the research programme from the researchers themselves. Finally, four experts who took part in the programme reflect upon the challenges that lie ahead in their respective fields in the new millennium.

Espoo, 12 February 2004

Mika Tirronen
Coordinator for Life 2000

2. Objectives of LIFE 2000

2.1. Research objectives

The Academy of Finland allocates a substantial proportion, up to 20 per cent or more of its research funding each year to research programmes. The idea of research programmes is to create synergy benefits that cannot be achieved with ordinary research grants. Every decision to launch a research programme is made on science policy grounds: it may be aimed at strengthening certain fields of research, at increasing cooperation between different fields, or at addressing issues of current social interest and importance.

Life 2000 was launched in response to the rapid advances that were being made on multiple fronts in bioresearch. The phenomenal progress that was seen in genome research created mounting pressure to develop Finnish know-how in the fields of functional genomics, proteomics and bioinformatics. Bioinformatics tools have become indispensable in virtually all lines of bioscientific inquiry: the analysis of sequence data, the study of molecule structures and the compilation of tissue testing results all require highly sophisticated bioinformatics tools.

At the same time the convergence of several different research traditions has presented completely new kinds of challenges for research in a number of fields, including neuroscience. Brain imaging results provide useful information for the molecule researcher and vice versa. Studies of brain function as well as DNA research have created new kinds of interfaces in the direction of information technology as well. As neurobiologists and developmental biologists have continued to probe ever deeper into molecular details, they have also needed more and more detailed information on the structures of molecules. Structural protein research and biophysics benefit from the same methods and support each other to an ever greater extent. Both of these are comparatively small fields of research in Finland, and it was one of the programme's main objectives to support and strengthen them.

Another line of work that is not very strong in Finland is research into the ethical, legal and sociocultural aspects of bioresearch. Life 2000 took on the objective of providing additional funding for this field of study and above all of tying it in more closely with bioresearch. This is crucially important because it is impossible to gain a proper understanding of the ethical problems involved in stem cell research, for instance, without detailed information about the research methods used and the objects of study. Likewise, it is difficult to appreciate the ethical or social aspects related to research without adequate concepts or sound information on the social impacts of bioresearch. Therefore it is essential that bioresearchers work closely with bioethicists.

2.2. Cooperation objectives

One of the objectives explicitly stated in the programme memorandum was the formation of larger research consortia, which was given special attention in the applications review process. Not only was the purpose to inspire closer cooperation

among research teams within disciplines, but also to inspire the creation of multidisciplinary research units. This did in fact happen in quite a large number of projects. The 89 research groups that took part in the programme formed 26 consortia and 13 individual projects. Measured in terms of overall funding, then, the number of research networks was quite considerable.

Interaction between the projects involved was also actively encouraged. Expectations were obviously highest for cooperation within fields of research, and particularly in major programme areas such as neuroscience and genomics. Special attention was given to supporting cooperation between bioresearchers and ELSA researchers. Other forms of cooperation were also promoted, most notably through the efforts of programme coordination.

2.3. Tasks and aims of programme coordination

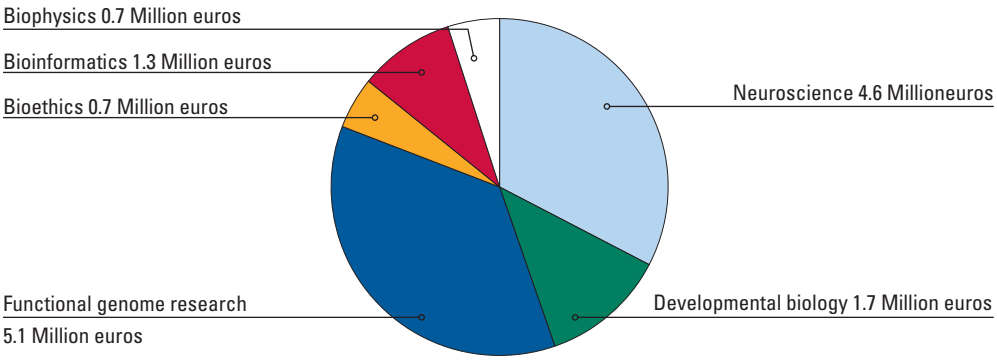
One of the key functions of any research programme is that of programme coordination. The Life 2000 research programme was coordinated by a full-time staff of two whose office was based in the Institute of Biotechnology at the University of Helsinki. The tasks and aims of programme coordination were set out in detail in a separate coordination agreement.

The main objectives of programme coordination included the promotion of various forms of cooperation, research meetings and scientific events as well as information and communication about the programme. The information and communication function was specifically charged with the task of increasing public awareness and knowledge of biotechnology in general. A Eurobarometer survey in the late 1990s had shown that people still know disturbingly little about different aspects of biotechnology. At the same time public perceptions and approval of bioresearch have become crucial to research funding. Bioresearch has enjoyed generous funding around the turn of the millennium. If the same trend is to continue, it is essential that appropriate mechanisms of regulation are in place and that there is ready access to open and impartial information about research.

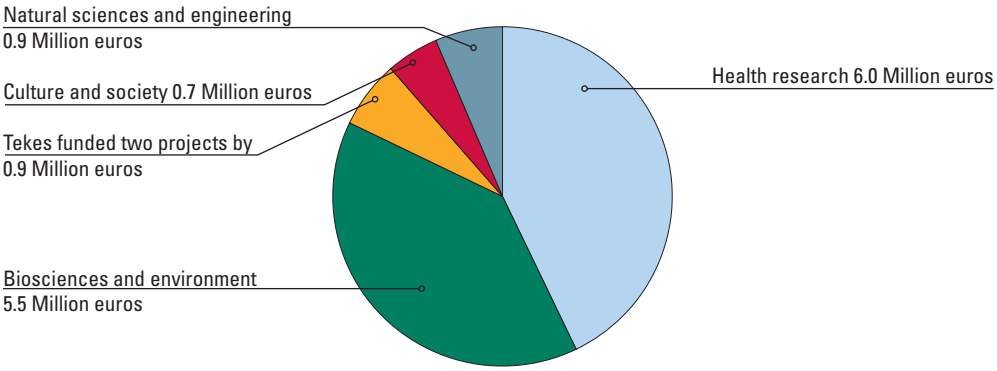
In addition to the principles set out in the programme memorandum and the coordination agreement, more detailed objectives were defined for programme coordination at the time that the programme was launched. To this end a scientific advisory board was appointed to the programme in connection with the opening seminar. The coordination strategy is described in closer detail in Chapter 4.

3. Structure and Funding of the Programme

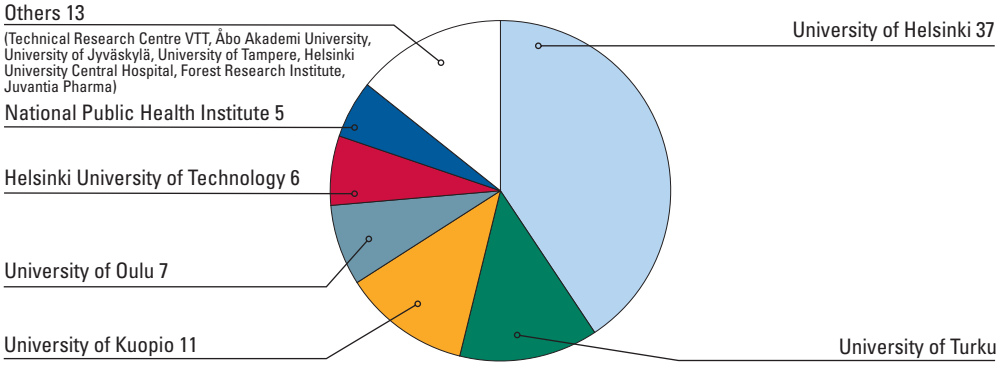
Research funding was made available to six programme areas as follows:



Funding was divided between the Academy's four Research Councils as follows:



Altogether 98 grants were allocated to 89 research groups that formed 26 consortia and 13 separate projects (see Appendix 1). All in all some 150 researchers received funding through the programme for a period of three years. The breakdown of the projects by host institution was as follows:



Almost four-fifths of the team leaders (78%, n=71) were men, one-fifth were women (22%, n=20). Most of the team leaders (33%, n=30)) were aged 45-50.

4. Strategic Planning for the Programme

The programme strategy was developed jointly by the programme steering group and the researchers themselves. Discussions were held with the researchers in different fields to expand upon the objectives and strategies identified in the programme memorandum. The researchers also had the opportunity to voice their views at the programme's opening seminar on 26 Oct 2000 at the Viikki Biocenter in Helsinki. Five workshops were held at the seminar to discuss the challenges facing the programme and its strategies in each programme area:

– Neuroscience (chaired by Melitta Schachner)
– Developmental biology (chaired by Gillian Morris-Kay)
– Functional genomics and bioinformatics (chaired by Shoshana Wodak)
– Biophysics (chaired by Tuomo Glumoff)
– Bioethics (chaired by Mika Tirronen)

The conclusions of these workshops were summed up in a plenary discussion which outlined the programme's objectives and strategies. A planning group then was appointed to take charge of strategic programme planning. Members were appointed from all programme areas and from all regions represented in the programme. The planning group members were the same throughout the programme's duration; they were:

– Neurosciences: Heikki Rauvala (University of Helsinki)
– Developmental biology: Seppo Vainio (University of Oulu)
– Functional genomics: Riitta Lahesmaa (University of Turku)
– Biophysics: Ritva Serimaa (University of Helsinki)
– Bioinformatics: Eero Castrén (University of Kuopio)
– Bioethics: Janne Hukkinen (Helsinki University of Technology, Espoo)

At the opening seminar researchers also had the chance to say what they expected of programme coordination. Surprisingly, many indicated they would want to see coordination adopt a low profile – which to all intents and purposes meant they wanted programme coordination to cause them as little extra work as possible in the form of reporting etc. On the other hand it was certainly appreciated that programme coordination did offer opportunities for significant synergy benefits. Most concretely, the researchers' expectations had to do with public relations and communication about research, popularisation and the organisation of scientific seminars and meetings. Programme coordination was expected to show independent initiative as well as support for initiatives coming from within research groups. All in all the researchers clearly had high expectations about the programme and the atmosphere at the opening seminar was one of great anticipation. The task of integrating bioethics with bioresearch was considered a special challenge, perhaps more so on the part of bioethicians than bioresearchers. However, there was a good turnout of bioresearchers at the opening bioethics workshop as well.

The following objectives were set for the research programme and programme coordination:

– *active contribution in main areas of research*
– *support for new types of functions and events*
– *interdisciplinarity*
– *targeted workshops*
– *support to invigorate dead spaces*
– *interaction between bioethics and biosciences research*
– *cooperation with other programmes and graduate schools*
– *active information and communication*

4.1. Active contribution in main areas of research

One of the key objectives of Life 2000 was to support networking and research meetings in all main areas of research. Specifically, each of the six areas was to organise a high-level scientific meeting with talks from invited speakers at the international cutting edge of the subject area. Some of the meetings were to have an international attendance as well.

4.2. Support for new types of functions and events

One of the leading ideas of programme coordination was to stimulate activities that would not have happened without the programme and programme coordination. Among the first tasks of programme coordination were to produce an inventory of existing series of meetings at various biocentres and universities and to identify areas where extra input was needed. The purpose was to avoid unnecessary overlap and to channel funding to those areas where the needs were greatest. In other words, it was decided not to sponsor existing series of meetings.

4.3. Interdisciplinarity

The inherently interdisciplinary nature of the research programme presented some special challenges to programme implementation and coordination. A conscious effort was made to promote interdisciplinarity in connection with research meetings and seminars by incorporating several approaches under the umbrella of the same theme. Indeed many of the programme areas formed quite natural partnerships: neurosciences and developmental biology, genomics and bioinformatics, developmental biology and bioethics, biophysics and bioinformatics, etc. This helped to generate not only scientific synergy benefits, but also to save money and resources.

On the other hand, we consciously tried to avoid artificial interdisciplinarity. For example, it is unlikely that either biophysics or bioethics would have benefited from bringing the two disciplines together. The prospects of genuine interaction was also thought to depend crucially on the form of cooperation. This was separately taken into account in the planning of all events. Cooperation and interdisciplinarity was always based on the identification of common interests and research themes.

4.4. Targeted workshops

In some fields of research there was an express need for special targeted workshops. These needs grew out of the research fields and often the researchers themselves. Most typically, they had to do with new emerging methods, networking needs or ongoing upheavals in the field of research. For instance, neuroinformatics was identified as a new and important line of inquiry within neurosciences, while in developmental biology and bioethics there was a felt need to respond quickly to the challenges thrown up by advancing research. In plant genomics, there was an urgent need to form partnerships with major European programmes. Targeted workshops provided a platform where researchers from a specific field of research could get together, but in many cases the theme of interdisciplinarity was prominent as well.

4.5. Support to invigorate dead spaces

In terms of research funding, the two biggest programme areas were neurosciences and genomics. Developmental biology and especially bioinformatics, biophysics and bioethics, on the other hand, were relatively small areas. This disproportion was taken into account in programme coordination as well: as far as possible, we wanted to make sure that the programme resources were allocated in a fair and balanced way. The importance of this was clearly highlighted in the case of developmental biology, for instance. There is a very strong and diverse tradition of developmental biology in Finland, yet no more than four projects were selected to take part in the programme from this field. Most of the field remained outside the programme. On the other hand, developmental biology saw some significant advances during the term of the programme: stem cell research made important progress and researchers had lively discussions on different cloning methods. These developments involved serious ethical considerations as well. Programme coordination sought to respond to these challenges by maintaining a spotlight on subjects of developmental biology throughout the programme. The same was done to a somewhat lesser extent in the case of biophysics, bioinformatics and bioethics (see Chapter 6).

4.6. Interaction between bioethics and biosciences research

Life 2000 was the first Finnish research programme in the biosector that took onboard the ethical, legal and sociocultural aspects of bioresearch. This posed certain requirements on programme implementation as well. One of the key challenges was to incorporate bioethics discussions as part of biosciences research and above all as part of biosector researcher training. The following objectives were set for the programme with respect to bioethics:

- to promote the national and international networking of bioethics researchers
- to develop bioethics education in Finland
- to increase awareness among ELSA researchers of Finnish bioethics research
- to familiarise ELSA researchers with Finnish biocentres
- to promote interaction between ELSA researchers and bioresearchers
- to increase bioresearchers' awareness of bioethical issues
- to organise high-level international meetings in the field of bioethics

4.7. Cooperation with other programmes and graduate schools

Both of the agencies that funded the research programme and programme coordination considered it important to have close cooperation with other research programmes and graduate schools in Finland. Where possible, the resources of different research programmes were pooled in organising scientific meetings and information exchange between different programmes was increased. It was considered a special challenge to develop researcher training in the biosector together with other research programmes. One of the main priorities was bioethics and its incorporation in researcher training. Bioethics education was developed closely with FinBioNet graduate schools.

4.8. Active information and communication

Bioresearch has an increasingly prominent and important role in modern society, impacting the prospects and structures of not only the economy and business and industry, but also such aspects as foodstuffs production and health care. For this reason it was considered important to increase public awareness of the development of bioresearch and related issues. This challenge was tackled by means of active information and communication about the programme's results, events and related issues of general interest. The researchers, too, stressed the importance of information and in this regard were particularly keen to have the support of the coordination office.

5. Programme Activities

5.1. Scientific activities

The programme's 89 research projects were carried out at eight universities, three research institutes and in one business company. The projects started up in August 2000 and ended in autumn 2003. Some 150 researchers received funding through the programme. Three years is a relatively long period in comparison with normal research funding and therefore gave the researchers an opportunity to plan slightly further ahead than they would do normally. All told, the projects produced more than 500 scientific publications (see the Chapter on the programme's outputs). A separate international evaluation will be conducted to assess the programme's scientific impacts.

5.2. Interaction within fields of research

Many of the research projects involved internal cooperation within the disciplines in question. For example, the neurosciences consortia involved several closely related approaches and research teams. In some projects even slightly more distant fields of neuroscience such as molecular neurobiology and brain physiology were integrated under one umbrella.

Targeted workshops were arranged to support internal cooperation within different fields of research. The initiative for such workshops often came from the researchers themselves. Among these targeted workshops that were addressed to specific needs within certain fields of research were the following:

- Annual Meeting of Developmental Biology, 27-28 Oct 2000, Hyytiälä
- Optimising the fMRI experiment workshop, 8-10 March 2001 HUT, Espoo
- Neuroinformatics Finland, 18 June 2001, Academy of Finland, Helsinki
- Exploratory workshop on stem cell research, 25-26 Nov 2001, Hyytiälä
- Biotech 02, 18-19 Sept 2002, Wanha Satama, Helsinki (Genomics session)
- Islet Development and Stem Cells in Diabetes, 3-5 April 2003 Biomedicum Helsinki
- Biotech Society, 29-30 Sept 2003, Dipoli Espoo
- Workshop on plant genomics, 31 Oct 2003, Academy of Finland, Helsinki
- Stem cell research in Finland, 15 Dec 2003, Biomedicum Helsinki

Targeted workshops are particularly useful in areas where there is much ongoing research, such as neuroresearch, developmental biology and genome research. The presence of a sufficient critical mass will facilitate cooperation and on the other hand create a need for networking and research meetings. In smaller areas such as biophysics and bioinformatics, it was considered a more viable strategy to set them up as part of larger units: this helped to generate the necessary critical mass, synergy and increased exposure (see Chapter 6).

5.3. Interaction between fields of research

Life 2000 involved several consortia that covered aspects from a number of different programme areas; indeed some of the consortia were difficult to slot into any of the

programme areas. Interaction between different fields of research was also supported and maintained by means of interdisciplinary research meetings. Most Life 2000 events included an interdisciplinary angle, and most meetings touched upon at least two fields of research. One of the events with a particularly strong interdisciplinary orientation was Scientific and Cultural Aspects on Anxiety (7-8 June 2002, Kiasma Theatre, Helsinki); an interdisciplinary event intended for the general public was also organised in connection with this meeting (6 June 2002, Finlandia Hall, Helsinki). This was an ambitious attempt to bring together a very diverse range of research traditions, including molecular neurobiology, neuropharmacology, psychology, psychiatry, cultural studies and theology. On the other hand, all these fields of research were included from the outset under the Life 2000 umbrella.

Other interdisciplinary events included:
- Biology for physicists (course), spring 2001 (biology & physics)
- Finnish Bioscience Days, 14-15 Sept 2001 (biophysics, structural biology, bioinformatics)
- Cellular Mechanisms of Development, 8-10 May 2003 (developmental biology & neurobiology)
- Ethics in Biomedical Research, 21-23 Aug 2003 (bioethics & biomedicine)
- Biotech Society, 29-30 Sept 2003 (different research traditions in bioethics)

The theme of interdisciplinarity was particularly pronounced in the programme's many (8) bioethics meetings which brought together the approaches of biosciences, biomedicine, philosophy, ethics, social sciences, economics and law (see Chapter 6.6). Interdiscplinarity was also a leading idea in many events organised for the general public and other target groups (see Chapter 7).

5.4. Interaction with the research community outside the programme

One of the main tasks of programme coordination was to create and develop interaction with various stakeholder groups. One such group was the research community outside the research programme. Although the programme was specifically designed with a view to promoting internal cooperation, it also provided an excellent opportunity to strengthen research in the biosector more generally. A conscious effort was made through programme coordination to increase the programme's spillover effects. This was considered particularly important in fields where large numbers of top researchers in the country were not directly involved. The most obvious case in point was developmental biology. Immediately after the opening seminar of Life 2000, Finland's developmental biologists convened at a national conference to discuss the future prospects of research in this field and to consider ways of stepping up cooperation during the term of the research programme. Consequently a number of developmental biology meetings and events were organised in which researchers from outside the programme were also closely involved (see Chapter 6.2).

Another area where it was considered important to have close links with the research community outside the programme was that of bioethics. Only two bioethics projects

were selected to take part in the programme, even though there is much research in the country dealing with the social dimensions of bioresearch. The main reason for the underrepresentation of bioethics was the small number of applications received from this field. It was considered important to redress this imbalance by maintaining close links of contact with other bioethicians working in Finland. This led to various activities in the field of bioethics, such as visits by bioethicians to the country's biocentres (ELSA meets Bioscientists I & II). More on this in Chapter 6.6.

Information on all Life 2000 events was made readily available to all biocentres, research institutes and universities outside of the programme as well. Many of the people attending Life 2000 events were from outside the programme.

5.5. Contacts with other research programmes

Programme coordination also sought to maintain close contact with other ongoing research programmes. One of the events organised to this end was the meeting of coordinators and researchers in charge of ongoing Academy research programmes at the Viikki Biocenter in April 2001. Following this meeting a proposal was submitted to the Academy concerning the provision of regular training for coordinators and programme leaders, which has in fact since then been implemented actively.

Scientific meetings were also organised in close cooperation with other ongoing research programmes. Over the three-year period in 2000-2003, the programme that came closest to Life 2000 in terms of contents and subject-matter was the Structural Biology Research Programme. Life 2000 worked closely with the BioBio Society and the Structural Biology Research Programme to organise the 2001 Finnish Bioscience Days, which focused on the themes of biophysics, bioinformatics and structural biology (see Chapters 6.4. and 6.5.).

In autumn 2003 Life 2000 joined forces with the Finnish Project Program on Plant Genomics and the ESGEMO Research Programme to host an exploratory workshop on plant genomics. Among the issues discussed here was the possibility of cooperation among plant genomics funding bodies from Finland, Sweden and Germany.

5.6. Contacts with graduate schools

Many of the Life 2000 events were organised closely with FinBioNet graduate schools. Among the programmes incorporated in the graduate schools' curriculum were training courses in popularisation and bioethics. A bioethics training module was also introduced to all directors and coordinators of FinBioNet graduate schools at a meeting in April 2001. The graduate schools also worked closely with Life 2000 in organising many scientific meetings, and students were credited for attendance at these meetings. One of the biggest events was Ethics in Biomedical Research (on 21-23 August at Biomedicum Helsinki), which was organised jointly with the Finnish Medical Association Duodecim, seven biomedical graduate schools and the graduate school in philosophy.

Here are some of the events that were organised jointly with graduate schools for graduate school students and young researchers:

- Popularizing Science, 4-5 Dec 2000, Viikki Biocenter, Helsinki (GSBM graduate school)
- Ethics in Biosciences, 4 May 2001, Viikki Biocenter, Helsinki (GSBM)
- Genes and Health, 12 Dec 2001, Viikki Biocenter, Helsinki (VGBS)
- Scientific and Cultural Aspects on Anxiety, 6 June 2002, Finlandia Hall, Helsinki (GSBM)
- Life children's party – An information seminar for the newly appointed group leaders, 30 May 2002, Viikki Biocenter, Helsinki
- Scientific and Cultural Aspects on Anxiety, 7-8 June 2002, Kiasma Theatre, Helsinki (GSBM)
- Cellular Mechanisms of Development, 8-10 May 2003, Biomedicum Helsinki (GSBM, HBGS, VGBS)
- Ethics in Biomedical Research, 21-23 August 2003, Biomedicum Helsinki (7 graduate schools)
- Exploratory workshop on bioethics, 29 April and 2 October 2003, Viikki Biocenter, Helsinki (VGBS)

5.7. Contacts with other stakeholder groups

The programme's other main stakeholder groups – the bodies financing the programme, decision-makers and people in the bioindustry and the media – were all the time kept up-to-date about what was happening in the programme. All this was based on a conscious information strategy that was implemented with the support of Academy of Finland Communications (see Chapter 7). The programme's newsletter, which included contributions solicited from politicians, professional journalists and representatives of the bioindustry, was delivered to all stakeholder groups. Stakeholder involvement in the programme was also supported by organising various events and panel discussions on topical issues, such as the ethical limits in stem cell research, the bioresearcher's responsibility, the regulation and ethical principles of biomedicine, information about research and questions related to the funding of different fields of research. The following lists some of the events where panel and other discussions were arranged:

- Opening seminar, 26 Oct 2000 (funding bodies, researchers, ministry and advisory committee representatives)
- Neuroinformatics Finland, 18 June 2001 (funding bodies, researchers)
- National discussion forum on stem cell research, 2 Nov 2001 (researchers, IVF clinics, decision-makers, ethics advisory committees, funding bodies)
- Ethics in Biomedical Research, 21-23 Aug 2003 (politicians, ethics advisory committees, journalists, researchers)
- Workshop on plant genomics, 31 Oct 2003 (funding bodies, researchers)
- Closing Symposium, 11 Dec 2003 (politicians, journalists, bioindustry, researchers)
- Stem cell research in Finland, 15 Dec 2003 (funding bodies, researchers)

The coordination office maintained close contact with the bioindustry throughout the programme. In 2001-2003, the office was involved in the planning committee for the BioTech01 and BioTech02 exhibitions in Helsinki.

– Biotech 01 Exhibition, 12-13 September 2001 Wanha Satama, Helsinki (Life 2000 session)
– Biotech 02 Exhibition, 18-19 September 2002, Wanha Satama, Helsinki (Genomics session)

5.8. International cooperation and tasks of national coordination

Life 2000 was not directly involved in other international research programmes. However the programme's coordination office did take part in several European coordination groups and served as national coordinator for several European programmes. These responsibilities included membership of the steering group and serving as national coordinator for the ESF programme Integrated Approaches to Functional Genomics, as well as participation in the planning group for the European AlphaGalileo press server. Furthermore, the coordination office was involved in the working group preparing the ERA-NET CA Towards European Coordination of Plant Genomics. This led to the start-up of the Finnish Project Programme on Plant Genomics (2003), which was accepted as an elligible partner to and the Finnish representative of plant genomics in the ERA-NET CA application submitted to the European Commission in October 2003. In its capacity as a sister project to this process, Life 2000 programme coordination was involved in initiating the exploratory workshop on plant genomics (Academy of Finland, 31 Oct 2003), which looked into the prospects of opening national research programmes and funding cooperation between Finland, Sweden and Germany in the field of plant genomics.

6. Programme Activities in Main Areas of Research

6.1. Neurosciences

Two areas of research received the largest slices of programme funding, viz. neurosciences and genomics. There is a strong and well-established research tradition in the field of neurosciences in Finland, and high-quality research is produced in all the country's major universities. The key challenge for programme coordination, therefore, was to support networking in neurosciences, where different lines of inquiry – molecular neurobiology, brain imaging, neuropsychology, neuropharmacology, etc. – have produced huge amounts of new information in recent years. The rapid proliferation of information has led to the same situation as in genome research: the sheer volume of information now exceeds the processing capacity available, which means that large quantities of research evidence threaten to remain without use unless there are decisive improvements in data processing, analysis, modelling and availability. This has created a need for a new branch of bioinformatics, i.e. neuroinformatics. Life 2000 programme coordination was involved in designing and organising the first national exploratory workshop on neuroinformatics at the Academy of Finland in summer 2001.

Neuroresearch is an increasingly interdisciplinary exercise that is more and more often characterised by attempts to open up broader perspectives on and synthesise different traditions of brain research. Scientific and Cultural Aspects on Anxiety was an ambitious project aimed at integrating different approaches around one theme of social importance. In addition, a high-level international meeting was arranged on Cellular Mechanisms of Development, where the focus was on developmental biology and molecular neurobiology.

Events for neuroscientists:
- Neuroinformatics Finland, 18 June 2001, Academy of Finland, Helsinki
- Scientific and Cultural Aspects on Anxiety, 7-8 June 2002, Kiasma Theatre, Helsinki
- Cellular Mechanisms of Development, 8-10 May 2003, Biomedicum Helsinki*

(*events marked with an asterisk are also discussed elsewhere in Chapter 6)

6.2. Developmental biology

Developmental biology received a rather small proportion of the research funds allocated to Life 2000 (4 projects), even though there is a very strong research tradition in Finland with a good international reputation. Programme coordination tried to redress this imbalance in various ways. At the beginning of the programme a "crisis meeting" was arranged and held in connection with the annual conference of developmental biologists at Hyytiälä in an attempt to see why the field had had such poor success in final review of applications for the Life 2000 programme. Professor Gillian Morris-Kay, who was the expert for developmental biology on the

international review panel, was invited to give a talk on her viewpoint as well as on the state and future challenges of developmental biology in Finland. The crisis meeting gave special attention to the question of how the new methods of genomics could be effectively integrated into research in developmental biology.

During the course of Life 2000 the field of developmental biology saw a lot happen in scientific terms. Continuing advances in cloning techniques and stem cell research gave rise to debate on whether or not Finland should allow nucleus transplantations for therapeutic purposes. An exploratory workshop was organised in the field of stem cell research in response to the need for a public policy statement on the ethical principles of stem cell research in Finland. The process was divided into two stages. First, stem cell researchers got together at the Hyytiälä forestry station to discuss the ethical parameters of stem cell research from a purely research point of view. If research was to continue to enjoy the approval of the general public, it was considered important that the ethical policy statement should come from the research community itself. Prior to the publication of this statement, it was debated at a national discussion forum on stem cell research among funding agencies, representatives of bioethics research and ethical committees as well as decision-makers. The position statement took a clear and firm stance against cloning for reproductive purposes, but supported somatic nuclear transplantation conducted for therapeutic purposes.

Questions surrounding stem cells were also discussed at various other events in the field of developmental biology. One high-level international scientific meeting was also arranged (Cellular Mechanisms of Development, 8-10 May 2003): this attracted much interest in the science media as well.

Developmental biology meetings:
- Annual Meeting of Developmental Biology, 27-28 Oct 2000, Hyytiälä
- Exploratory workshop on stem cell research, 25-26 Nov 2001, Hyytiälä
- National discussion forum on stem cell research, 2 Nov 2001, Biomedicum Helsinki*
- Islet Development and Stem Cells in Diabetes, 3-5 April, Biomedicum Helsinki
- Cellular Mechanisms of Development, 8-10 May 2003, Biomedicum Helsinki*
- Stem cell research in Finland, 15 Dec 2003, Biomedicum Helsinki

(*events marked with an asterisk are also discussed elsewhere in Chapter 6)

6.3. Functional genomics

Functional genomics was the biggest but at once the least coherent programme area in Life 2000. Issues tackled in this field ranged widely from cancer biology and predisposing genes to asthma through the Finnish disease heritage and mitochondrial genetics to protein secretion in yeast, plant genetics, plant pathogens and the cold tolerance of the birch. Indeed the main similarities were to be found in methodology rather than the biological questions addressed.

One of the first steps in the programme was to establish the need for various meetings and seminars in the field of genomics. Since there is an annual national genomics meeting in the country, a major investment in a comparable meeting would hardly have made financial sense given the limited coordination budget. The coordination office organised one high-level international scientific seminar in the field of genomics, and in addition efforts were made to support the networking of Finnish research in plant genomics with European research programmes. The Life 2000 coordination office was involved in preparing the Finnish Project Programme on Plant Genomics, which was the Finnish partner to the European ERA-NET CA Towards European Coordination of Plant Genomics. A Plant Genomics workshop (31 Oct 2003) was organised with a view to exploring the possibilities of research and funding cooperation in the field of plant genomics between Finland, Sweden and Germany.

Life 2000 programme coordination also served as national coordinator for the ESF Integrated Approaches to Functional Genomics programme. Through this forum Life 2000 sought to encourage Finnish researchers to apply for ESF funding and to organise genomics training courses in Finland.

Genomics meetings:
- Biotech 02, 18-19 Sept 2002, Wanha Satama, Helsinki (Genomics sessions)
- Workshop on Plant Genomics, 31 Oct 2003, Academy of Finland, Helsinki

6.4. Biophysics

Along with bioethics, biophysics was the smallest programme area in Life 2000 (2 projects). This meant, on the one hand, that the task of internal coordination would be relatively simple and straightforward, but on the other hand that the task of increasing the exposure of biophysics research and integrating it with broader fields of study would be a major challenge. For this reason biophysics (as well as bioinformatics, see below) was singled out as one of the main themes for the Finnish Bioscience Days 2001, which were jointly organised by Life 2000, the Structural Biology Research Programme and the BioBio Society. It was felt that bringing biophysics, structural biology and bioinformatics together in one high-level scientific meeting would be a nationally unique and significant event. Indeed, it attracted a large number of leading international experts.

Biophysics meetings:
- Biology for physicists, Viikki Biocenter, spring 2001
- Finnish Bioscience Days, 14-15 Sept 2001, Viikki Biocenter, Helsinki*

(*events marked with an asterisk are also discussed elsewhere in Chapter 6)

6.5. Bioinformatics

Bioinformatics was another small programme area, involving three projects. There is only little bioinformatics research in Finland, although on the other hand the tools and methods of bioinformatics were probably used in all Life 2000 research projects.

Bioinformatics was one of the main themes of the Finnish Bioscience Days in 2001, which was organised by Life 2000 together with the Structural Biology Research Programme and the BioBio Society. The meeting was one of the biggest meetings organized by Life 2000 coordination office. The meeting had several distinguished international experts as invited speakers.

Bioinformatics meetings:
– Finnish Bioscience Days, 14-15 Sept 2001, Viikki Biocenter, Helsinki*

(*events marked with an asterisk are also discussed elsewhere in Chapter 6)

6.6. Bioethics

Bioethics was a minor programme area in terms of funding volume, but it had a very central role indeed with respect to contents and public image. There were very few projects in this programme area, just one research group and one consortium. However there is more and more research in this field in Finland, and there is a growing interest in the social dimensions of biosciences.

One specific target group for bioscientists was represented by young researchers. The aim was to develop bioethics education in collaboration with the FinBioNet graduate schools. Working closely with the GSBM graduate school, the programme organised on 4 May 2001 the first bioethics course ("Ethics in Biosciences") that was open to all graduate schools. The concept of the course was also marketed to all directors and coordinators of FinBioNet graduate schools (Scandic Hotel Continental, April 2001).

Contacts between bioethicians with bioresearchers were supported and encouraged in various different ways. The most important meeting here was Ethics in Biomedical Research (21-23 Aug 2003), which coincided with the visit to Finland by the Board of the International Association of Bioethics (IAB). This meeting provided a forum for exchanges of views among prominent international bioethicians and domestic bioresearchers and bioethics experts on various questions related to biomedical research: biomedical research as part of society, vulnerable groups as research subjects, use of genetic information, and stem cells, embryos, cloning – ethical borders.

Biotech Society was the first international scientific meeting in Finland on the subject of the regulation and commercialisation of bioresearch, providing a rare opportunity for researchers concerned with issues of regulation and commercialisation to get together and exchange views. The concept met with a very positive reception indeed, especially among the foreign visitors. At the exploratory workshop on bioethics, graduate school students reviewed the Master's theses on bioethics subjects by four theology students and acted as their opponents. The students regarded the seminar as very useful and thought the custom should be continued. At the ELSA meets Bioscientists (I & II) meetings, bioethicians were invited to a tour of the country's biocentres, where they learned about their research and other activities.

One of the major events in the field of bioethics was the national discussion forum on stem cell research, which drafted a policy statement on the ethical principles of stem cell research in Finland. The meeting was convened in response to the stem cell debate and legislative processes elsewhere in Europe, for instance in Britain (see also Chapter 8.5).

Bioethics events:
- Ethics in Biosciences, 4 May 2001, Viikki Biocenter, Helsinki
- National discussion forum on stem cell research 2 Nov 2001, Biomedicum Helsinki*
- ELSA meets Bioscientists, 25 Mar 2002, Viikki Biocenter, Helsinki
- ELSA meets Bioscientists, 10 Dec 2002, BioCity Turku
- Biosciences for theologists, Viikki Biocenter and Dept of Practical Theology , 3 and 13 Dec 2001
- Exploratory workshop on bioethics, 29 April and 2 Oct 2003, Viikki Biocenter, Helsinki
- Ethics in Biomedical Research, 21-23 Aug 2003, Biomedicum Helsinki
- Biotech Society, 29-30 Sept 2003, Dipoli Espoo

(*events marked with an asterisk are also discussed elsewhere in Chapter 6)

7. LIFE 2000 Information and Communication Activities

Laura Walin

Life 2000 had a full-time coordination staff of two whose job it was to make that the research programme produced added value to the public investment of 14 million euros that was poured into the programme over three years. Information activities had a key part to play in achieving this goal. This Chapter reviews and assesses the communication methods and practices of the Life 2000 programme with a view to offering some food for thought to coordinators of future research programmes.

7.1. Experiences from Life 2000

7.1.1. Website

An Internet website is an essential means of communication for any credible research project today. At an office run by two biologists, the only viable option was to pay for an outside consultant to set up and run the project website, which was produced in both the Finnish and English language. Visual appearance was one of our priority concerns, and we especially wanted to have a front page that was immediately attractive. The website address (http://life2000.helsinki.fi) was also short and punchy. Furthermore, the idea of the website was that it should support both external and internal programme communications.

Among the first items posted on the website was an information package which included the programme memorandum, information on the applications process, a full list of the projects involved and their contact information, and contact information for the coordination office. The programme's newsletters (see below) were also published in pdf format online. The website was also intended as an active events calendar and a brokerage for vacancies in the biosector. Job vacancies could be posted by anyone, but before publication they were submitted to the coordination office for approval. Information on upcoming events could only be added through the coordination office

Although the coordination office was able to update the website, its structure was designed and created by an outside consultant. This caused some difficulty towards the end of the programme when the website's calendar function and some other updating tools crashed following the installation of a new operating system and the consultant who had set up the system had moved to another job. In practice this meant that during the last nine months of the programme we were able to post advertisements for any other than the research programme's own events, provided that the event had its own website. This also hampered the communication of the results of the programme, which was carried out by a press release and the press conference in the context of the closing symposium in December, 2003.

There was no counter on the programme's website so we have no way of saying how often it was visited, or how important it was to researchers and other stakeholders.

7.1.2. Newsletter

The main channel of communication between the programme and its outside stakeholders was the programme's newsletter, which appeared five times between 2000 and 2003. Each issue concentrated on a selected theme: the idea was that the newsletter was built around the dialogue between researchers and the theme in question. These themes were selected by the coordination office in close consultation with Academy Communications. There was no need to revise this editorial policy during the course of the programme. However, since the newsletter had such a prominent part in external communications, it might have been useful to have closer consultation with the funding bodies about the specific contents of each issue.

The newsletters had the following themes: Researchers and coordination, Bioindustry, Support from science for decision-making, Information about biosciences, and Bioresearch and citizens. Contributions were solicited from researchers involved in the programme as well as from other people working in the biosector, including Cabinet Ministers and MEPs.

The programme's stakeholder groups were identified in discussions within the coordination office and with the programme steering group. Throughout the programme's lifetime the main target groups for external communications were Finnish biosector researchers and students, bioresearch funding agencies, the Finnish bioindustry, government officials related to the bioresearch sector, advisory boards and committees, science journalists and the general public. The newsletter had a circulation of 500. Some 350 copies were mailed to stakeholder lists compiled the coordination office, the rest were handed out at various events. Hardly any copies remained in hand.

7.1.3. Press conferences

All in all the programme's coordination office hosted or funded 32 events. Some of them were training seminars or other smaller events that were of no general interest and therefore did not warrant public information. Ahead of major events that had broader social relevance, however, the coordination office organised press conferences, sending out invitations to general interest as well as science journalists about a week ahead of time. At the conferences we would usually have a few invited researchers first give brief talks on the subject in question, and then journalists would be to ask questions and conduct interviews. These conferences were typically attended by 5-10 journalists. On the day, the press were also sent an information bulletin that contained somewhat more detailed information than the invitation. The coordination office received invaluable help from the communications professionals at the Academy and the University of Helsinki in preparing these press releases and bulletins.

Staging press conferences required a rather intensive input by the coordination office. However we did not have the resources to monitor the impacts of these efforts. Three items broke the news barrier: the right of use of genetic data in Finland in connection with the Ethics in Biomedical Research conference in August 2003 (appearing on Channel Four TV news and in Helsingin Sanomat, the biggest daily in Finland); the faltering competitiveness of biotechnology in Europe in connection with the Biotech Society meeting in October 2003 (in Kauppalehti and Taloussanomat, two business-news dailies), and the opening seminar (covered by YLE 1 TV breakfast news).

The Ethics in Biomedical Research conference also attracted some international attention: BBC Radio broadcasted an interview from the meeting with one its invited speakers, Professor Hasna Begum from Bangladesh. The interview touched on one of the main themes of the conference, i.e. global justice in the commercial and medical application of the results of bioresearch.

General interest and news reporters did not attend our press conferences with much regularity. More frequent visitors included journalists from medical and health magazines as well as reporters from the Finnish News Agency and the Finnish Broadcasting Company who were interested in bioresearch. The University of Helsinki magazine had extensive coverage of all the events organised by the coordination office, often mentioning the Academy of Finland and the National Technology Agency Tekes and even the research programme by name.

7.1.4. Science breakfasts

From relatively early on the coordination office hit upon the idea that if science journalists received even a basic introduction to the often complex issues of bioresearch, this might help to lower the reporting threshold. As the Academy had been toying with the same idea, a series of so-called science breakfasts was started in the autumn of 2000 at the Academy. The idea was to provide interested journalists with background information on some very specific theme. At the same time, the purpose was to squeeze in some news item. The first science breakfast, which was on DNA microchips, concluded with an interview with Riitta Lahesmaa, which was run on MTV3 news. Depending on the subject, the science breakfasts have attracted an audience of 5-20 journalists. Life 2000 coordination office has also been involved in organising breakfasts related to the bioindustry and stem cells.

7.1.5. Electronic newsletter

About midway through the research programme, the researchers involved received via e-mail a bimonthly and bilingual (Finnish and English) newsletter which included current information on research funding available and forthcoming events from as many different programme areas as possible. The researchers were asked to send in information about events in their own fields, but no such information ever reached the coordination office.

7.1.6. Training in popularisation

The coordination office also provided training to researchers in the art of popularisation. Joining forces with the GSBM graduate school and Helsingin Sanomat, the office hosted in autumn 2000 a two-day course on popularisation where professionals gave instruction and guidance to young researchers on how to communicate about science to the general public. The first day consisted of theoretical instruction, on the second day exercises done by the researchers were critically reviewed. The second part of the course was held at the Helsingin Sanomat offices, where the science editor provided feedback on the pieces written. Overall the course was a rather successful concept; there is no doubt much need for this kind of training in the future as well.

7.1.7. Coordination office's projects

The shape and direction of research programme coordination depends inevitably in large part on the individuals behind the coordination effort, because both the researchers and the funding agencies have very limited resources to invest in coordination. We at the Life 2000 office considered it an important challenge to inspire public debate on and to increase education in bioethics in Finland, and on the other hand to report to the general public informed on the results of research. Leaning on these principles, the coordination office produced a TV documentary entitled '"The researcher's' choices", which follows a day in the life of a bioresearcher and looks at some of the ethical choices and questions that come up in the job. The preliminary version of the film was presented in the closing symposium, and the final cut is currently being processed in collaboration with YLE1 Teema channel, where it will be most likely broadcasted later on.

The same theme of popular education also cuts through the volume on new methods of biomedicine edited by the coordination office staff (forthcoming in Finnish by Tammi in 2004). In this book, leading Finnish bioresearchers and bioethicians introduce the new diagnostic tools and therapies that have been made possible by advances in molecular medicine and discuss some of the issues they have raised.

7.2. Information and communication activities in research programmes: problems and dilemmas

7.2.1. Whose message – and who should send it?

Although Finland has made huge investments in bioresearch and although hundreds of people are engaged in cutting-edge research, it is still quite rarely that there are any newsworthy breakthroughs that need to be communicated to the general public. If and when there is such a breakthrough, the research group itself, the host university and the funding organisation would all be more than keen to break the news themselves. As universities and funding bodies usually have professional organisations in place to cover all their communications needs, one may well ask what role remains for programme coordination to perform in this situation. Coordinators are recruited on the basis of scientific merits (a PhD is required in one

of the programme areas), and in most cases any experience of communication will only be acquired on the job of coordination. I myself would be more than pleased in this situation to leave the task of communication to the professionals. If the job is done by the university, the communications department can consult the researcher directly. Academy Communications, for its part, can always consult the coordination office to make sure it has the facts right, although obviously the researcher in question is always the most reliable source.

If this is accepted, the coordination office's communication role is clearly restricted to information about events related to the programme itself: the opening and closing seminar, information about meetings and conferences arranged by the research programme, and internal communications. If there is good cooperation with Academy Communications, both parties will have an excellent opportunity to develop their know-how during the course of the programme: the Communications department will gather useful contacts with researchers working in the field in question, learn about research practices and terminology, whereas staff at the coordination office will learn the basics of communication.

7.2.2. Monitoring the impacts of communication

One of the main difficulties with regard to the information and communication activities in the Life 2000 programme was that hardly any effort was made to monitor the impacts of the work we did: with the exception of a few isolated examples, it was impossible to say whether this work was of any real use. We do not know how many people visited the project's website, we do not know whether people read the newsletters we mailed to them, we do not know whether researchers opened the e-mails we sent to them, we do not even know how often journalists wrote about the subjects we told them about at our press conferences.

This lack of feedback obviously makes it very difficult to improve and develop communications during the course of the programme. At the very least the project website should have a mechanism that allows for monitoring the number of visitors. One or two people do not have the time to follow all the material that is published in the media. If there is a real interest in monitoring the impacts of information and communication, that would need to be done by the funding bodies' own communications departments or by an outside consultant. It is also extremely difficult to assess the impacts of internal communications. Every e-mail that is sent to researchers has to be assessed on the basis of the utility of the information it contains, or on the basis of researchers' assessments of that utility; it has to be in proportion to the trouble that the researcher has to go to in order to open the message and react in one way or another. If the flood of e-mails becomes too overwhelming, any messages from the coordination office's address will automatically be deleted even before it is even opened.

Information and communication in research programmes is always a collective effort involving not only the coordination office, but also funding agencies, universities and research institutes as well as individual researchers. Open debate and discussion about the role and objectives of communications from an early stage

helps to ensure that the interests of all parties are taken into account and that the resources available are allocated in the most sensible way. At least so far the general public is certainly not inundated with information about bioscience and bioresearch, so there is still plenty of work for all of us!

8. Assessing the Results and Impacts of LIFE 2000

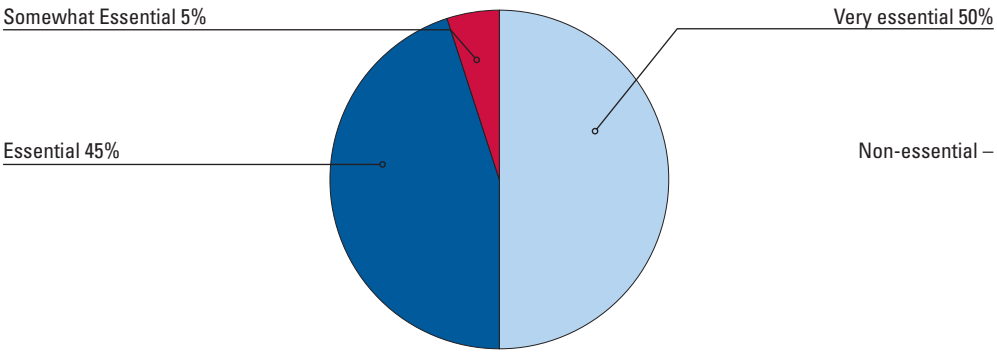
The results and impacts of research can be approached and weighed from various angles. They can be considered from the vantage-point of research itself, in which case we would look at the number of publications produced, networks of cooperation created or the introduction of new methods. Impacts can also be studied from a broader perspective, i.e. in terms of the exposure and visibility of research and its social significance. However there is no single, unambiguous way to measure impacts. Research often produces results over a very long period of time; sometimes neither the research community nor the society around will see the impacts of those results until years after their publication.

Most typically, the results and scientific impacts of research results are measured by reference to the number and quality of publications produced. However even this approach is not entirely unproblematic. A citation index known as the impact factor has been developed to measure the scientific significance of journals and publications, but that does not always provide an accurate measure of the true weight of a given article. The true value of many reports that may be well ahead of their time, may not become apparent until decades later. One publication in a less prestigious scientific journal may have a greater impact on the development of science that many high-visibility publications in highly respected scientific series.

This Chapter of our report discusses the results and impacts of the Life 2000 research programme. One of the main sources here is a questionnaire study carried out among programme researchers in October 2003, which was designed to measure the scientific publishing activities of the research groups and to produce a kind of self-assessment of the programme. In the end the most important panel of experts in assessing the significance of a research programme consists of the researchers themselves: if they feel that research programmes are an important and useful form of research funding, then it makes sense to continue and further develop the programme policy. If, on the other hand, researchers feel that the programme does not generate any added value, then serious questions must be asked about whose interests the programme really serves.

8.1. Significance of Life 2000 from a research funding point of view

When the funds made available to the programme were allocated between the research groups, most found that the sum they received was slightly short of what they had applied for. This inevitably affected their research plans as well. On the other hand, through their participation in the programme the teams had gained access to three years of steady funding, which is a major asset in view of project implementation. When the research groups were asked about the significance of the funding they received through Life 2000 as a proportion of their overall funding, the responses were as follows:



All research teams felt that the monies they had received through the programme were at least somewhat essential. About half described the funding as very essential. Over half of the teams reported that funding through Life 2000 accounted for 10-30% of their project's total funding (Figure 1); these figures ranged from as little as 2-3% to up to 75% of overall funding. In relative terms the funding was obviously more significant for smaller than for larger research groups.

8.2. Scientific impacts

In an analysis of the number of publications produced through the Life 2000 programme, we need first of all to consider some of the distinctive characteristics of bioresearch. Research teams in this field typically work on several projects at the same time, and in many cases the work involves cooperation among large numbers of researchers. In practice then, the input of the individual researcher and thus the research funding is divided among several projects. Articles are co-authored by a number of researchers and are often written on a teamwork basis. It can take years for research results to mature into scientific articles. Indeed it is extremely difficult to say with any certainty which results have been produced with monies received through the Life 2000 project. It is, by contrast, often easier to say how a project outline in the original research plan has progressed and what kinds of results have come out of that project. However, even plans submitted in the programme application are not funded entirely through the one programme, but the monies come from several sources.

According to our questionnaire at the end of the programme, 61 groups indicated that they had published 1,716 scientific articles during the Life 2000 programme, of which 450 were said to have been produced within the framework of Life 2000. If these figures are extrapolated to all the 89 groups, it can be estimated that more than 500 publications were produced in the programme. On average then, 26% of the publications produced by the research teams were funded entirely or partly from Life 2000 monies. This is more or less in line with expectations, bearing in mind that for most teams Life 2000 funding accounted for 10-30% of overall funding. In practice the funding is divided between more than one project, which very much overlap in terms of the themes covered.

It is impossible to give any exact statistics for the number of articles produced in the Life 2000 programme. For the reasons set out above, this is problematic even in theory, and in practice the research groups assess their own results in very different ways. On the basis of the responses received upon conclusion of the programme in December 2003, one team produced on average 7,5 Life 2000 articles (range 0-71). The cost of one Life 2000 article would thus be around 21,000 euros.

According to the final reports, altogether 55 doctoral theses were produced within the framework of the programme.

8.3. Assessments of the value added generated by the programme

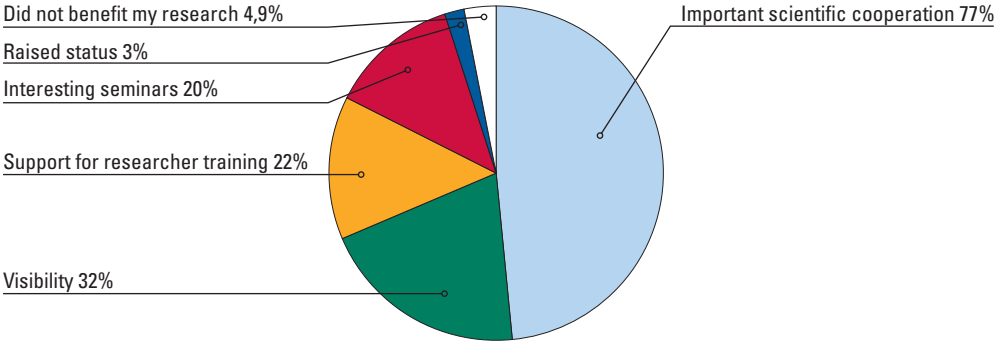
A research programme differs from regular project funding both in terms of the range of themes covered and in terms of coordination. Research programmes are specifically designed to generate scientific and social value added. This is achieved through scientific cooperation, research meetings, researcher training and increased visibility and exposure.

Researchers themselves have an important part to play in assessing the value added generated by a research programme. Life 2000 researchers were asked whether they felt they had achieved value added through the programme. The vast majority or 95,1% (n=57) said they had, while 4,9% (n=4) said there had be no value added. Bearing in mind how far-ranging and heterogeneous this programme was, this can be considered an excellent result. In such a large programme it would probably be quite difficult to record a full 100%. Satisfaction with the value added produced by the programme is obviously a sum of many factors. It depends upon programme planning and the clarity of its objectives, application instructions, the choice of projects, the internal coordination of research projects and consortia, the attitude and activity of researchers as well as programme coordination.

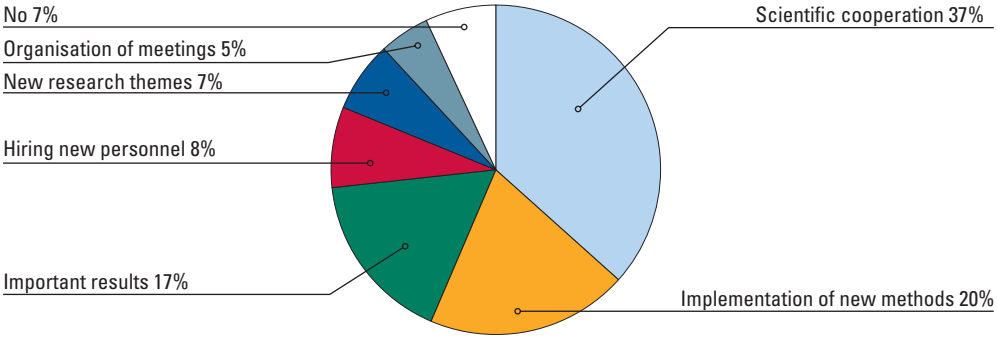
It is clear from the responses we received that some consortia had better cooperation than others. In some cases the planned research project had not produced the expected results in the early stages, and therefore the plans for cooperation had been dropped straight away. Such failure may very much detract from the programme's perceived value added. Likewise, the small groups that had rather unique subjects did not necessarily benefit as much from the value added achieved through coordination.

- Long-term funding (3 yrs)
- Funding also available for temporary, multidisciplinary projects
- Funding corresponded better with needs than regular project funding
- Centres of excellence can also apply
- Opportunity to develop new approaches
- Strong support for networking and cooperation
- Allowed for more in-depth research than would otherwise have been possible
- Created a broader context and subject-matter for research
- Increased visibility – Life was a familiar concept to all

Question: Apart from the direct funding received through the programme, did your involvement in Life 2000 benefit your research? If yes, please specify how?



Question: Did you achieve something that would not have been possible without the Life 2000 research programme? If yes, please specify what that was?



Question: What additional benefits did the Life 2000 research programme offer when compared to regular project funding?

- Generated more information
- Opportunity to disseminate useful information
- Interesting seminars
- High awareness of bioethical issues
- Coordination provided valuable help and advice

The researchers' assessments of value added clearly highlight the importance of scientific cooperation, new methods and exposure and visibility. No less than 77% of the research groups felt they had gained significant benefit from the programme through scientific cooperation. This is a very high figure indeed which also reflects the large proportion of consortia among all projects: 69% of the projects involved in the programme were consortia. However, individual research teams also felt they had gained value added in the shape of cooperation. On these grounds we may conclude that the programme was highly successful in terms of its goal of promoting cooperation. One fifth (20%) of the groups indicated that they had implemented new methods, which would have not happened without the Life 2000 programme.

Implementation of new methods is therefore another major source of value added. The early application of new methods is a demanding and time-consuming process that ill fits with the often hectic everyday routines of research teams. In this regard Life 2000 has been extremely successful. Many thought the funding they had received through the programme was generous when compared to regular project funding. They were particularly pleased to see support go to new kinds of bold and adventurous, even high-risk ventures.

8.4. Research programme as a problem for research

Not all impacts are always and necessarily positive. In addition to its positive impacts, research programmes can also have adverse effects – if not on society as a whole, possibly on research itself. It is important to look at these impacts so that the research programme policy can be further improved and developed. Judging by the responses from our questionnaire study, there are clearly aspects about research programmes with which researchers are not entirely comfortable. Some of these have to do with the additional tasks required (e.g. reporting), which nonetheless are unavoidable in this kind of funding arrangement. Some of the responses, however, give cause to a more detailed examination:

Question: What are the downsides of research programmes when compared to regular research funding?

- May lead to excessive reporting
- Too restrictive in a thematic sense, exclude research groups
- May lead to artificial networks and consortia
- You have to modify your research plans according to current fashions, even though the research itself is effectively the same
- May favour large consortia, even though smaller ones are often more efficient
- If they need to work together, researchers will do so regardless of funding, i.e. the requirement of cooperation as a funding criterion is a waste of money
- May lead to opportunism
- May detract from resources for local cooperation

Question: What were the downsides of Life 2000 specifically?

- Too broad and heterogeneous
- Three years is too short a time
- ELSA groups were small and lacked coherence
- The amount of funding received was much less than applied for
- One funding decision/project, regardless of how good a review of the project had received

Several responses reflected concerns about artificial and trendy phenomena. Successful research requires a long-term efforts, mechanisms that have been built up over years or decades and that will only begin to produce results after long periods of "product development". Such a research group cannot keep changing direction according to the latest whims and trends, but it has to be consistent in its

work. Fashionable methods or research themes, such as DNA chips and stem cells, may have an appealing ring to them, especially if ample funding is available, but do they also present a threat to research itself? Massive media attention and generous financial investment may well sidetrack research, leading ultimately to poor or mediocre results. Each group must of course assess these risks itself when drafting its plans and applications. Many responses stressed the importance of basic project funding which gives the researcher greater freedom in putting together applications, without setting too many boundary conditions. All in all both types of funding, i.e. research grants and research programmes, received strong support from the researchers.

8.5. Social impacts

Life 2000 represented a substantial investment of public funding in bioresearch. One of the key objectives of the programme was to increase the visibility of bioresearch. Visibility also ties in closely with public approval, which is necessary for all publicly funded research. We therefore need to ask, did the Life 2000 research programme have any broader social relevance?

This is not an easy question to answer. Information was made readily available on the events organised under the programme's umbrella, some of which were purposely aimed at audiences outside the programme. Bioethics issues in particular were given much prominence. Bioethics was also included among all the themes covered at the science breakfasts organised for science journalists. Indeed the programme did occasionally attract quite intense interest in the media: on the eve of the programme's opening seminar on 26 October 2000, YLE's breakfast news arranged a studio interview on Life 2000 and the development of biotechnology in Finland, focusing especially on neuroresearch. International exposure was gained in connection with the Ethics in Biomedical Research meeting where BBC Radio interviewed Professor Hasna Begum from Bangladesh on global equity in bioresearch. Programme coordinators and researchers were also interviewed by TV and radio journalists in connection with numerous events. At the Ethics in Biomedical Research and Biotech Society meetings Finnish researchers were interviewed by the main TV channels. Press conferences were well attended (see Chapter 7).

Life 2000 also produced a documentary on "The researcher's choices – studying the ethics of bioresearch", which looks at some of the choices faced by a young bioresearcher. In addition, nine Finnish experts discuss some of the social aspects of bioresearch. Negotiations on the TV rights and the final formula of the broadcasting (one document + mini series) are ongoing at the time of writing.

Furthermore, several articles written by the programme coordinators on bioethics research, stem cells and cloning, all emerging issues during Life 2000, were published in Helsingin Sanomat and regional newspapers. An open, national discussion forum involving stem cell researchers, representatives of IVF clinics and bioethicians was set up around the theme of stem cells: this forum produced a policy statement on the ethical principles of stem cell research in Finland. The statement also stands as a position document on the EC Convention on Human Rights and Biomedicine, which

prohibits the production of embryos for research purposes. The policy statement takes a critical stance on cloning for reproductive purposes (human reproduction) and adheres to the EC Convention in all other respects apart from recommending acceptance of therapeutic nucleus transplantation in Finland. This would require the insertion of a proviso in the Convention at the time of ratification, and possibly amendments to the Act on Medical Research. The EC Convention will only be ratified following the entry into force of the new act on IVF treatments.

Seminars intended for audiences outside the research community included:
- Scientific and Cultural Aspects on Anxiety, 6 June 2002, Finlandia Hall, Helsinki
- Finnish Science Days, 8 Jan 2003, Porthania, Helsinki (Life 2000 session)
- How to become a child, 7 Mar 2003, Porthania, Helsinki
- Is childlessness a disease? 8 Mar 2003, Porthania, Helsinki

9. LIFE 2000 Revisited: Coordination's Point of Wiew

9.1. Life 2000: larger than life

In terms of funding volume Life 2000 was the largest research programme ever launched by the Academy of Finland and Tekes for purposes of funding both basic and applied research in the biosector. Covering six programme areas and 89 research groups, it was also exceptionally large. Indeed, some researchers felt that Life 2000 was too big and too heterogeneous. And they certainly have a point; it is not easy to see the connection between such fields as biophysics and bioethics, for instance. On the other hand, some researchers felt that simply being part of something such massive had intrinsic value: Life 2000 was so big that involvement in it alone gave the research teams increased exposure and status. As one of the respondents said, "Life 2000 is a concept that everyone knows."

As far as programme coordination was concerned, the heterogeneity of the programme presented a very special set of challenges. Some of the programme areas formed quite natural partnerships, but in some cases it was extremely difficult to see any real connection. We at programme coordination were determined to find real, concrete interfaces and to avoid artificial and unnecessary forms of collaboration. On the other hand the heterogeneity of the programme also offered interesting opportunities. Neurosciences, developmental biology, genomics, bioinformatics and biophysics form various natural combinations that we tried to identify and foster. Especially in the case of smaller programme areas the linking of closely related subject-matters benefited all parties and often helped to attract larger audiences and to give greater exposure to events.

Perhaps the main difficulty stemming from the programme's heterogeneity was having to try and come up with events that would be of interest to all the programme groups. Indeed with the exception of the programme's opening and closing seminars, this aim was eventually dropped.

All in all Life 2000 certainly met many of the goals set out at its inception. It might have been easier to coordinate a somewhat more focused and longer-term programme, but on the other hand Life 2000 offered some truly creative challenges for coordination.

It is clear from the feedback received from the researchers that the programme met the targets that were set for collaboration. Most of the groups felt that they had found valuable new contacts through the programme. Exposure and visibility were also considered important, and some participants said they were particularly pleased with the seminars organised under the Life 2000 umbrella. Many regarded the opportunity to try out new methods as valuable. And what is most important, most of the groups said the programme had helped them generate valuable scientific results.

9.2. On research and cooperation

Research is inherently an organic exercise in which challenges and new problems unfold with the progress of research. Research in itself generates new needs and new preconditions for cooperation. The developmental biology group that is working to purify a protein that regulates development, needs to apply the tools of structural biology and bioinformatics. It is very difficult to generate this kind of cooperation by means of coordination. The research teams need to work independently in this regard, nor do they usually feel that they need outside help. The best expertise in the creation of cooperation comes from within the group and the research community itself.

A conscious effort was made to avoid unnecessary meetings; whenever joint events, training and research meetings were arranged, this was done in response to the researchers' own needs and interests. It is obvious that in such a major programme it is not possible to have complete equality of collaboration among all the groups involved. There were so many research groups in the programme that personal visits to each of them would have been difficult to arrange, nor would it really have served the purpose. Contacts were therefore maintained by e-mail and phone, and meetings were arranged mainly in connection with other programme events. It was particularly pleasing to see such an active participation at the opening seminar: 220 programme researchers and representatives of stakeholders took part.

Programme coordination had particularly active and fruitful interaction with the bioethics researchers in the programme. This was a conscious choice on the part of the coordinators. Active efforts were made to try and bridge the gap between bioresearchers and ELSA researchers. The work that was done in this field was also exciting and inspiring, and created many new forms of activity that hopefully will be continued in the future.

9.3. On bioethical discussion and debate

It is a common refrain that people in Finland are not very good at talking. Indeed, discussions and debates here are less fiery than elsewhere, nor do people perhaps feel very comfortable on big arenas, but this does not mean to say that we lack the skills of discussion. In a European comparison the Finnish debate on bioethics is unusually moderate and smooth. Whereas in other countries the discussion is coloured by religious dogmas and other clashes, in Finland it goes along more interactive and open lines. Ours is a liberal atmosphere, and there is also a strong confidence among the general public in researchers, the university institution and medicine.

Discussion on bioethical issues seems to be particularly active among young researchers. The interest of young scholars in bioethics was clearly evident in the very first bioethics course organised with the GSBM, which attracted more than one hundred graduate school students from around the country. The senior researcher's interest in bioethics remains more an open question. Some researchers have a clear vocation and the resources to engage in this kind of debate, but this is not a very numerous nor a very visible group.

Perhaps the most enthusiastic discussions and debates were waged at the exploratory workshop on bioethics, which was organised together with the VGBS graduate school and theology students. Here, graduate school students critically reviewed the theology students' Masters' theses. The young aspiring researchers tackled the challenge with great gusto, and once they had recovered from the initial shock they felt they had picked up many new ideas. The theology students, too, were pleased with the opportunity to view their work from a fresh perspective. The debate was deep and intense, continuing well beyond official working hours, leaving many wondering why such workshops are not organised more often.

In conclusion then, it is clearly important that bioethics teaching is established as an integral part of researcher training in the biosector. Young researchers are surprisingly well equipped to weigh the validity of bioethical argumentations, and they have delightfully many ideas on the subject.

9.4. Is anyone there?

One of the main tasks of programme coordination was to organise and host meetings for the researchers involved in the programme. Given all the effort and money that was invested, a recurring concern was how to get these researchers to attend. There are no end of scientific seminars and symposia for researchers. Senior researchers in particular go to many international meetings each year, and there are various seminars and others events even at home, especially at major biocentres. With all this on offer, how do you get people interested in yet further seminars? Does it make sense to organise new seminars in the first place?

Many of the Life 2000 seminars were aimed at audiences also other than the programme researchers. The purpose of this was to promote the networking of researchers outside the programme and to spread the programme's resources. Given the cost of organising the events, it was also important to try and get as many participants as possible. Nevertheless there were events where participation was poor. This was particularly the case on the latter day of the meeting on Scientific and Cultural Aspects on Anxiety (7-8 June 2002). Clearly, excessive multidisciplinarity, an exotic venue (Kiasma Theatre) and a Saturday are not the best possible combination with a view to attracting a large audience. Yet information had been provided to researchers on the meeting, and the people who did attend felt the concept worked very well.

We studied the participation of Life 2000 researchers in the events organised by programme coordination using a questionnaire submitted to the research groups:

How many Life 2000 events did you attend?
- 0-17 / group
- on average 4,5 attendees /group (in all 28 seminars)
- on average 14,2 Life members /seminar
- on average 80 attendees altogether /seminar
- 195 euros / Life 2000 research group member
- 34 euros / participant

9.5. Researchers and coordinators

The researcher's main job is to do research. As the amount of research funding and the number of funding channels continues to increase and competition continues to stiffen, researchers today find themselves spending more and more time doing other things: preparing applications, writing reports, attending meetings and working on expert panels. Under these pressures it is not easy for the researcher to take a wholly uncritical view on the coordination activities involved in research programmes. Programme coordination is easily perceived as an extra threat that has been set up for purposes of controlling and complicating the researcher's job. Excessive meetings may give rise to fear and apprehension.

These threat perceptions should be taken seriously. The goals set for coordination, the coordinator's enthusiasm to think up new things and desire to generate cooperation and visibility provide endless opportunities to create extra work. These risks were certainly acknowledged in developing the coordination strategy for Life 2000. They were also raised in discussions with the researchers at the opening seminar. At the same time, we also tried to listen to the researchers' hopes and expectations with regard to coordination. In what way can coordination *support* and *promote* research? We also tried to keep the researchers' reporting duties at a minimum, and normal compensation was paid for solicited writings. As far as possible, meetings were organised in response to researchers' own needs.

We did not succeed in every respect. Some researchers felt they had not received the services of programme coordination, or that the events we arranged were too distant to them (either in regional or thematic terms). Indeed the venues for most events were in and around Helsinki, which did cause some resentment. However, since most of the researchers (and the coordination office) were based in Helsinki, we felt this was a justified decision.

Because of the extent of the programme, some programme areas and research groups received less attention from the coordination office than others. In this regard the criticism we received is certainly justified. The programme's website also failed to perform up to standards, most particularly in terms of frequent server downtime. The coordinators did not always have the expertise or the resources to address the problems as promptly as they should have been.

All in all the coordination office had good cooperation with the researchers, however, and any critical feedback that did come our way was sound and well justified. There was also a fair amount of positive feedback. All this helped us to improve and develop our coordination efforts during the course of the programme. At its best our collaboration with researchers was enthusiastic, encouraging, creative and diverse. We had excellent networks of cooperation with many researchers. Contacts with other research programmes and graduate schools were also good. The joint events with the graduate schools were particularly inspiring.

Where did programme coordination succeed?
– Did not require too many reports

– Provided increased visibility (popularisation)
– Provided a lot of useful information
– Excellent/Interesting seminars
– Provided much support for interdisciplinary activities (seminars, courses)
– Support for networking
– Genomics and bioethical subjects had a strong representation
– Did not force researchers into useless cooperation
– Gave research teams a free rein
– Positive and constructive attitude
– Not too much paperwork

Where did programme coordination fail?
– There could have been more neurosciences events and information
– Some meetings were too broad-ranging
– Some meetings were in Finnish
– Inconsistent website performance (slow updates and frequent server downtime)
– There could have been more joint events
– Did not do enough to encourage cooperation between research groups
– There could have been more information on the programme's results

9.6. Is there life after Life?

The coordination network required by a major research programme cannot be set up overnight; it takes time to create close working contacts with all the researchers and stakeholder groups. From this point of view three years is definitely too short a time for such a large programme. No sooner is the network up and running than it has to be closed down again. In this regard it would certainly make sense to have a longer and/or more focused research programme.

Many researchers agreed that the programme was too short, even though research programmes do as such give researchers a more secure source of funding compared to ordinary project funding. However a timespan of 4-5 years would give more leeway for planning cooperation and an opportunity to try out more ambitious joint projects.

Finland is a small country where it is relatively easy to coordinate research activities. The small size of our country is an important national asset if only we know how to make the best use of it. This requires close networks of information and cooperation between different research institutes and organisations. In this sense it seems a waste of resources to completely dismantle the organisation of programme coordination. Integrating coordination with the operations of the Academy's Administrative Office would no doubt be beneficial in this sense. On the other hand, this kind of arrangement might distance programme coordination from researchers working in the field. One alternative would be to locate more or less permanent, national coordination facilities in the universities. In the final analysis, however, the success of coordination depends upon the expertise of the people working on the job, their professional attitude and ability to cooperate with other people. This job is done easier by the fact that Finnish researchers have plenty of these qualities themselves.

10. Future Prospect

Below, four researchers who took part in the Life 2000 programme discuss the challenges that lie ahead for bioresearch from the point of view of their own discipline and the Life 2000 research programme as a whole. Juha Partanen (University of Helsinki, Institute of Biotechnology) was involved in the developmental biology component of the programme and was one of the main organisers of the Cellular Mechanisms of Development meeting that concentrated on the neurosciences and developmental biology. Samuel Kaski (HUT, Espoo) represented the bioinformatics component of the programme; he discusses the role of bioinformatics in future neuroresearch and genome research. Ritva Serimaa (University of Helsinki) represented the biophysics component and was a member of the programme's planning group. Finally, Juha Räikkä (University of Turku) discusses some of the ethical and social questions related to bioresearch.

Development Biology in the Age of Genome Research

Juha Partanen, Academy Fellow, University of Helsinki

Finnish research in developmental biology is a well-established and internationally well-respected line of inquiry. In recent years the discipline has begun increasingly to branch out beyond its primary orientation and become integrated as part of several other disciplines, such as neurosciences and cancer biology: in fact the trend has been going on for more than a decade now, not only in Finland but internationally as well. This tendency of integration has largely come about as a result of the development of gene research and genomics as well as our increased understanding of the diverse functions of genes: development and cancer biologists, for instance, are concerned at the cellular and molecule level with very similar phenomena, only the contexts of their research are different. An excellent example of technology-driven integration is provided by transgenic animals, most notably transgenic mice, which have drawn the attention of many cell and cancer biologists to phenomena that fall within the domain of developmental biology. Several genes that are disturbed or otherwise involved in diseases, also steer individual. It is possible that information obtained from a different model is directly applicable to other lines of inquiry, or that it throws up new problems and questions for those. This is why it is more and more important for researchers from different disciplines to work more closely with one another.

The integration of developmental biology and other disciplines is probably reflected in the Life 2000 programme as well. The programme involved surprisingly few consortia under the heading of developmental biology, namely four. On the other hand, many other Life 2000 consortia dealt with questions of embryo and organ development. Furthermore, Life 2000 sponsored several conferences in the field of developmental biology, the biggest of which was the Cellular Mechanisms of Development symposium in Helsinki in May 2003. As the name of the symposium implies, this meeting shared the same goal of integrating developmental biology with other disciplines. Judging by the large number of participants (some 250), the organisers were quite successful. All in all then, Life 2000 aimed to integrate developmental biology with other disciplines.

The integration of different disciplines is unquestionably an important exercise and possibly even fruitful. On the other hand, it is unlikely that any discipline can flourish and develop in the long run merely as an auxiliary line of inquiry. It is therefore crucially important that the continuity of basic research in developmental biology is secured. The only way the discipline can be of use to others in the future is through solid basic expertise and know-how.

Basic research in developmental biology looks set to gather ever greater importance in the future. This assumption is supported by three ongoing lines of work or trends in development: functional genome research, the development of cell imaging and stem cell research.

Functional gene research in the wake of major genome sequencing projects will both require and benefit knowledge and expertise in developmental biology. For instance, the mouse genome mutagenesis programmes that are currently underway will require special expertise in several areas of developmental biology, physiology and pathology. On the other hand, the mutant mouse lines produced in these programmes will be a hugely valuable resource for developmental biologists and researchers working in the field of disease genetics, for instance. Finnish scientists are at the very cutting edge of research in several areas of developmental biology (e.g. dental development, the development of the circulatory system, the development of the urogenital systems, many areas of neurobiology). It is the expertise of these researchers that will be most in demand, and they will benefit most from the advances in functional genome research.

Most Finnish research in the field of developmental biology uses mouse models, genetically modified mice in particular. However, science and university policy here has failed, in my opinion, to create an adequate infrastructure for this line of work. Arrangements are urgently needed to facilitate the rapid and flexible exchange of genetically modified mice lines between Finnish researchers and foreign colleagues. In my own personal experience even very minor and simple investments in this area can help significantly to raise the standards of research. There are also some major European projects in the field of mouse genomics in which Finnish science organisations should be actively involved (e.g. PRIME – Priorities for mouse functional genomics research across Europe: integrating and strengthening research in Europe, coordinated by Professor Steve Brown).

Functional genome research has advanced much further in its work with other than vertebrate model organisms, such as the fruit fly. Methods and lessons learned from other model organisms have often been successfully applied in research with mice and other vertebrates as well. For this reason it is important that continued support is made available to work in the field of developmental biology and genetic research with also other model organisms than mice.

Another prominent future trend in developmental biology is its integration with cell biology. Genes function at the cellular level, and cell behaviour regulates the formation of tissue. This is why research into developmental biology phenomena and gene function is increasingly shifting from the tissue level to the cellular level. In this line of work, too, it would seem that research on the fruit fly is one step ahead of vertebrate models. On the other hand, cell biologists are showing increasing interest in how cells function in their normal environment. One indication of the anticipated integration of cell and developmental biology is provided by the recent decision of *Cell*, the most prestigious science journal in molecular biology, to launch a sister journal called *Developmental Cell* that will concentrate on the early stages of cell development. These tendencies of integration will certainly be boosted by technological advances in cell imaging (e.g. multiphoton microscopy, live cell/tissue imaging). The effective use of imaging methods and their further development will require not only investments in new equipment, but also competent and specially trained experts.

A third factor that is bound to add to the future importance of developmental biology is the prospect of medical applications that require expertise in developmental biology. A good example is provided by stem cell research, which is expected to pave the way to treatments based on cell replacement. However the use of stem cells derived from embryos still requires their controlled differentiation into the desired type of cell. This means they can only be used if we learn to understand the normal development of cells and tissue. The identification of somatic stem cells possibly contained in tissue itself and their activation or an understanding of their regulatory mechanisms requires in-depth knowledge of the normal development of tissue.

In the near future then, we can expect to see research devote more and more attention to developmental biology, both as an independent line of inquiry and as part of applications oriented research.

Bubbly Bioinformatics

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New methods of measurement are having a profound impact on genomics, and eventually on other fields of biology and medicine as well. First of all, these methods mean we can now carry out genome-wide measurements of the structure, function and associations of genes and the proteins they produce. Secondly, much of the measurements data are being entered into massive databases with general application. And thirdly, the full-scale use of these databases in biomedical research is generating a revolution in its own right. Modelling and data analysis are crucial to understanding the function of biological systems on the strength of information drawn from these databases. Bioinformatics, a discipline concerned with the use of computational and mathematical methods in resolving biological problems, is very much at the heart of this third revolution.

In what follows it is my intention briefly to discuss, from the researcher's point of view, two problems related to doing bioinformatics: (i) the integration of basic research in computational and mathematical and quantitative methods and basic research in biomedicine in such a way that both can benefit; (ii) the dilemma of long-term research vs. rapid reaction to ongoing changes, which is particularly acute in such in-vogue disciplines as bioinformatics. Scientific revolution, it seems, is invariably followed by an enthusiastic atmosphere of experimentation, with lots of novelties being tested and everyone wanting to have a share of the action. However, not all new ideas are workable, and eventually the mass interest will turn somewhere else. Since bioinformatics is crucially important to so many other disciplines, it is important to ask how we can make sure that things keep moving forward even after the initial enthusiasm has waned.

Background: jointly accessible databases

Genome sequence databases came into the public domain in the wake of the human genome project. All the information in these databases is quite readily available and accessible. No doubt the genomes of many other species will eventually be made available in general-purpose databases as well.

The situation is not yet quite the same with other measurement datasets, such as those on gene expression as measured by means of microarrays. Databases are available primarily because all major scientific journals require that these materials are published at the same time as the related articles are released. Although projects are now underway that are compiling gene expression data for several organisms into databases, the methods and practices of measurement are not yet sufficiently standardised so that one could speak of general-purpose databases.

Open databases are internationally accessible; there is no intrinsic value in having a national database. Databases that directly support Finnish research are of course useful, and it may also be suggested that it is good to be involved in setting up

international standardised databases, simply for reasons of gaining the experience and know-how as well as decision-making powers. Comprehensive general-purpose databases will be important cornerstones of genomics research in the future as well.

Opportunities: the data analysis and systems perspective

The genomics revolution is creating a need for new kinds of methods and thus new opportunities for methods development. Purely hypothesis-driven empirical research in biology can be complemented by means of data-driven, hypothesis-generating research. In other words, it is possible to generate broader hypotheses that even cover the whole cell system. As the new approaches continue to mature, their application brings a competitive advantage, and the integration of data analysis and the modelling approach in biomedical research will probably become essential.

The mining of databases with a view to making new discoveries requires data-driven, flexible models and powerful algorithms. In addition, more specific models are needed to generate and test system-wide hypotheses. One particularly hard challenge is presented by the development of general-purpose methods that still are specific enough for application in biomedical research. By a general-purpose method, I mean a flexible tool that adapts to the dataset in hand and that produces results that are sufficiently accurate for the application in question with less manual modelling.

One specific opportunity that now has opened up is by the development and distribution of software for purposes of analysing genomics databases. This software must obviously be based upon workable methods of data analysis and modelling. Distributing the software in the public domain will benefit all the parties involved, as the people who have developed the methods will be cited by the end-users. Commercial interests are not necessarily at variance with the requirements of openness, as the popularity of open source software goes to show.

Indeed programs are by now available for various purposes, but for most tasks they are not yet as standardised as measurement data. However the standardisation of software banks is if possible an even harder task than the standardisation of functional genomics materials. Yet the trend is already evident: several scientific journals encourage the publication of program codes, and there are a number of methods banks; one example in the field of bioinformatics is the Harvard bioconductor project (www.bioconductor.org). These kinds of projects might provide an opportunity to integrate Finland's strong expertise in information technology and computational and mathematical and quantitative methods in a field where there is an apparent demand for new kinds of methods.

Problem: integrating data analysis and biology

When the use of databases is integrated with biological research, the methods of data analysis are of immediate use to biomedical research. There is, in other words, a clear demand for training among biologists in the field of computational and mathematical and quantitative methods. Although this is no easy challenge, the

solution should be reasonably straightforward. It also makes sense to provide training for students with applied bioinformatic on with a background in biomedicine.

The application of the results of computational and mathematical and quantitative methods is thus clearly useful to biomedical research, but what about basic research in computer science and mathematics? If it has no use, then it suffices to provide training in computational and mathematical methods to biologists. The problem with original research is that it is notoriously slow, the scientific risks involved are high, and the results largely unpredictable. In the end it all boils down to the question as to whether it is enough to tackle biological problems using existing methods, or whether it is worthwhile to invest time and effort in the generalisation of methods, or even in the development of completely new types of methods.

A closely related question is whether computational and mathematical and quantitative methods can benefit from biomedical research. This question needs to be resolved in order to encourage the best researchers in the field to take an interest. There are plenty of challenging and even high-profile problems that need to be tackled in bioinformatics, but why develop methods designed to resolve extremely difficult and ill-defined problems in functional genomics when there are other research subjects to choose?

Original research in computer science and mathematics is probably needed in tackling the most important, highly complex problems of biology, especially in new data-driven research, because there are no set solutions to the new kinds of problems. These problems are to be found particularly in genome-wide systemic phenomena, where both parties must do original research. The less risky alternative is longer-term work with several biomedical problems, which is at once aimed at generalising the methods applied. At the very best the new incentives can generate new paradigms in computational and mathematical and quantitative methods.

At the level of basic research the only way that cooperation can succeed is if researchers in both fields understand each other's perspective and if they appreciate the importance of the work done in each other's fields. This has to be taken into account in practical research culture: studying another field and communication with people working in other fields is highly time-consuming and requires a long-term commitment.

Gaining merits is another problem. Both disciplines show more appreciation for basic research in their own fields. In the end, however, the success of bioinformatics depends on its appeal among good, competent researchers. The new challenges in the new disciplines will ensure that there is enough appeal for some time ahead, but the fastest and most meticulous method developers will probably have realised by now that this is a difficult field and there are no shortcuts to success. One of the drawbacks is that work in the middle ground between biology and computer science and mathematics does not yield merits in either field to the same extent as work that concentrates on one or the other field. In other words there is a need here for a new set of merits criteria, a continuum from basic research in computer science and mathematics to basic research in biology and medicine so that each intermediate

stage earns sufficient respect. The criteria will probably evolve out of their own accord as the field becomes more established, as long as research is done consistently over longer periods and funding policy is likewise forward-looking. If bioinformatics really is useful, it will eventually produce a competitive edge.

The problem of funding: long-term consistency or rapid response to ongoing changes

Every new discipline needs to have a substratum which sustains its growth. That substratum is created by mathematicians and other scientists who apply computational and mathematical methods trying out bioinformatics applications. Functional genomics has reached this stage some time ago, driven by the appeal of the new discipline. With time, the substratum will gradually begin to produce the methods that can provide effective solutions to he problems of bioinformatics. However, it always takes some time for the real problems of the new area to take shape, and in the interim it is virtually impossible to predict which way the most profitable trends will turn. Large numbers of projects may fail. This kind of temporary "bubble" is probably an unavoidable part of revolution.

Once the initial rush is over there are no more quick-draw prizes up for grabs, and the in-vogue discipline will have shifted somewhere else. However, it is likely that the main bioinformatics problems that are most crucial to biomedical research still remain of least partly unsolved, and new research problems have also emerged. When all who remain are those researchers who are truly committed to resolving the real problems, the challenge is to make sure that long-term funding is available. Indeed for mathematical and computational basic research this long-term commitment is probably even more important than the absolute amount of funding.

On the other hand many upheavals have followed from the development of new measurement techniques, ingenious applications and the changing applications needs, and this will probably happen in the future as well. For instance, techniques such as DNA microchips are now being used for ever new tasks.

A successful response to revolution requires either good luck or a preparedness to take advantage of the revolution. The latter, in turn, requires a prepared mindset and fast reaction. This calls for a dual strategy: the tradition of long-term funding for basic research helps to prepare ahead, while opportunities should be created for fast responses. As a funding policy, the former consists of research that is selected on strict criteria but that is not necessarily conducted on a large scale, the latter consists of risk funding.

Biophysics Research – Plenty of Challanges in the Pipeline

Ritva Serimaa, University of Helsinki

The biophysicist uses methods of scientific experimentation or modelling to study biological systems: molecules, cells, complete organisms or populations. Her aim is to understand how the system works, which in turn requires an understanding of the structure of the system. One of the main challenges in this line of work is to identify the factors that can impact the state of the system. One aspect of biophysics is the development of new research methods. A concept closely related to biophysics is that of biological physics, which has grown up out of the need to inject a stronger element of physics in biology (IUPAP). The biophysicist and the biological physicist share the same goals, but whereas the biophysicist is expected to have a training in both physics and biosciences, this does not necessarily apply to the biological physicist. I myself belong to the latter category, and my biophysical work may also be described as research into the soft condenced matter physics.

Two of the projects in the Life 2000 research programme were classified as biophysics projects: they were concerned with the structures and catalytic mechanisms of membrane proteins (Mårten Wickström) and with the dynamics of macromolecular complexes and the function of molecular machines (Dennis Bamford, Roman Tuma and Ritva Serimaa). There were also other projects in the programme that involved work in biological physics, such as a medical project on the development of modern brain imaging methods and the application of these methods in functional research of the human brain (Risto Kauppinen, Riitta Salmelin, Mikko Sams).

The research problems tackled by biology are broad-ranging and the most fruitful biophysics and biological physics studies take place in groups involving expertise from various different disciplines, such as biology, medicine, physics, chemistry, statistics and computer sciences. For instance, the innovative multidisciplinary laboratory that was founded at Stanford University a few years ago – Bio-X, which has a staff of some 50 researchers – is concerned to study the function of different biological systems using both experimental and modelling methods, and it also offers teaching in how to address these kinds of broad problems. Researchers at Bio-X have access to a broad spectrum of methods and equipment, from a powerful parallel computer system to synchrotron radiation beamline. James Spudich, whose brainchild the laboratory is, was hard put to contain his enthusiasm at the time of launching Bio-X: "We will have failed if the only thing that happens is what we can imagine now".

Medicine offers a whole host of research problems for biophysics to tackle. One major public health problem in Finland is presented by atherosclerosis, the reasons of which still remain largely unknown. Blockages appear for instance at the intersections of blood vessels, and it is thought that mechanical tension plays a role in their development. The nanometer level structure of LDL particles in water solution has been established by means of X-ray small angle scattering and electron

microscopy. This problem continues to present research problems for biophysics, ranging from the experimental examination of LDL particle fusion through to the modelling of flows.

Botany is another source of research challenges for biophysics. The syntheses of the most common macromolecules of the cell wall, i.e. cellulose and lignin, have already been extensively studied using the methods of biology and chemistry, but less so using the toolbox of biophysics. It is known that the shape of wood cells and the orientation of cell wall microfibrils relative to the fibre axis are dependent on the cell distance from the pith. Cellulose microfibrils are helically oriented with respect to the fibre axis, and the the pitch of the helix and the strength characteristics are clearly associated. What is required in addition to gene regulation to produce a tree stem that can withstand the force of winds and the weight of snow? Can these characteristics be influenced by means of plant breeding? The Wood Wisdom programme (1998-2001) involved this kind of research in biological physics. Projects within this programme used experimental and modelling methods to study the transportation of water in trees and the structure of the wood cell wall at nanometer level.

Biophysical experiments are in many ways very challenging and a wide range of expertise is needed in designing and implementing these experiments, and indeed in analysing their results. How to design an experiment in which there are not too many variables? How to stabilise the conditions of the experiment? It is also important to bear in mind that there is always natural variation in biological systems. In order that valid conclusions can be drawn from the results, a large number of samples will usually have to be studied, which in turn means large numbers of experiments and much laborious analysis.

The key to understanding the associations between system structure and system function lies in molecular biophysics. X-ray crystallography and nuclear magnetic resonance spectroscopy (NMR), the highly efficient methods of structural research, have both been developed by physicists. Crystallography requires crystallisation of the macromolecule under investigation, whereas NMR can provide coordinate-level structural data on the macromolecular solution. Many other methods that are based on X-ray or neutron radiation allow for studying the system in its natural state. These kinds of structural research methods will not give the coordinates of atoms in an imperfect system, but they will provide such information as the degree of crystallisation and the size of the crystals (powder diffraction, wide angle scattering) or the size and shape of the aggregate in the solution (small angle scattering). Intensive synchrotron radiation can be used to shed light on such aspects as the distribution of elements at different points of the sample (microfluorescence analysis) or the degree of oxidation of the metal atoms contained in the sample, the distances and numbers of immediate neighbours (absorption spectroscopy, anomalous scattering). In other words, a great deal of information can be gleaned from systems so long as we know what we are looking for with our measurements. For instance, we used surface diffraction to follow the organisation of the HFBII hydrophobin protein on the surface of water and saw how its crystal structure changes with layer drying (Hasylab, Hamburg). Major international centres are not of course the only possible sites of important biophysics research. Roman Tuma, for

instance, has used the LIFE 2000 program to develop equipment based on an optical trap for studying molecular motors.

Modern synchrotron radiation sources, such as the joint European ESRF in Grenoble and the planned PETRAIII in Hamburg, offer interesting new opportunities for experimental biophysics research. Measurements can now be based on ever smaller samples and ever smaller concentrations in solutions. Measurement times are also shorter, and the state of the system can be followed as a function of time with ever shorter time steps. Applications might include the formation of a virus, or monitoring the synthesis of a biopolymer. Crystallisation, for instance, is easy to detect. Scatter measurements can be done using a beam with a diameter of no more than one micrometer, which allows us to home in accurately on a certain part of the sample on which we need structural information. An example is provided by the experiment conducted by my research group at ESRF, where we focused a narrow X-ray beam through the pore of a tree cell: this allowed us for the first time to measure the orientation distribution of the cell wall cellulose microfibrils relative to the cell axis.

Biological systems are highly complex from a modelling point of view as well. It is very rarely we have a problem where we can apply traditional methods of quantum mechanics or classical mechanics, which are used to model structures at the atom level. Indeed research in biological physics is needed precisely for the development of highly efficient methods that can be used to predict the characteristics and development of large systems. One particularly interesting problem is the folding of proteins in different conditions. How can a protein organise itself in such a way that it does not become too stable? The study of folding has also produced challenges for experimental molecular biophysics. For instance, studies of the formation of amyloid fibrils have made extensive use of synchrotron radiation as well as microdiffraction and small angle scattering methods.

The work that physicists are currently doing to develop experimental and mathematical methods will significantly contribute to the study of biological systems. Most biophysics research teams in Finland have been set up less than 10 years ago, and they continue to need both funding and networking support. It is encouraging to see – and one hopes this trend will continue – that graduate schools in both biology and materials sciences have enrolled postgraduate students who are oriented to biological physics. Biophysics should be integrated in all research programmes in the biology sector. The decision taken in the Life 2000 programme to incorporate biophysics as a separate thematic area, is a good and praiseworthy move.

An interesting theme for a new research programme might be the development of the biological system, which would apply experimental or modelling methods to look at how a system, say a cell, responds and adapts to the requirements of the environment and how the cell structures evolve. There would be no shortage of research topics in this area: studies could cover everything from molecular systems to the physical modelling of evolution. Molecular biophysics may come very close to materials science indeed: after all a biological system of nanometer size can provide an excellent natural model of self-organising material. On the other hand research

into the molecular interactions, clusters and micelle formation that is needed in nanomaterials development and in the linking of bio- and synthetic materials, has purely biological interest as well.

One theme for a research programme that would not be biology but in which biology would certainly play a significant role, would be the research use of synchrotron and neutron radiation. The programme would obviously include basic research projects in physics, especially solid state physics, but also projects in biology, biophysics and chemistry. Medical physics would naturally be involved as well, after all Finnish researchers are continuing to work on the development of new and more accurate imaging methods for the detection of cancer. One theme might be the study of a biological system in its natural state. Biology, medicine and environmental sciences would offer a host of interesting problems for which new methods of measurement, processing and modelling could be developed. In measurements carried out as a function of time, radiation detectors are mainly two-dimensional, which is why a few days' measurement distance may produce tens of gigabytes of data. The programme might also include projects processing large quantities of data, which would tie in with Finnish grid plans. This kind of project would be important in the sense that it would increase awareness of different uses of synchrotron radiation, increase the use of synchrotron radiation in Finland and provide added depth to research here.

Ethical and Sociocultural Impacts of Biological and Genetic Research: Trends in Development and Future Prospects

Juha Räikkä, University of Turku

The ethical and social impacts of biological and genetic research have been studied both in Finland and elsewhere from the vantage-point of various disciplines, including law and philosophy. Legal and philosophical research has studied the impacts of biological and genetic research primarily from the point of view of how this line of work and its applications affect social equality and privacy protection, for instance.

International discussion and debate on bioethics in the 1990s and through to the new millennium has focused on such issues as stem cell research, human cloning, gene therapies, genetic monitoring and gene tests, gene patenting, the safety of GM foods, the welfare of transgenic animals, the growth of animals experiments with gene technology and the environmental impacts of GM crops. Some of these themes are still very much in the headlines, and there is still heated debate on the legitimacy of stem cell research, for example. On the other hand, some themes are now beginning to recede. Books on the ethics of cloning are no longer appearing at a rate of two per month. Xenotransplantation is also on its way out.

One issue that is currently at the centre of much attention is the hearing of citizens ahead of the launch of new research projects. Although the main concern is with the practical issue of how exactly to arrange such hearings, questions of principle are closely involved as well. Who should have say in decisions regarding to the location of field experiments, for instance. What obligations do the various parties have vis-à-vis one another? Should hearings be arranged in the form of public discussions?

Principles are also a central concern in discussions on the growing of GM crops, which of course ties in closely with the issue of hearing. Safety considerations are crucially important in growing crops, but these considerations cannot be properly taken into account without sound and complete information. How should the principle of caution be interpreted? Theoretical debate on the content and application of the principle of caution is ongoing, and the practical significance of such debate is quite obvious.

In the field of biomedicine, work is continuing to develop gene tests, which is reopening the debate on the ethics of these tests. Gene tests yield information not only on the person who is being tested, but also on next of kin. Should these tests be allowed in the first place, who should cover the costs, should the tests in some situations be compulsory, who should have access to the information produced by these tests, and what kind of impacts will the tests have in the long run? One of the risks involved in gene testing is that it may cause inequality among citizens if genetic information is used in making decisions where that information should not be used.

In the future the debate on bioethics will inevitably expand to take in assessments of so-called nanobiotechnology. Applications of nanobiotechnology range from

different kinds of biomarkers to the "improvement" of motor function in humans. In this way nanobiotechnology throws up challenges that have to do specifically with the protection of privacy, but also with broader notions of humanity and freedom. The ethical and social assessment of nanobiotechnology should be started before applications really begin to flow into the marketplace, for instance in border control. Does human freedom consist in security or privacy?

In the future the focus of ethical debate will no doubt increasingly shift towards the assessment of biomaterials and to the nature of new foodstuffs. Foods with beneficial health effects, for instance, may raise questions about the relationship between foods and medicines.

Although the assessment of the ethical and social impacts of biological and genetic research most typically revolves around very concrete issues – for instance the ethics of reproductive technologies – bioethics has and will continue to engage in more general discussions about the biosector and closely related themes. New interpretations are evolving in sociobiology, and researchers are interested in the relationship between biology and ethics. The idea that some solutions are "natural" or "unnatural" has led researchers to dwell upon some profound issues on the relationship between man and nature.

As bioresearch continues to evolve, its ethical and sociocultural assessments will continue to gain increasingly importance as well. Although ethical research is fundamentally a critical exercise, it nonetheless ultimately helps us to understand bioresearch and brings citizens and bioresearchers closer together.

Appendix 1: LIFE 2000 Projects

NEUROSCIENCE:

Coffey, Eleanor & Courtney, Michael: Stress activated protein kinase signaling in the brain, its role in stress and differentiation processes: regulation by scaffold proteins

Donner, Kristian: Molecular and cellular mechanisms of the retina limiting basic visual functions

Hari, Riitta: Temporal dynamics of human percepts and cortical functions

Hietala, Jarmo, Castrén, Eero & Tanila, Heikki: Neurobiology of psychosis

Ikonen, Elina & Saarma, Mart: Integration of cellular lipid dynamics and signaling in neuronal cells

Kalimo, Hannu: CADASIL: Hereditary disease of arteries causing brain infarcts and dementia

Kauppinen, Risto, Salmelin, Riitta & Sams, Mikko: Studies of human brain functions: Implementing a high-field fMRI into multimodal MEG and EEG imaging

Keinänen, Kari, Pasternack, Michael & Taira, Tomi: Calcium-permeable AMPA receptors: from molecules to function

Näätänen, Risto, Palotie, Leena & von Wendt, Lennart: Molecular genetic and neurocognitive profiles in autistic spectrum of disorders

Pitkänen, Asla, Penttonen, Markku & Ylinen, Aarne: Activity dependent molecular, cellular and network plasticity in the Amyglada - biological basis for emotional learning and epileptiogenesis

Rauvala, Heikki, Kilpeläinen, Ilkka & Taira, Tomi: Extracellular matrix-associated proteins in the development and activity-dependent plasticity of neuronal connections in brain

Saarma, Mart, Airaksinen, Matti, Kaila, Kai, Rivera, Claudio, Timmusk, Tonis & Voipio, Juha: Neutrotrophic factors and GABA: Cross talk in brain development and plasticity

Soininen, Hilkka: Risk genes in Alzheimer's disease - proteomics and functional genomics approach

DEVELOPMENTAL BIOLOGY:

Jänne, Olli & Toppari, Jorma: Androgen signaling in testicular development and differentiation Androgen signaling in testicular development and differentiation

Partanen, Juha, Frilander, Mikko & Savilahti, Harri: Genomic tools for studies of gene functions in mice: generation of tissue-specific mutations using in vitro DNA transposition and site-specific recombination

Ruskoaho, Heikki, Pihlajaniemi, Taina & Vainio, Seppo: Signaling pathways for cardiac hypertrophy and heart failure

Väänänen, Kalervo, Härkönen, Pirkko, Lassila, Olli & Lönnberg, Harri: Bone and immune cells: How estrogen regulates differentiation of the common stem cells

FUNCTIONAL GENOMICS:

Aaltonen, Lauri: Linkage disequilibrium mapping utilizing genomic mismatch scanning in the Finnish population

Alitalo, Kari: Functional analysis of factors governing cell growth and angiogenesis

Aro, Eva-Mari: Novel gene functions and protein-protein interactions during biogenesis of photosynthetic membranes

Jacobs, Howard: The human mitochondrial proteome: Genes involved in mtDNA maintenance

Kere, Juha, Mannila, Heikki & Lahesmaa, Riitta: From positional candidate genes to functional networks in asthma, a multifactorial disease

Keränen, Sirkka: Functional analysis of novel yeast genes involved in protein secretion

Meri, Seppo: Comparative proteomic analysis of complement sensitive vs. resistant microbes and tumor cells

Palotie, Leena, Jalanko, Anu, Lehesjoki, Anna-Elina & Ulmanen, Ismo: Functional genomics of Finnish disease genes

Palva, Tapio, Heino, Pekka, Koski, Veikko & Junttila, Olavi: Photoperiodism and winter hardiness in birch

Romantschuk, Martin, Palva, Tapio & Saarilahti, Hannu: Pathogenicity islands in plant pathogenic bacteria

Valkonen, Jari & Mäkinen, Kristiina: Utilizing a plant virus as a gene expression vector for production of biomolecules for industrial uses in plants

Vihko, Pirkko, Goldman, Adrian, Juffer, André, Jänne, Olli & Soininen, Raija: Function of prostate-specific proteins

Winqvist, Robert: Genetic risk factors in breast and ovarian cancer

Ylä-Herttuala, Seppo & Alitalo, Kari: Gene therapy employing endothelial growth factors and receptors

Ylä-Herttuala, Seppo, Kulomaa, Markku & Oker-Blom, Christian: Further Development of Baculovirus Vectors, their Large-Scale Production and Testing *in vitro and in vivo* with Validated Experimental Animal Models

BIOINFORMATICS:

Castrén, Eero & Kaski, Samuel: Analysis of functional genomics data using self-organizing maps

Johnson, Mark, Panula, Pertti, Scheinin, Mika, Slotte, Peter, Soini, Erkki & Wurster, Siegfried: Multidisciplinary attack on understanding G-protein coupled receptor function in the nervous systems of vertebrates

Söderlund, Hans, Kalkkinen, Nisse, Penttilä, Merja, Sarvas, Matti & Ukkonen, Esko: A global molecular approach in the study of microbial stress

BIOPHYSICS:

Bamford, Dennis, Serimaa, Ritva & Tuma, Roman: Dynamics of macromolecular assemblies and function of molecular machines

Wikström, Mårten: Structures and catalytic mechanisms of membrane proteins

ETHICAL ASPECTS AND SOCIO-CULTURAL IMPACTS:

Hukkinen, Janne: Socio-cultural dimensions of technological change: The case of Finnish biotechnology

Häyry, Matti, Räikkä, Juha & Salokannel, Marjut: The ethical, legal and sociocultural aspects of bioscientific research and its applications

Appendix 2:
Events organised under Life 2000

Seminars

2000:
Opening seminar, 26 Oct 2000, Viikki Biocenter, Helsinki
Annual Meeting of Developmental Biology, 27-28 Oct 2000, Hyytiälä
Popularizing Science, 4-5 Dec 2000, Viikki Biocenter, Helsinki

2001:
Optimising the fMRI experiment workshop, 8-10 Mar 2001, HUT, Espoo
Biology for physicists (course), Viikki Biocenter, spring 2001
Ethics in Biosciences, 4 May 2001, Viikki Biocenter, Helsinki
Neuroinformatics Finland, 18 June 2001, Academy of Finland, Helsinki
Biotech 01 Exhibition, 12-13 Sept 2001, Wanha Satama (Life 2000 session)
Finnish Bioscience Days, 14-15 Sept 2001, Viikki Biocenter, Helsinki
Exploratory workshop on stem cell research, 25-26 Nov 2001, Hyytiälä
National discussion forum on stem cell research, 2 Nov 2001, Biomedicum Helsinki
Biosciences for theologists, Viikki Biocenter and Dept of Practical Theology, 3 and 13 Dec 2001
Genes and Health, 12 Dec 2001, Viikki Biocenter, Helsinki

2002:
ELSA meets Bioscientists, 25 Mar 2002, Viikki Biocenter, Helsinki
Life children's party - Information package for newly appointed group leaders, 30 May 2002, Viikki Biocenter, Helsinki
Scientific and Cultural Aspects on Anxiety, 6 June 2002, Finlandia Hall, Helsinki
Scientific and Cultural Aspects on Anxiety, 7-8 June 2002, Kiasma Theatre, Helsinki
Biotech 02 Exhibition, 18-19 Sept 2002, Wanha Satama, Helsinki (Genomics session)
ELSA meets Bioscientists, 10 Dec 2002, BioCity Turku

2003:
Finnish Science Days, 8 Jan 2003, Porthania, Helsinki (Life 2000 session)
How to become a child, 7 Mar 2003, Porthania, Helsinki
Is childlessness a disease? 8 Mar 2003, Porthania, Helsinki
Islet Development and Stem Cells in Diabetes, 3-5 April 2003 Biomedicum Helsinki
Cellular Mechanisms of Development, 8-10 May 2003, Biomedicum Helsinki*
Ethics in Biomedical Research, 21-23 Aug 2003, Biomedicum Helsinki
Biotech Society, 29-30 Sept 2003, Dipoli Espoo
Bioethics Exploratory Workshop, 29 April and 2 Oct 2003, Viikki Biocenter, Helsinki
Workshop on Plant Genomics, 31 Oct 2003, Academy of Finland, Helsinki
Closing symposium, 11 Dec 2003, White Hall, Helsinki
Stem cell research in Finland, 15 Dec 2003, Biomedicum Helsinki

The Research Programme on Biological Functions, Life 2000, was the largest research programme ever launched in Finland for purposes of funding both basic and applied research in the biosector. Running for three years from 2000 to 2003, it had a budget of 14 million euros and involved no less than 89 research groups.

The subjects covered in the programme were exceptionally far-ranging: there were six main areas of study, viz. neuroscience, developmental biology, functional genomics, biophysics, bioinformatics as well as ethical, legal and sociocultural issues related to bioresearch.

This report reviews the programme's progress over these three years, looking separately at different programme areas, the coordination and the information activities as well as the outcomes of the programme from the point of view of the researchers involved and other stakeholder groups.

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