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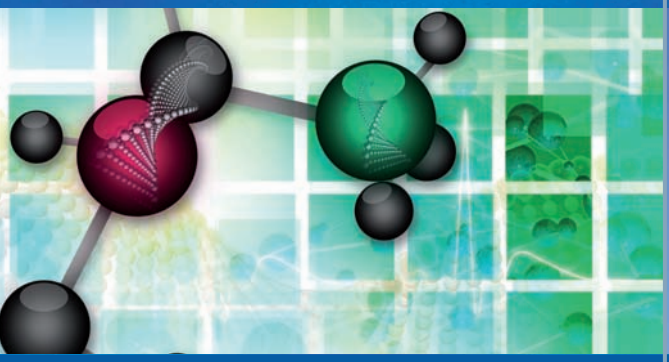
Chemistry Research in Finland 2005–2009



Evaluation Report

Academy of Finland
Research funding and expertise

Publications of the Academy of Finland 1/11

Chemistry Research in Finland 2005–2009

Evaluation Report

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Description

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Abstract

This report presents the findings of an international panel convened to evaluate chemistry research in Finland. The panel consisted of Professors Kenneth Ruud (chair), Claudine Buess-Herman, Jennifer Green, Helena Grennberg, Søren Rud Keiding and Torsten Linker and Directeur de Recherche Gabriel Wild.

The evaluation includes 41 chemistry units and covers the years 2005–2009. The evaluation is based on interviews and unit self-evaluations. Of the units, 35 were interviewed by the panel and six were assessed based on the evaluation form only. The report includes the panel's observations and recommendations and is divided into three main sections. The first section provides an overall look at the chemistry field and deals with research quality, funding, personnel resources, infrastructure, education, internationality and societal impact. The second section focuses on the different chemistry subdisciplines: analytical chemistry, chemical engineering, industrial chemistry, materials chemistry, organic chemistry, polymer chemistry, physical chemistry and theoretical chemistry. The third section contains the unit evaluations. The report also includes statistics with key figures on chemistry research in Finland.

According to the evaluation panel, chemistry research in Finland is at a very good international level overall, with some research units placed at the international cutting edge. However, there are a number of units – often single-professor units – that are of subcritical size and that are not conducting research at an international level. Another weakness is that some units do not actively engage in collaborations at the national or international level. Finnish chemistry research would benefit from a stronger international focus and the recruitment of personnel and students from outside Finland. The research infrastructures within Finnish chemistry research are very high-quality, but maintaining them at their current level would require a national investment and upgrade plan. The overall funding of chemistry research is at a satisfactory level, but the panel is concerned that the competition-driven funding does not encourage research groups to take new initiatives. Nevertheless, the research by the units covers all significant aspects of chemistry and caters well to the Finnish chemical industry. The panel is somewhat concerned that the focus on industry-related research may put basic chemistry research in jeopardy.

The panel notes that the graduate school system has made PhD training in Finnish chemistry research more effective. However, more efforts are needed. For instance, the average PhD completion time should be four years. This will require longer-term and more secure funding schemes and improved project planning.

Key words	Chemistry, research policy, research funding, evaluation, analytical chemistry, chemical engineering, industrial chemistry, materials chemistry, organic chemistry, polymer chemistry, physical chemistry, theoretical chemistry	
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Tiivistelmä	Kansainvälinen arviointipaneeli on arvioinut Suomen kemian alan tutkimuksen tason. Paneelin jäsenet olivat Prof. Kenneth Ruud (pj.), Prof. Claudine Buess-Herman, Prof. Jennifer Green, Prof. Helena Grennberg, Prof. Søren Rud Keiding, Prof. Torsten Linker ja Directeur de Recherche Gabriel Wild. Arviointi käsitti 41 kemian yksikköä ja kattoi vuodet 2005-2009. Paneeli perusti arvionsa yksiköiden täyttämiin itsearviointilomakkeisiin sekä haastatteluihin. 35 yksikköä haastateltiin ja kuuden yksikön kohdalla arvio perustui pelkästään lomakkeisiin. Raportti sisältää paneelin havainnot ja suositukset, ja siinä on kolme pääosiota. Ensimmäisessä tarkastellaan kemian alaa kokonaisuutena ja käsitellään tutkimuksen laatuun, rahoitukseen, henkilöstöön, infrastruktuuriin, koulutukseen, kansainvälisyyteen sekä yhteiskunnalliseen merkitykseen liittyviä kysymyksiä. Toinen osa käsittelee kemian osa-alueita: analyyttinen kemia, epäorgaaninen kemia, teknillinen kemia, materiaalikemia, orgaaninen kemia, fysikaalinen kemia, polymeerikemia ja teoreettinen kemia. Kolmas osa sisältää yksiköiden arviot. Lisäksi raportti sisältää tilasto-osion, johon on koottu keskeiset alan tutkimusta kuvaavat tunnusluvut. Paneelin havainnon mukaan kemian tutkimus on Suomessa korkealla tasolla ja osa yksiköistä on alansa kansainvälisessä kärjessä. Jotkin yksiköt jäivät sen sijaan kansainvälisen tason alapuolelle, ja monet, varsinkin vain yhden professorin johtamat yksiköt, olivat paneelin mielestä liian pieniä. Toinen vakava puute monissa yksiköissä oli vähäinen yhteistyö sekä kotimaassa, että kansainvälisesti. Toimintaa tulisikin yleisesti kehittää kansainvälisempään suuntaan, ja henkilöstöä ja opiskelijoita tulisi aktiivisesti rekrytoida ulkomailta. Tutkimusinfrastruktuurin taso on varsin hyvä, mutta tämä tason säilyttäminen tulevaisuudessa vaatisi koordinoidumpaa kansallista strategiaa. Kemian alan tutkimusrahoituksen taso on yleisesti ottaen tyydyttävä. Paneeli oli kuitenkin huolissaan siitä, että kilpailuun perustuva tutkimusrahoitus ei rohkaise panostamaan uusiin aihealueisiin. Muuten kemian alan tutkimus kattaa kaikki oleelliset osa-alueet ja palvelee hyvin teollisuuden tarpeita. Paneeli oli kuitenkin huolissaan siitä, että liiallinen keskittyminen teollisuuden kannalta tärkeisiin tutkimusaiheisiin voi johtaa kemian perustutkimuksen tason kärsimiseen. Tutkijakoulujärjestelmän todettiin tehostaneen alan tutkijankoulutusta, mutta kehityksen tarvetta on edelleen. Tohtorintutkinnon suoritusaikatavoitteen tulee olla neljä vuotta. Tämä edellyttää pitkäjänteistä rahoitusta ja aiempaa parempaa projektikokonaisuuksien suunnittelua.	
Asiasanat	Kemia, tutkimuspolitiikka, tutkimusrahoitus, arviointi, analyyttinen kemia, epäorgaaninen kemia, teknillinen kemia, materiaalikemia, orgaaninen kemia, fysikaalinen kemia, polymeerikemia, teoreettinen kemia	
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Preface

This is the report of an ad hoc international panel convened by the Academy of Finland to conduct an evaluation of basic research in the field of chemistry in Finland. The report has been prepared specifically for the Academy, which reserves the right to use the contents as it sees fit. As the report is expected to reach a wide audience, the evaluation panel hopes its deliberations will promote a useful, constructive debate within the Finnish chemistry community.

The evaluation panel would like to thank the Academy of Finland for entrusting it with such an interesting, important and challenging task, the evaluation steering group for providing a clear mandate for the evaluation and for providing valuable feedback during the panel's work on the final evaluation report. Special thanks for organising the material and making all practical arrangements during the hearing week goes to Science Adviser Kati Lüthje, Project Officer Henriikka Kekäläinen and Director Susan Linko at the Academy of Finland. The panel would also like to thank the evaluation coordinator, Dr Mikko Lensu, for much assistance in all parts of the evaluation process.

While the hearings and meetings with staff at the units under evaluation took place in September 2010, the information-gathering process, including factual information, self-evaluation and bibliometric analysis, began in January 2010. The evaluation panel would like to use this opportunity to thank the research units involved for their dedication to the evaluation process, for the time they spent in preparing the necessary self-evaluations that provided the panel with much valuable insight into the units' activities, and for their engaged presentations and lively discussions during the hearings.

The project has involved comprehensive assessments of research efforts at the research group level. The process of achieving insights into such a wide variety of research efforts and reaching a fair assessment of their strengths and weaknesses has required substantial efforts by all parties involved in the process. In spite of the substantial scope of the project, the panel feels that it was able to obtain sufficient information for balanced and fair assessments. The panel is confident that its analyses and recommendations are well founded and hopes that the report will be viewed as a constructive basis for improvement, development and change.

Executive summary

Chemistry research in Finland is at a very good international level overall, with some research units being at the international cutting edge within their fields. At the same time, there are a number of chemistry units that are of subcritical size and that are not conducting research at an international level, neither in terms of quality nor in terms of quantity. A characteristic feature of these units is that they do not actively engage in collaborations within their university, at the national level or internationally.

Many chemistry units in Finland are in effect single-professor units. This cannot be regarded as an efficient use of resources at the departmental level, and often leads to too strong dependence on the qualities of the professor. In many cases, these units have insufficient administrative support. The universities should therefore consider the organisation of these units. Clear research strategies should also be developed, as a number of units do not have a strategy or have not properly rooted their strategy in the research staff.

Finnish chemistry research would benefit from a stronger international focus in terms of international networking and the recruitment of PhD students, postdoctoral students and faculty members from outside Finland. Too many units have largely recruited their faculty members among their own alumni.

Overall, the research infrastructures within Finnish chemistry research are at a very high level, and all active research groups have access to the necessary infrastructures locally. The research infrastructures would benefit from a national coordinated plan for investment in and upgrading of large-scale infrastructures, including clear plans for collaborations. This would ease the general concern of the units about maintaining infrastructures at their current level.

The overall funding of chemistry research is at a satisfactory level. However, the balance between the different funding instruments does not seem optimal. The competition-driven funding has allowed active groups to reach an internationally leading level. At the same time, research funding at the universities is limited, and groups less successful in external fundraising are at risk of not having the means to develop a sufficient level of activity. This can potentially lead to missed opportunities for Finnish chemical research. The panel recommends the establishment of minimum support for small consumables and a minimum amount of research time for faculty members at the universities.

The research conducted by the evaluated units covers all significant aspects of modern chemistry and caters well to the needs of the Finnish chemical industry. The panel has not found any important directions missing or over-represented in the Finnish chemistry research ecosystem, although a certain concern is raised in relation to fundamental experimental physical chemistry. In this domain, much of the current research in Finland is focused on the use of physical chemistry rather than on the development of the physical chemistry methods themselves.

Wood and pulp chemistry has a strong position in Finland, but the amount of this activity in relation to the scientific quality as documented in this report should be further analysed by national stakeholders; that is, by those in need of the research (relevant chemical industry), the funding agencies (Tekes and Academy of Finland) and the research-performing organisations (universities and VTT). Such a study should also consider to what extent the organisation and cooperation of the activities in this field are at a level that ensures an optimal use of the funding in this domain.

Industry-related research funding is essential to many research groups. The panel is concerned that the importance of this funding may lead to research with too narrow a focus and too short time horizons. Basic chemistry research is therefore in jeopardy. As a thorough and detailed understanding of different areas of chemistry is mandatory in order to maintain an internationally competitive level of research and to develop industry in new areas of chemistry, the amount of and time horizon for industry-related chemistry research needs to be carefully monitored and assessed by the stakeholders (universities and the chemical industry) so as not to jeopardise the long-term viability of Finnish chemistry research.

In general, PhD training in Finnish chemistry research has until recently not received sufficient attention. A PhD degree takes too long to complete and too many students fail to obtain a PhD degree altogether. The graduate schools have in this respect had an important structuring effect and increased the awareness of the PhD training process. However, more efforts are needed to reduce PhD completion times and improve PhD supervision. It must become a clearly stated goal that the average time to complete a PhD degree should be four years, including some limited time spent on teaching. The funding instruments that support PhD students must have project periods that allow the students to complete their degree within the duration of the project.

1 Introduction

1.1 Panel members

Kenneth Ruud, the chair of the panel, is Professor of Theoretical Chemistry at the University of Tromsø, Norway.

Claudine Buess-Herman is Full Professor of Analytical Chemistry at the Faculty of Sciences of Université Libre de Bruxelles, Belgium.

Jennifer Green is Professor of Inorganic Chemistry in the Department of Chemistry at the University of Oxford, UK.

Helena Grennberg is professor of Organic Chemistry at Uppsala University, Sweden.

Søren Rud Keiding is Professor in Physical Chemistry at the Department of Chemistry, Aarhus University, Denmark.

Torsten Linker is Full Professor of Organic Chemistry at the Department of Chemistry at the University of Potsdam, Germany.

Gabriel Wild is Directeur de Recherche and Director of the Reactions and Chemical Engineering Laboratory in Nancy, France.

The full personal profiles of the panel members are available in Appendix B.

1.2 Background of the evaluation

In 2009, the Academy of Finland Research Council for Natural Sciences and Engineering decided to conduct an international evaluation of publicly funded chemistry research in Finland. This was motivated by several strategic decisions and reports that targeted the chemistry field and raised issues concerning the future demand for PhDs, the role of applied and basic research, and recent trends in the quality and productivity of chemistry research. However, the most important factor was perhaps the Academy's research impact assessment "The state and quality of scientific research in Finland 2009", SIGHT2009, where one of the recommendations was to evaluate the chemistry field. There was also an assessment, from the viewpoint of chemical industry, being prepared by Tekes, the Finnish Funding Agency for Technology and Innovation, on the available chemistry expertise at universities and research institutes.

The Research Council also wanted to get an overall view of the impact of Academy of Finland funding in the field and information on how to improve the Academy's funding instruments and optimally target its resources. Apart from the Academy's general research grants, this concerned the impact of graduate schools, whose funding is administered and partly covered by the Academy, the Centre of Excellence programmes, which are funded primarily by the Academy, and the Finland Distinguished Professor Programme (FiDiPro).

The Strategic Centres for Science, Technology and Innovation also give rise to expectations for the future. The strategic centres are cooperative bodies, usually organised as independent companies, where different actors appear as stakeholders. The centres aim at more integrated innovation chains combining basic and applied research in a mid- and long-term perspective. The first of the strategic centres, Forest Cluster Ltd, is especially relevant in the context of this evaluation as the future importance of chemistry to the forest sector, albeit already at a high level, is expected to grow. The timeliness of the evaluation is further supported by the fact that 2011 has been announced as the International Year of Chemistry.

Most importantly, chemistry research is strategically important to the future of Finnish society, business and industry. In terms of the gross value of production, the chemical industry is Finland's second largest industrial sector after the technology industry. In 2009, the gross value of production totalled EUR 16 billion, accounting for 17 per cent of total industrial output. During the same period, chemical industry value-added amounted to EUR 3.5 billion, or 16 per cent of all Finnish industriy. Petroleum products contribute about 40 per cent and basic chemicals nearly one-third to the gross value of production, respectively. In terms of value added, basic chemicals are the largest product group and 25 per cent is accounted for by plastic products. About 40 per cent of chemical industry products are exported, accounting for 17 per cent of total exports. R&D investment by the industry amounted to EUR 356 million in 2009. There is a long tradition of collaboration between the chemical industry and universities, and university education and research are more important for this industry sector than for the Finnish industry on average. It is expected that this evaluation is beneficial also for the chemical industry after the strategies for university collaborations have been revised.

1.3 Organisation of the evaluation

The Research Council for Natural Sciences and Engineering appointed a steering group to supervise the evaluation process. The steering group held its first meeting in November 2009, chaired by Pirjo Vainiotalo, member of the Research Council (2007–2009) and Professor at the University of Joensuu. Professor Vainiotalo was replaced at the beginning of 2010 by Erkki Oja, who is Chair of the Research Council and Professor at Aalto University. The other members were Technology Director Mika Aalto from Tekes (later replaced by Senior Technology Adviser Erja Ämmälahti), Research Director Lars Gädda from Forest Cluster Ltd, Assistant Director Riitta Juvonen from the Chemical Industry Federation of Finland, Director Ilkka Kruus from Danisco Sweeteners Ltd, and Senior Adviser Janica Ylikarjula from the Confederation of Finnish Industries.

The steering group appointed Dr Mikko Lensu as the scientific coordinator of the evaluation. On behalf of the Natural Sciences and Engineering Research Unit of the Academy of Finland, the process was managed by a team composed of Director Susan Linko, Science Adviser Kati Lüthje and Project Officer Henriikka Kekäläinen.

The steering group then convened an international expert panel, which was appointed by the President of the Academy of Finland to carry out the evaluation.

1.4 Implementation

The steering group identified eight major chemical subdisciplines in the 41 research units to be evaluated. The evaluation covered the five-year period 2005–2009. One unit belongs to a large governmental research institute while the remaining units are research groups, laboratories or departments from nine universities.

The Academy prepared an evaluation form that was sent to the units at the end of December 2009 and asked for it to be returned in mid-February. The steering group later extended the deadline to mid-March, due to the lack of responses from certain units. The evaluation form consisted of two parts. Part I contained tables for quantifiable data on research profile, resources and research output: research fields, personnel, funding, publications, education and collaboration. Part II asked for the unit's self-assessment with the following headings: Research Strategy, SWOT, Infrastructure, Publications, Self-Evaluation, Collaboration, Societal Impact, Administrative and Educational Load, and Future Prospects. It was stated that selected parts of the information given in Part I could be published in the evaluation report while Part II was intended for evaluation purposes only. It was also stated that no data concerning individual researchers would be published.

The objective of the evaluation, as defined to the expert panel in the Terms of Reference (Appendix C), was to evaluate chemistry research in Finland during the period 2005–2009. The panel was asked to look at the research from three different viewpoints: reviewing the field as a whole, the different subfields, and the unit level; comparing the quality, innovativeness and efficiency of the research with international standards; and providing recommendations for the future development of chemistry research in Finland. Besides scientific quality, important issues included personnel and career policies, researcher training, adequacy of resources, and networking.

Of the 41 units selected, 35 were interviewed by the panel, while six units were assessed based on the evaluation form only. This decision was justified by the limitations of what the panel could be expected to accomplish in five days and, on the other hand, by a wish to include certain units strong in chemistry but not clearly profiling themselves as chemistry units. The interviews planned for 19–23 April 2010 had to be cancelled due to the closure of European airspace and were finally conducted during 13–17 September. The interviews had a typical duration of 70 minutes and consisted of a short introductory presentation by the unit followed by a discussion between panel members and unit representatives. At least three panel members were present during each interview. After the interview the panel had a short session for collecting observations and opinions.

1.5 Key figures

The total funding for the 41 evaluated units amounted to more than EUR 300 million during the five-year evaluation period, or more than EUR 60 million per year, of which 44 per cent was core funding and 56 per cent external funding. Of the external funding, Academy of Finland funding accounted for 13 percentage points and Tekes funding for 14 percentage points. These two funding bodies thus stood for about 60

per cent of the external funding. The units had a total of 84 professors and the total staff accounted for 1100 full-time equivalents (FTEs). The number of FTE research staff was 890, of which 370 belonged to senior research staff. The units produced a total of 4700 journal articles or 23 per unit per year, or 2.5 per senior researcher per year. The number of completed MSc and PhD degrees was 240 and 70 per year, respectively.

1.6 Notes on terminology and style

(i) This report presents the views of the evaluation panel. In this introductory section and in the Appendices, the panel has been assisted by the editor and the Academy of Finland; otherwise the panel as a whole is responsible for the text. However, various parts of the report were initially contributed by different panel members, resulting in small variations in style that may be visible in the report. In general, the length of the discussion in different parts of the report should not be interpreted to reflect the scientific quality of the discussed matter.

(ii) The host organisations of the units are abbreviated as follows:

AU	Aalto University
LUT	Lappeenranta University of Technology
TUT	Tampere University of Technology
UEF	University of Eastern Finland
UH	University of Helsinki
UJ	University of Jyväskylä
UO	University of Oulu
UTU	University of Turku
VTT	VTT Technical Research Centre of Finland
ÅA	Åbo Akademi University

(iii) The report also includes the following abbreviations:

COST	European Cooperation in Science and Technology
FP	European Union Framework Programme
FTE	Full-time equivalent
MS	Mass spectrometer/spectrometry
NMR	Nuclear magnetic resonance
Tekes	Finnish Funding Agency for Technology and Innovation

2 Overall assessment of the quality of chemistry research in Finland

2.1 Quality and scope

Finnish chemistry research is overall at a very good level. There are a number of research groups that are at the international cutting edge. Particularly noteworthy is that these excellent research groups cover all of the various subdisciplines of chemistry that have been part of this evaluation, and that these units are hosted by a number of different universities. This diversity in terms of both scientific topic and geographic location is a particular strength for Finnish chemistry research and education, and should be maintained in order to ensure high-quality research-based education of chemists for local industry, and to provide the necessary research-based support to facilitate the future success of the Finnish chemical industry.

Even though Finland has a number of internationally leading research groups, there are number of groups that are of subcritical size, leading to research that is insufficient in quantity and, in some cases, also in quality. The institutions hosting these units need to consider how to strengthen these groups, either by making larger units with common research goals (but pursued by different scientific methods) or by increasing the staff. In a few cases, the evaluated units do not meet international standards, whereby the host institutions must give careful consideration to the viability of these groups.

Many chemistry units in Finland are single-professor units, supported by lecturers and researchers. In general, this makes the unit highly dependent on both the scientific and administrative qualities of a single person. The panel would therefore in general recommend that larger units be created in order to provide a larger scientific collaborative environment, improved administrative support and less dependence on the qualities of a single professor.

A particular strength of Finnish chemistry research is its strong connections to relevant Finnish industry. At the same time, this focus must not come at the expense of core competency in basic chemistry research. There is a strong desire in the research community to pursue fundamental research, which is to a certain extent thwarted by the level of available funding. The institutions, the Academy of Finland and the Ministry of Education, Science and Culture need to ensure that there are funding opportunities for fundamental chemistry research in a wide range of topics. This is important for Finland's ability to develop new industry based on innovative science in domains outside the present focus of Finnish industry, science whose applicability may not be apparent at first.

Recommendations:

1. Ensure sufficient funding opportunities for fundamental chemistry research in a wide range of topics.
2. Create larger research units to reduce the dependency on individual professors and improve administrative support.

2.2 Funding

Considering the overall average amount of external funding, chemistry research in Finland appears at first well-funded, and the highly competition-based funding scheme has allowed some research groups to reach an internationally leading level. At the same time, at many institutions, little or no support for research is provided by the universities in terms of time spent on research. For the groups with the largest amount of external funding, a large fraction of the funding is obtained from Tekes, giving a strong bias towards industry needs. This industry-oriented funding threatens to weaken the international impact of some parts of Finnish chemistry research due to the very short time horizons and narrow focuses of these research projects. It could also potentially undermine the long-term need to develop a strong methodological and scientific foundation for the activity in the research groups. The funding of basic research in the core disciplines of chemistry is thus at an adequate to good level.

The panel supports the highly competition-based research-funding scheme that has led to world-class Finnish chemistry research. However, as little or no time for research or consumable support is provided through the universities, in some cases, the panel is concerned that Finnish chemistry research is at risk of missing opportunities. The less high-performing research groups, in particular those experiencing changes of generation or topic, may be unable to muster up the necessary resources to develop to their full potential and to a level where they could secure external funding. The difference between research groups that are able to attract external funding and those that are not (either from the Academy, Tekes or other sources) may therefore be further accentuated over time, potentially leading to missed opportunities and an overall lowering of the level for both research and researcher training. In the long term, this will impact negatively on the quality of Finnish chemical research.

While the panel supports competition-driven research funding, it would recommend that the different universities and the Ministry of Education, Science and Culture, through its university funding, consider the possibility of providing a minimum amount of research time (both as a right and as an obligation) and financial support to faculty members in order to ensure the competitiveness of the academic staff when applying for external funding. This will also ensure that the teaching is research-based. Such an expansion in funding should not involve an increase in total staff, but rather provide the necessary framework to allow existing personnel to perform high-quality research. It is also important that university departments prioritise within their own budgets a minimum funding to cover day-to-day expenses for consumables needed as part of the research activities of the units.

The Academy of Finland is the only larger funding organisation that supports basic chemistry research in Finland. It is therefore important that the Academy is provided with a research budget that allows core chemistry competencies to be supported and maintained without forcing research groups too strongly to meet the needs of Finnish industry. This is important in order to secure the future competitiveness of the Finnish chemical industry.

Tekes is an important source of external funding for many research groups. Recent changes in Tekes' funding requirements make it more challenging to establish effective research consortia, and the timeline of funded research projects seems in many cases too short.

The Strategic Centres for Science, Technology and Innovation are a fairly new instrument and one that has been going through recent revisions in its profile. As such, it is difficult to evaluate the importance and impact of the strategic centres on Finnish chemistry research at this time. However, it is important that this instrument consolidates its form and function to ensure its success.

The Finland Distinguished Professor (FiDiPro) programme has been used, with great success, by one of the evaluated units to attract leading international researchers to Finland. Considering the panel's concerns regarding the general lack of recruitment of faculty members from outside the units, the FiDiPro programme should be used more actively by the research units in order to improve international recruitment and collaboration.

There does not seem to be a unified practice for handling overheads on external projects within the different universities and departments. Some universities pass a proportion of grant overheads to the fundraising groups. This has been beneficial in increasing the diversity of research and enabling development and replacement of essential equipment. The panel supports such arrangements whenever possible in relation to the financial situation of the local department.

Although current funding levels appear adequate, there was widespread anxiety as to the threat of reduced funding in the future, arising from the at times very large degree of external funding in unit budgets.

Recommendations:

1. Ensure that projects funding PhD students can run for the full four-year PhD period (see also section on PhD training).
2. Increase the time horizons of industry-related research programmes.
3. Consider the funding of a minimum amount of research time for academic staff over the core budget of the units, as well as a minimum funding for consumables, without increasing the total number of staff within chemistry in Finland.

2.3 Recruitment

Many of the units evaluated have recruited both temporary and permanent staff largely among their own alumni. In a few cases, this strategy has been successful thanks to the high quality of the research conducted in the unit and the level of the recruited students. In some cases, this in-house recruitment has been driven by a high degree of specialisation in the research group, in other cases by the availability and use of specialised instrumentations not available at many other sites. Unfortunately, in some cases the in-house recruitment appears to have been motivated primarily by a need to ensure the continuation of existing activities. In-house recruitment does therefore appear to limit the development of many groups, making some of the groups strongly dependent on a single professor.

In many interviews, the language requirements (Finnish or Swedish) were suggested as a limiting factor in how widely new faculty members could be searched. The panel is of the opinion that language should not be a limiting factor. New faculty members can easily be utilised for teaching at a higher level (MSc or PhD) until they master Finnish or Swedish at a level that allows them to participate in undergraduate teaching. It is important that new faculty positions at all levels be announced internationally to ensure

the continued success of Finnish chemistry research. In order to make such positions attractive also at the lecturer level, a minimum amount of research time and support should be guaranteed for these normally highly teaching-dominated positions.

International recruitment at the PhD and postdoctoral level is more varied among the evaluated units. In many cases, recruitment at these levels is largely local, but also without an apparent driving force for considering international recruitment. The panel feels that most research groups would benefit from a more active international recruitment policy, and from more actively encouraging Finnish PhD and postdoctoral students to travel abroad for extended periods of time. The panel's concerns about the excessive local recruitment of new faculty members would also be mitigated if the recruited personnel spent significant time in an international research group.

Recommendations:

1. Increase international recruitment at all levels: PhD students, postdoctoral students and faculty staff.
2. Increase international mobility during PhD studies.
3. Increase the national mobility of PhDs.

2.4 Infrastructure

Overall, the quality of the research infrastructure in terms of experimental equipment is very good, in some cases outstanding. However, local variations and differences exist by necessity, due to the continuous replacement of equipment. For a few units, the experimental infrastructure was not of an international standard, affecting the quality of the research conducted.

In general, the panel would encourage increased collaboration on the use of large experimental facilities that cannot be duplicated at many research units. Except for local collaborations arising from geographical proximity, the panel found very few examples of collaboration on large and expensive infrastructure, which would be valuable for the research of different research groups. Ensuring collaboration on and access to infrastructures of a national character is important in order to define a cost-effective research system that allows for high-quality research at the different Finnish universities. The panel recommends that a long-term plan be developed in order to maintain the high quality of the research infrastructures.

In terms of technical support, the different units seem in general to have sufficient access to high-quality technical staff, either within the units themselves, or as part of departmental or faculty-level technical support units.

In terms of administrative infrastructure, the landscape is much more varied. Whereas some units seem to have sufficient administrative support, in others much administrative work ends up with the professor of the unit. Part of the reason for these differences can probably be traced to the small amount of administrative support in general, often consisting of 1–2 persons who therefore have to have a very broad competence in budgeting, project management and teaching administration. Many groups complained of the increasing burden of bureaucracy, demanding time that would be better spent on research. The panel is of the opinion that for the smaller units, larger administrative units supporting several research groups may, if they remain service-oriented, be a more efficient way of providing necessary administrative support.

Recommendations:

1. Develop a long-term strategy for maintaining and further improving infrastructures.
2. Consider measures for increased collaboration on the use of advanced instrumentation.

2.5 Relevance to society and to the field of chemistry

Overall, Finnish chemistry research is very relevant to the needs of society. The needs of industry and society, especially environmental concerns, have often guided the units' choice of research area. The units produce candidates of relevance to industry and society at large in sufficient amounts and with the right competence. There are, however, some concerns regarding the age of the candidates graduating.

With Finland's strong tradition as a pulp and paper nation, it is not surprising that wood-related chemistry, engineering and biotechnology are present at several of the evaluated units, and that a number of units do very good research of relevance to this important industry sector. However, for the panel, it is not obvious whether all "wood" units have as unique a profile as they are stating. The panel therefore strongly encourages collaborative efforts towards increased cooperation, visibility and efficiency.

Other activities relate instead to materials chemistry and to the pharmaceutical industry.

The panel is somewhat concerned about the funding situation for basic, long-term chemistry research. It is important that core competency in chemistry-related disciplines be maintained at a sufficiently high level and given room to focus on method development rather than on solving a specific problem using existing methodology. Generic methodologies are often applicable in a number of different areas and for different industrial problems, but require long-term and stable funding and expert knowledge in specialised fields. The panel is particularly concerned about the fields of physical chemistry and analytical chemistry, including electrochemistry, where the majority of the activity seems to be directed towards the application of methods rather than the development of new methodology.

Recommendations:

1. Develop funding programmes that support fundamental methodology-oriented research.
2. Develop funding programmes for supporting industry-related research with a longer time frame.
3. Evaluate the national strategy and division of labour between the research units working on wood- and pulp-related research.

2.6 PhD training

In general, PhD completion times in the evaluated units are too long, being on average 5–6 years, with an age of graduation of approximately 32–33 years. Partly, this seems to be due to a historically rather large teaching obligation for PhD students, as well as to the fact that the students need to work also outside the university in order

to provide the necessary income for their daily subsistence. The percentage of students that leave their PhD studies prior to graduation also seems too high, possibly due to a lack of funding, arising partly from too long PhD studies and partly from the fact that research project funding periods do not match the time needed for study completion. It is unfortunate that the amount of teaching PhD students need to do depends on the funding source. The panel recommends that all PhD students be given an equal, but limited, teaching obligation, possibly financed as an additional contribution on top of the research grant (without increasing the total time of the PhD studies significantly).

The panel is of the opinion that the level of supervision of PhD students has been too low. In recent years, some units have been able to reduce the average PhD completion time to four years by closely following up the scientific progress of the students. The many different graduate schools have led to an increased awareness of scientific supervision and the time needed to complete the PhD studies.

More attention needs to be paid to PhD training, and it should be a clearly expressed goal that a PhD degree should be obtained in four years of study, including a limited amount of teaching, and that the students should graduate at or before the age of 30 (assuming that they have otherwise had a normal study progression). It is important that the different units recognise the importance of and implement regular supervision of PhD students. The graduate schools are an important means of ensuring high-quality and good progression, in addition to leading to increased national research collaboration. The graduate school system should therefore be continued and strengthened. Research units not participating in national graduate schools should consider establishing local graduate schools.

There is a need to increase interaction and awareness regarding the quality and relevance of PhD training programmes. This includes systematic follow-up of PhD graduates in terms of their employment to ensure that the graduate training programme meets the needs of both society and academia. It is also important to follow up PhD students who do not complete their studies in order to identify bottlenecks in the PhD training.

PhD students should be encouraged to visit international research groups during their PhD studies. This is particularly important for PhD students not participating in national graduate schools, where national mobility is a central element. In general, the panel believes that the national graduate schools should encourage both increased international mobility and mobility between the participating research units.

Recommendations:

1. Reduce the average PhD completion time to four years.
2. Reduce the number of PhD students not completing their PhD studies by providing a more secure funding scheme for research projects involving PhD students.
3. Improve the quality of PhD training and supervision, for example through an increased use of local and national graduate school programmes.
4. Implement a nationwide standard for PhD students' teaching duties that does not depend on the PhD students' source of funding.
5. Evaluate the relevance of PhD training programmes to the needs of society.

2.7 Internationalisation

A majority of the evaluated units are publishing actively or very actively in international journals and are encouraging PhD students to participate in international congresses. Nevertheless, the international visibility of Finnish chemistry research is low and does not reflect all topical and geographical facets. In general, the amount of international exchange is too low, with little mobility among PhD students and postdoctoral students both leaving and coming to Finnish research groups. However, there is a great deal of variation between units. Some units have very active visitor programmes and clear strategies for sending local students abroad, whereas other units hardly display any international collaboration or exchange, except through participation in international conferences.

Activities towards recruiting international postdoctoral researchers to Finland on 1–2 year contracts and activities aiming at sending a higher proportion of Finnish chemistry PhDs abroad for funded postdoctoral studies would rapidly promote chemistry research in Finland internationally. In a longer perspective, researchers returning with postdoctoral experiences and international contacts will be able to find new directions more efficiently and address future chemical challenges more productively.

The funding opportunities offered by the EU Framework Programmes seem to be underutilised. Considering the high international standards of some of the evaluated units, they should utilise the 'People' Specific Programme to secure additional funding and increased international collaboration.

A particular concern is the rather strong inbreeding tendencies observed in many units, in combination with the lack of clear incentives for PhD students and postdoctoral researchers to go abroad as part of their training. The long-term viability of some research groups is in jeopardy due to a lack of fresh ideas and new approaches entering the local research unit. This effect is further enhanced by the common practice of hiring local students to combined lecturer/researcher positions. The unit leaders need to be more actively engaged in career planning for staff members having completed their first postdoctoral period, to avoid too long periods of employment on temporary and uncertain external funding, in particular when there are few opportunities for obtaining permanent employment.

There are opportunities for permanent faculty members to take sabbaticals. Whereas some groups do take advantage of this programme, there is probably much more potential, and measures should be implemented to encourage an increased use of sabbaticals as a means of increased internationalisation. The dependency of some units on a single professor is in many cases preventing a more active use of sabbaticals.

The units consider the Academy Professorships awarded by the Academy of Finland to be highly prestigious awards confirming the high quality of the research being performed in the unit. Research posts as Academy Professor allow researchers to focus on their research for a period of up to five years, which is very beneficial for the recipients. In some cases, this may also provide opportunities for junior faculty members to take on more responsibility within the unit and to engage in independent research. The panel recognises the prestige of the Academy Professor funding, but would like to question whether the unit as a whole would not benefit more from using some of this funding to provide external stimulus in the form of incoming

visitors, in particular in view of the general low level of international collaboration in Finnish chemistry research.

Recommendations:

1. Enhance the mobility of PhD students during their PhD studies.
2. Increase the recruitment of foreign postdoctoral researchers and encourage Finnish PhD students to travel abroad.
3. Increase Finnish participation in EU research programmes.
4. Increase the number of faculty members with a degree from a different university (Finnish or international) than their permanent employer.

2.8 Recommendations to the Academy of Finland

There is an overall satisfaction with the funding provided by the Academy of Finland, as it is the only generally available source of funding for basic research. The panel supports the competition-based research funding policy currently used by the Academy, a strategy that clearly has led to a rather high number of world-leading research groups for a country of Finland's size.

The panel has no indications that the Academy's evaluation processes do not meet high quality standards or ensure that the best project applications are selected for funding. However, there seems to be some uncertainty in the research communities on the evaluation processes and on whether factors not communicated influence the decision processes. In general, the Academy needs to be more open and transparent in its handling of applications, evaluations and funding decisions, and all criteria that are applied in the evaluation process must be clearly stated in the documents for an open call for proposals. Included in this documentation should also be information on at what stage in an evaluation procedure certain evaluation criteria are being considered, if these differ.

For research projects that involve training of PhD students, the project period open for application should match the time required to complete a PhD degree, to avoid financial uncertainty during the PhD studies and to reduce the number of students not completing their degree due to a lack of funding.

It is important that the Academy of Finland maintain its focus on funding basic research at a high international level, and that the majority of its portfolio is kept for basic research without the need for industrial collaborations or immediate societal relevance.

Considering the importance of securing external funding for maintaining a research activity in a research group (since this is in principle not secured by university funding in some cases), it is important that newly hired faculty members have the opportunity to secure funding for their new research activity. The panel thus suggests the establishment of a national, competitive funding opportunity for young faculty members, for example modelled on the European Research Council (ERC) Starting Grants or the European Science Foundation (ESF) European Young Investigator Awards, but at a national level. An alternative or complementary approach would be for the Academy to fund ERC Starting Grant applications that are recommended for funding but not supported by the ERC due to limited budget resources.

Considering the low level of mobility in many units, both nationally and internationally, a time-limited funding instrument for increased international collaborative exchanges should be considered. This instrument should not focus on funding people, but rather the additional expenses incurred by mobility, and should help raise the international awareness of high-quality Finnish chemistry research and increase Finnish awareness of relevant international research groups. The goal should be to increase Finnish participation in the many available international mobility instruments.

2.9 Recommendations to the Ministry of Education, Science and Culture

With the increased interest in research directions such as nanotechnology and biotechnology, as well as the continued importance of the wood and pulp industry and the materials and pharmaceutical chemistry, chemistry is a strategically important research discipline for any university, and for Finland as a whole. Research-based training is also important to a modern, technology-driven society, and one of the most important assets of basic research at universities is the students they educate and train in curiosity-driven research. The ability to question new observations based on a solid understanding of basic chemistry and physics is essential in order to further society in terms of solving societal problems and creating new industry.

It is important that universities are given sufficient funding to be able to maintain their competence through infrastructures of high international standards and to allow them to maintain their current staff levels. The competitive nature of the Finnish funding system may potentially lead to missed opportunities, which is why the Ministry of Education, Science and Culture should consider increasing the budget of the chemistry departments. This would allow all education to be research-based by providing faculty members a right and obligation to do research, as well as a minimum funding for daily consumables necessary in an experiment-oriented activity such as chemistry. Such an increased level of funding should not come at the expense of the competitive external funding and should not lead to staff increases.

The need to support local chemistry research has dispersed chemistry research across many Finnish universities. This is a challenge for a field of research that requires good and expensive infrastructures and a minimum size in order to produce research at an international level. Not considering chemistry-related units outside this evaluation, the panel in particular finds that the chemistry units at the University of Eastern Finland, the University of Oulu and Tampere University of Technology are of subcritical size. These universities, in a dialogue with the Ministry, should consider the local needs for chemistry research and education, and take measures to ensure that the important core activities are maintained at a viable level, possibly at the expense of a broad chemistry profile.

For these universities, as well as for selected units at some of the other Finnish universities, it should be considered whether a merger of small subcritical units into larger and sustainable units should be encouraged. It is, however, important that clear research strategies and focus areas be developed for these research units to avoid a merger in name only. The merger should lead to research that is competitive at an international level by having the necessary broadness in expertise relevant for the strategic focus of the units.

3 Evaluation of the major chemical subdisciplines in Finland

3.1 Analytical chemistry

Analytical chemistry comprises a wide set of concepts and methods useful in various areas of science, pharmacy and medicine. Analytical chemistry is present at the different Finnish universities and research centres either as a separate unit or as part of a unit also connected to other chemical disciplines.

The development of analytical tools by the different units is most generally directed to environmental and bioanalytical issues. Analytical chemistry also directly supports research in inorganic chemistry, applied chemistry, materials chemistry and pharmaceutical chemistry. Moreover, the research in the field is in some cases motivated by the needs of specific industries, in particular the wood industry.

The most active research directions pursued by the analytical chemistry groups are focused on the development of separation techniques, in particular chromatographic, electrophoretic and mass spectrometric methods, the development of sensing devices, and sample preparation for organic and inorganic trace analysis. In addition to more traditional approaches, some units also have research activities within the field of nanoscience.

Due to its great diversity and close interaction with many other scientific disciplines, analytical chemistry is, in most countries, only partially covered and rather dispersed among universities and research institutes. Expertise in a wide range of spectroscopic techniques, thermal and surface analysis as well as microscopy methods can be found within various chemical departments in the Finnish universities or research centres.

The research quality and its international impact vary among the evaluated units. The most active analytical chemistry units should continue to perform good and innovative research in order to attract a large number of students who will readily find employment and fulfil the needs of society.

The panel finds that a closer collaboration between the many different small research groups dealing with inorganic trace analysis would be beneficial.

Research mobility, both inward and outward, has to be encouraged for all units.

Overall, the experimental infrastructures and equipment are very good and should at least be kept at the current level by providing sufficient funding to develop, update and replace the instrumentation in the future.

3.2 Chemical engineering

Chemical engineering is seen as an engineering science, interacting with chemistry but not being an integrated part of chemistry research. Only two groups under the label "chemical engineering" were visited by the evaluation panel (AU, PCC at ÅA), whereas some other groups were mentioned and evaluated based on written reports

only (LUT, UO). Some groups were not evaluated because they had been considered as parts of other fields (in particular environmental or energy research). It is therefore difficult to form an opinion on the overall qualities and scope of chemical engineering research in Finland.

The panel is of the opinion that there is, to some degree, a lack of interaction between chemistry and chemical engineering, and that most of the chemical engineering groups seem to be too isolated. There is a clear need for better nationwide collaboration between Finnish chemical engineering units. Cooperation between chemical engineering units and chemistry (or environmental or energy engineering) units would also be beneficial. Such collaborations do exist in some places (PCC at ÅA, the grouping of different units in a separate science centre at LUT), but not in all places (AU, UO). A recurring theme appearing in a number of chemistry units is biorefinery, either wood-based (in almost all units) or non-wood-based (UO). The rational design of biorefineries is a seminal example of a field in which cooperation between chemistry and chemical engineering would be beneficial.

3.3 Industrial chemistry

Industrial chemistry is not defined by its scientific content, but by its applications. Its limits are therefore difficult to define, and most of the units included in this evaluation are more or less "industrial chemistry" units. Many of the units have relevant industry funding or funding from Tekes and carry out good applied research (in the case of VTT, this is the core activity) along with fundamental research. One surprising observation to the panel was that collaborations between "industrial chemistry" and "chemical engineering" do not seem to be frequent, except in the case of the Process Chemistry Centre (PCC) of Åbo Akademi University (ÅA) and in particular the Industrial Chemistry and Chemical Engineering unit.

A closer examination of the groups having "industrial" or "applied" chemistry in their names reveals that these groups investigate either applied catalysis (AU) or wood chemistry (UJ). VTT is of course a special unit in this respect, since its primary aim is industrial applications, trying to encompass all fields of applied chemistry.

With Finland's strong tradition as a pulp and paper nation, it is not surprising that wood-related chemistry, engineering and biotechnology are present at several of the evaluated units. For the panel, it is not obvious whether all "wood" units have as unique a profile as they are stating. The panel therefore strongly encourages collaborative efforts towards increased cooperation, visibility and efficiency. Some competition between the larger units in this field (Forest Chemistry at AU, PCC at ÅA) is unavoidable and even healthy, but the panel recommends a nationwide organisation of the research in the field for all of the other smaller units (e.g. Applied Chemistry at UJ).

A number of units advocate the concept of "biorefinery", be it for wood (in most cases) or other bioproducts. However, a general overview of the different parts of such biorefineries and a life-cycle analysis of such processes are still missing. Finland (along with Canada) is certainly one of the most advanced countries in this field, and it would be timely for the relevant research units to join forces and provide state-of-the-art activity in this interdisciplinary field.

Applied catalysis is present in a number of units (in particular in Industrial Chemistry at AU, Inorganic Chemistry at UH, Organic Chemistry at UJ, Organic

Chemistry at UO, Materials Chemistry at UTU, Industrial Chemistry and Reaction Engineering at ÅA), and, indeed, one of the last EUROPACAT meetings, the premier European catalysis conference, was organised by a group from ÅA. However, there does not seem to be much contact between these teams, nor with the chemical engineering groups. The ÅA unit Industrial Chemistry and Reaction Engineering covers the whole field from catalysis to catalytic engineering, and might be a nucleus for a collaborative effort in Finland in this field.

3.4 Inorganic chemistry, materials chemistry and radiochemistry

The role of chemistry in understanding, transforming and utilising matter leads inorganic chemistry to contribute to an ever widening variety of fields from, for example, the role of metals in enzymes and organic transformations, through the traditional study of the chemistry of the elements, to the increasingly important synthesis of new functional materials. The seven units that come under the headings of inorganic chemistry, materials chemistry and radiochemistry have focused their efforts strategically on particular fields under this broad umbrella.

The quality of the research is overall excellent, with some groups demonstrating significant international impact. The necessary synthetic skills are very strong. The development of atomic layer deposition (ALD) in Finland has given inorganic research a boost, which has been exploited both in fundamental research and in collaboration with industry. The area of nanoparticles and their functionality is of increasing interest. Molecular inorganic chemistry is of excellent quality, but the efforts are more dispersed and a coherent national strategy is needed to strengthen this key area. Though the fundamental nature of the research is apparent, there is a strong desire to make the outcomes relevant to a broad range of environmental concerns.

The wide range of research areas needs to be sustained by a variety of expensive instrumentation. Most units were very satisfied with the facilities available to them. In the molecular field, instrumentation was largely shared with organic groups in a cooperative manner. The shared facilities for material characterisation at ÅA and UTU have been particularly successful. Nevertheless, there is widespread concern as to whether future funding levels can maintain the quality of vital instrumentation.

The experimental research is complemented throughout by computational and modelling work. This is either carried out within the groups or by collaboration with dedicated theoretical groups. The predicted relation of structure and function is of considerable value in guiding synthesis.

In general, the quality of the research in these areas is of a very high standard and the current directions should continue to be pursued. The formation of a national collaboration coordinating the inorganic and materials contribution to energy research is a desirable future direction.

3.5 Organic chemistry

All universities in the evaluation are pursuing research and teaching in the field of organic chemistry. This is very valuable, since organic chemistry has a key role in chemical and molecular sciences. Although not all universities have a separate

laboratory or other organisational unit, the subfield contributes to both educational programmes and the overall external funding of universities.

The level of instrumentation for organic chemistry research is at present good or very good, with all evaluated units having access to suitable major instruments, for example modern or quite modern nuclear magnetic resonance (NMR) spectrometers, in addition to less expensive equipment. There is a concern that not enough funding will be present in the future for maintaining and possibly also further improving the current level of instrumental infrastructures, which is essential in order to keep up with the international competition. The panel recommends that researchers, universities and funding agencies jointly develop sustainable strategies for both major and minor instrument maintenance and investments.

Several research units or subunits are applying organic chemistry methods to certain groups of starting materials, and polymer and non-polymer wood origins are not uncommon. A common objective is to produce fine chemicals of interest to bioscience applications or to obtain knowledge of macromolecular structure. This general area of research has a long and successful tradition, and the research quality spans from excellent to acceptable. Wood-related chemistry with strong organic components is abundant in Finland, and the panel recommends that the actors strategically consider whether all current wood chemistry is correctly placed.

The units' activities aiming at the determination of functional properties of other molecular, biomolecular and supramolecular systems using advanced spectroscopic, spectrometric and crystallographic methods are strong. The quality of these activities is excellent or outstanding particularly at units with high competence in both organic synthesis and advanced characterisation techniques.

Fundamental methods development and synthetic organic chemistry – the platform for all applications – are present but not equally strong at the evaluated units. Although the panel recognises that the active and mutually beneficial collaborations between the research units and chemical companies explain the focus on applied rather than basic research, this is a field that needs to become more proactive.

From an international perspective, several units are performing excellently but on too small total budgets. The panel recommends that activities in both fundamental and applied organic chemistry be strengthened at these units.

Some of the cross-disciplinary applied research at the evaluated units has international visibility, as has the highly fundamental research in methods development and new trends in catalysis. A common denominator for these units is a regular presence of international postdoctoral researchers, active for 1–2-year periods each and with worldwide recruitment.

3.6 Polymers and other organic materials

Polymer chemistry has a long tradition in Finland and many of the evaluated units work to some extent in this subfield of chemistry. The influence of wood as a very common raw material is seen in many research projects where biopolymers such as lignin and cellulose are starting materials for chemical transformations and structural elucidations. Such activities are ongoing not only within dedicated polymer units but also at organic, biotechnological or engineering laboratories. It is not evident to the panel if all activities are ideally placed.

Strong and active collaborations between the polymer units and chemical companies are beneficial and explain the focus on applied rather than basic research. On the other hand, there is some lack of real basic research on biopolymers, which should be remedied. The panel recommends more activities towards raw materials as energy sources, possibly in the field of biofuels.

The traditional petroleum-based synthesis of polymers, which is very common in other EU countries, is a rather small activity in Finland. The units should consider strengthening efforts towards basic research on catalysis and new processes on polymer production. The investigation of material properties of polymers is historically strong in Finland, and more recent endeavours into amphiphilic polymers, polyelectrolytes, nanocomposites and other smart materials offer promising prospects. The panel recommends activities also towards conducting polymers.

Overall, polymer chemistry in the widest sense is a strong research subfield in Finland and contributes considerably to the external funding of the units working in this area and to active and vital collaborations with industry on more applied research projects. However, basic research on important topics such as catalysis and polymer synthesis is less visible. The panel recommends that a clear strategy be developed concerning the chemistry research on wood-based biopolymers, relating to the future directions of the wood industry in Finland. If the wood industry continues to be an important supplier of raw materials, research on biofuels production would be an attractive topic. Regardless of the future strategies of the paper and pulp industry in Finland, polymer research activities towards petroleum-based polymers should be enhanced.

3.7 Physical chemistry

In its contemporary definition, physical chemistry is the application of the laws, principles and experimental techniques of physics to chemical problems. Physical chemistry thus covers an extremely wide range of topics and overlaps strongly with modern nanoscience and molecular physics. In the present evaluation of Finnish chemistry, the panel has evaluated physical chemistry topics ranging from relativistic theoretical chemistry and quantum simulations of liquids to the chemistry of printing and wood. Thus, physical chemistry encompasses everything from the study of a single isolated molecule to the complex macromolecular interactions taking place in the extraction and refining of biomaterials from wood materials. As theoretical chemistry in Finland is described separately, we will here focus on experimental physical chemistry in Finland.

Physical chemistry in Finland is in general at a very high scientific level, in particular as regards the groups working in high-resolution and ultrafast spectroscopy. In addition, there are smaller activities with a strong local expertise or unique instruments. There are also singular examples of research activities at an unacceptable level.

The majority of the units reporting physical chemistry as a key component in their research activities are working in wood chemistry, polymer chemistry, printing chemistry, radiochemistry, etc. They are thus primarily working with the tools of physical chemistry, and are not directly engaged in developing new tools and techniques.

Experimental physical chemistry is generally demanding in terms of both resources and infrastructure, and, consequently, high-profile activities are less

frequently encountered in smaller research environments. At the same time, physical chemistry is also, through links to nanoscience and physics, often responsible for introducing new experimental techniques and analytical tools in chemistry. The panel is concerned that experimental activities in physical chemistry in Finland are becoming too weak. It is important that key competencies in experimental physical chemistry (electrochemistry, spectroscopy, etc.) be maintained and developed. The panel recommends that fundamental methodology-oriented research in experimental physical chemistry be strengthened.

3.8 Theoretical chemistry

The field of theoretical and computational chemistry is strongly represented in Finland, with activity at almost all of the universities participating in the evaluation. In the units specialised in theoretical and computational chemistry, the research is of a high international standard, and in a few cases at an internationally leading level. A strength of the theoretical and computational chemistry community in Finland is that it covers all scales of simulations, from high-level quantum ab initio theory to coarse-graining methods in the domain of molecule-based methods.

Compared to the other Nordic countries, method development has a less prominent role in theoretical chemistry in Finland. Instead, the focus is more on the use of state-of-the-art methodology in an innovative manner. The panel supports this research profile as it allows for strong and fruitful collaboration between theoretical and experimental research groups.

There seems to be a high degree of collaboration between the different theoretical chemistry groups, to some extent supported through the Laskemo Graduate School of Computational Chemistry and Molecular Spectroscopy. The panel strongly supports this activity.

Many experimentally oriented research groups have in recent years become increasingly active in computational chemistry, using theoretical methods to shed new light on their experiment-driven problems. The panel sees that such modelling will become an integrated part of the research portfolio of most experimental units in the future, and thus recommends that computational chemistry be one of the techniques to be used in most research groups. However, it is important for Finland that experimental chemistry be maintained at a high international level. The panel is concerned about the observations that some experimental scientists appear to be moving a large part or all of their research activity into computational chemistry, as this does not seem to be the right strategy in order to produce science of a high international standard.

The panel finds that the current level of computational chemistry in the experimental research groups is of acceptable to good scientific quality, but not of a high international standard. To ensure a sufficiently high scientific level for these new activities, the panel feels that it is important that the experimental groups create strategic alliances with the many dedicated theory groups in Finland or abroad, for example with jointly supervised PhD students. An active recruitment policy to attract leading computational chemists with interests in the interface between theoretical and experimental chemistry, still with a scientifically independent theory profile, will also be important in this process.

4 Unit evaluations

4.1 Aalto University, Analytical Chemistry

Overview

The unit is composed of one professor, one senior lecturer and three PhD students. No technical or administrative personnel are attached to the unit. During the period of evaluation (2005–2009), four Master's theses were produced and two doctorate degrees were completed. About three quarters of the unit's budget comes from core funding and the rest from the Academy of Finland and a graduate school.

Research profile

The research of the unit is focused on the field of luminescence (photoluminescence, chemiluminescence, electrochemiluminescence). The unit's activities also include combining the ongoing research with fabrication methods and devices in collaboration with external partners (integrated electrode chips, printed electrodes, etc.).

Research quality

During the period of evaluation the team produced 26 papers and four granted patents, with little publication activity in the most recent years. The publications have mostly been published in good international analytical and electrochemical journals. The research is essentially limited to luminescence techniques and more particularly to hot electron chemiluminescence (HECL). The hot electron electrochemistry research performed by the unit is a controversial topic and its main activities date back more than a decade. The impact of the group's results is very limited. The university owns the IPR in work within the development of methods and devices, and the technology has been transferred to small Finnish companies.

Research environment

The research environment is poor. The instruments are mostly donations from industry. Only equipment for luminescence and electroluminescence is available for research activities. The size of the group is small and the senior staff are occupied full-time with teaching and administrative tasks. No technical support is available within the unit. The unit has initiated the creation of the National Graduate School of Chemical Sensors and Microanalytical Systems (CHEMSEM) and is still active within this structure.

Research networking and interaction

National research collaboration with university groups is only through the Graduate School CHEMSEM. There is no collaboration mentioned with the electrochemistry group at AU. Recent work on electroluminescent metal nanoclusters has been performed in collaboration with Swiss partners. The unit has contacts with Finnish companies for the development of analytical methods and the follow-up of technology after patent transfer from the university to the company.

Recommendations

The evaluation panel recommends that the research strategy of the unit be completely reworked. In its present form, the unit is too small and the equipment outdated, and the unit's research focus is too narrow and also controversial. Consequently, the level of research in the unit is too low, both quantitatively and qualitatively. Analytical chemistry is a very wide and open field that requires constant attention to the research strategy. The panel recommends that the unit become more proactive and ambitious in the development of new topics other than HECL. As part of the new strategy, the panel strongly recommends that the unit to a much larger extent initiate collaborations with other research groups in Finland and abroad to search for new and more fruitful research directions.

From the discussions with the unit, the panel is uncertain to what extent the unit will be able to revitalise its research activity, in particular considering the amount of teaching offered by the unit, which severely limits the research activities. The university needs to either strengthen the group with a new professor with a strong international research record, or direct the activity of the group exclusively towards teaching activities.

4.2 Aalto University, Chemical Engineering

Overview

The unit comprises (average values during the evaluation period) one professor, one senior researcher, four postdoctoral researchers or teaching assistants, 14 PhD students, two research engineers, one laboratory manager and one secretary. It should be noted that the unit changed its director in 2008, and that the majority of its members are below the age of 40. About one-third of the funding resources was core funding, the rest being essentially direct industry and Tekes funding.

Research and education

The research field is at the borderline of the scope of this chemistry evaluation, since the research done by this team clearly belongs to mainstream chemical engineering, not to the field of chemistry.

In educating engineers in the field of process industries, a good education in chemical engineering is a necessity. Such an education has to be based on a research team in the field of chemical engineering. This relatively small chemical engineering unit fills this position, and thus provides an important educational activity.

The research topics tackled are quite diverse, even if the methodology underlying the many different research directions is quite coherent. The subjects range from the measurement and modelling of thermodynamic vapour-liquid equilibria to the fundamental investigation of trickle-bed reactors, gas-liquid stirred tank reactors, adsorption processes, microdistillation, chlorine dioxide bleaching of pulp, and the modelling of pulping.

Research quality

It is difficult to judge the strategy of the unit, since it is mainly doing methodology-oriented research. VLE (Vapour-Liquid Environment) is ongoing work and is providing original experimental data that are needed in applications of chemical

engineering. The other application fields investigated look more opportunity-driven (involving a lot of industrial contacts) than strategically thought out, even if the team takes care to conduct mainly methodological research.

The time spent on completing PhD theses used to be rather long, but has in recent years been reduced to satisfactory length.

The quality of the research is good. The publication output is at an appropriate level, and the articles are published in good chemical engineering journals.

Research environment

The infrastructure corresponds to the research strategy of the unit (small equipment, no chemical reaction investigations). The discrepancy between two-year project funding and the duration of a PhD thesis is seen as problematic.

Research networking and interaction

The national industrial contacts are adequate, as are the relations with the other chemical engineering teams in Finland. International relations are almost nonexistent.

Recommendations

The lab is very weak on international collaborations; this should be corrected. The unit does not yet take enough advantage of the structure of the Department of Biotechnology and Chemical Technology to develop mutually profitable collaborations.

The range of research topics studied is quite wide. However, scientific supervision is provided by only one professor and two postdoctoral researchers. It might be advisable either to somewhat restrict the number of subjects or to try to recruit an additional senior research scientist.

4.3 Aalto University, Industrial Chemistry

Overview

The unit is moderately sized, consisting of about 20 persons, including one full-time professor, one half-time professor and five postdoctoral researchers. More than half of the funding is external and comes, in order of importance, from Tekes, the EU, industry, the Academy of Finland and graduate schools. On average, two PhD students and five Master's students graduate each year.

Research profile

The research is focused on catalytic processes and in particular on the understanding of reaction selectivity and catalyst stability via evaluation of catalyst performance, catalyst characterisation and kinetic modelling. The main topics that have been pursued are the understanding of the role of sulfur in hydrodeoxygenation (HDO) reactions, the development of non-sulfide catalysts for HDO reactions, the development of noble metal catalysts for auto-thermal reforming of diesel fuel, new biocomponents from glycerol for gasoline blends, and the characterisation of porous catalysts based on kinetic modelling of TPD (temperature-programmed desorption).

Research quality

The group does excellent experimental research and is well recognised within the international heterogeneous catalysis community. The group has a clear research strategy and all aspects are well integrated. The group's results are published in high-ranked journals in the field. The research impact is evidenced by invited presentations at scientific conferences and by memberships in editorial boards of scientific journals and international scientific boards.

Research environment

The group acts as an integrated unit. The research environment is excellent. The equipment for high-quality catalytic research (bath and continuous flow reactors, various catalyst and chemical characterisation methods as well as analysis equipments) is available within the unit. By participating in the Center for New Materials at AU, the unit also has access to an equipment pool including microscopes. The research environment is attracting international postdoctoral researchers and local graduate students that are trained within a graduate school. The teaching and research tasks are distributed among all members of the group.

Research networking and interaction

There is very good networking activity considering the size of the group. The unit has close cooperation with industry and much active collaboration with VTT and Finnish as well as foreign universities. The unit is a partner in several EU projects, including the network of excellence IDECAT (Integrated Design For Catalytic Nanomaterials), which has been transformed into ERIC (European Research Institute on Catalysis), and the EU-China Cooperation for Liquid Fuels from Biomass Pyrolysis (ECOFUEL), Marie-Curie IRSES (International Research Staff Exchange Scheme, FP7). Networking is also provided through the unit's participation in a graduate school.

Recommendations

The group should maintain its research strategy and keep the balance between fundamental and applied research. The panel agrees with the concerns expressed by the unit regarding the possible threats from a future decrease in external funding. External funding is in general quite fragmented and limited to short periods. This has negative implications on the implementation of long-term basic research and on the career development of researchers. The unit should continue to be active in funding and networking at the EU level. However, the mobility of researchers has to be encouraged. Mobility is still limited, despite the good networking: a very high proportion of the senior staff members were educated within the unit. Stronger collaboration with AU chemical engineering and other units is also encouraged. For the long-term viability of the unit, especially considering the upcoming retirement of the unit head, the panel recommends that AU soon initiate the recruitment of a professor using an international open call.

4.4 Aalto University, Forest Technology

Overview

This is a large department (more than 150 people, budget more than €10m), but the present evaluation concerns only the chemistry part of the department. The average values over the reference period are: three professors, four senior researchers, one postdoctoral researcher and 24 PhD students. A steady growth can be seen during the period: in 2009, more than 60 people belong to the chemistry part of the department, among them four professors, eight other senior or postdoctoral researchers and 25 PhD students. Roughly one-fifth of the total funding was core funding, the main external resources coming from Tekes and industry (30–40% each). There has been a steady increase of global funding, which is mainly thanks to an increase in Tekes funding (more than 50% of the budget in 2009).

Research and education

Some years ago, the research was mainly targeted at forest industry and at pulp and paper. The research later expanded to all possible uses of biomass, in an attempt to get the most value out of the biomass and view the whole value chain. In parallel, the modification of the Master's programme from "Forest Products" to "Bioproducts" led to a marked increase in the quality of the students applying.

The research is structured around a number of subtopics (biorefineries, new materials, fibre/paper products, fibre/wood products, environmental management).

Research quality

The quality of the work is excellent in all of the different teams, which seem to be quite independent but cooperative, each team having one or two senior researchers. The number of high-quality senior researchers the unit has managed to attract, also at the professorial level, is impressive, and the PhD group is also international, and, judged by the nature of the subjects treated, interdisciplinary as well. The publication output is very good, and it is evident that there is top-quality management, leading to a lively interdisciplinary and international exchange of ideas and good practices.

In the chemistry of forest products, this is certainly an international-level, top-quality unit.

Research environment

The infrastructure is very good, especially considering the whole Otaniemi site, with VTT nearby. The discrepancy between two-year project funding and the duration of a PhD thesis is problematic, as noted in almost all units.

Research networking and interaction

The national industrial contacts are very good. The international mobility is exemplary, both as regards the people from other countries choosing to work in this lab, and the people from the lab spending time abroad.

Recommendations

The group should maintain its strategy, which results in extensive research of a very high quality.

The name of the group does not do justice to the depth and breadth of its research work. The group's international mobility (in both directions) is an example for other chemistry labs in Finland.

4.5 Aalto University, Inorganic Chemistry

Overview

The unit's average personnel over the review period was 1–1.5 professors, two postdoctoral researchers and seven PhD students. The unit has changed its head during the review period and recently expanded the number of PhD students to more than ten. The unit's core funding accounts for 62 per cent of the total funding and its external funding comes from the Academy of Finland, Tekes and industry.

Research profile

In line with the strategy of AU, the unit's own overall strategy is to improve and increase the efficiency and environmental sustainability of processes using natural resources and products using new materials. The unit's projects relate to the modern areas of sustainable energy technologies, new materials and nanotechnology. The tools are principally tailored oxide synthesis combined with atomic layer deposition (ALD). The group is among the pioneers in this field. The unit also aims at advances in basic and applied science and at the education of young scientists in new materials research.

The group is small but productive and tackles problems in a number of significant areas. The research covers both the basic science of inorganic materials and the development of new technological useful materials. ALD is used for the formation of complex oxide films on a variety of substrates. New oxides are synthesised with potential applications in superconductivity, thermoelectrics, electrodes for fuel cells and batteries, oxygen separation and storage and spintronics. A recent new development is the use of ultra-high pressure in ALD processing.

Research quality

The research is of high quality and internationally leading. The use of ALD for tailored synthesis of ternary oxide layered materials is innovative, as is the development of these techniques for organic polymers and hybrids. The publication rates are impressive for the group's size and most publications are in top journals. The research impact is evidenced by the number of requests for collaboration received from industry.

Research environment

The research environment is excellent. The essential equipment is available in-house and collaboration gives access to some additional measurement techniques like SEM and TEM (scanning/transmission electron microscopy). There is a sufficient number of good graduate students wanting to join the group. The group is possibly undersized and would benefit from additional senior research staff who would also

assist with the supervision of research students, since the lecturers almost exclusively do teaching. The unit could possibly benefit from more technical support.

Research networking and interaction

The unit's collaborations are exceptionally strong. The exchange of personnel with Japan is very active. The unit cooperates with the ALD group at UH. There is extensive collaboration with industry, in part embodied by the presence of a part-time professor with extensive industrial experience. The expertise of the group is sought by a number of industrial companies and has resulted in a number of patents. The different collaborations have not led to a very large number of incoming visiting students to the unit.

Recommendations

The group should maintain its direction and level of achievement, which is impressive in such an important and challenging area. In time, a strategy should be evolved for moving into new related areas. The group could possibly benefit from interaction with the theory group of the Physics Department at AU and from a strengthening of the collaboration with the electrochemistry group. The group should try to increase the number of visiting postgraduate students. The panel recommends that AU consider strengthening the group's activity through additional faculty members as part of its general emphasis on materials science.

4.6 Aalto University, Organic Chemistry

Overview

The Laboratory of Organic Chemistry is part of the Faculty of Chemistry and Materials Science at AU School of Science and Technology. During the evaluation period, the unit had on average two professors on a full-time equivalent (FTE) basis and about six FTE other senior researchers, with more than ten individuals as international postdoctoral research fellows for 1–2 years each counted in this category. In addition, 15 FTE PhD students (quite constant number of students) have been active in the unit. The total average active research staff amounts to 23 FTE. Funding was with a near 1:1 proportion of core to external funding, with almost equal contributions from the Academy of Finland and Tekes and industry. The unit participates in national graduate schools. During the evaluation period, examinations of MScs were at 5.4 a year and PhDs at 1.6 a year. PhD students are typically engaged in undergraduate teaching to approximately 10 per cent. The research staff FTE figure was higher at the beginning of the evaluated period than at the end, while the number of PhD student FTEs remained stable.

Research profile

The unit has a long history of successful work on methods-oriented organic synthesis, in particular asymmetric synthesis utilising the amino acid part of the chiral pool. Elements of mechanistic studies by experiments or calculations are present. Other highly related themes are total synthesis of natural products, combinatorial chemistry, organocatalysis and miniaturisation of reactions.

Research quality

The research in the evaluated period is of a high quality, and was disseminated as a high number of good to excellent papers in appropriate and well-recognised international journals in the field. However, considering the level of funding and the size of the unit in senior researcher FTEs, the output in the evaluated period is low.

The unit is internationally well-recognised, as reflected in numerous conference invitations and the high number of incoming postdoctoral researchers from Europe.

Research environment

The available in-house infrastructure is adequate, although currently the organisation for handling and maintaining heavy instruments is not to the full satisfaction to the unit head. More advanced instrumentation is available on campus or elsewhere in the Helsinki area, but the unit, as was stated in the interview, does not often use these facilities.

Research networking and interaction

The unit participates in national graduate schools, and has initiated a successful Tekes collaborative programme for methods development involving the methods-oriented synthetic organic chemistry groups in Finland as academic partners. The unit is active in the Nordic arena (NordForsk programme on selective synthesis) and has been involved in several COST actions in the evaluated period. The international network of the head of unit is impressive, and the second professor holds several commissions of trust. The number of papers with non-departmental (national and international) co-authors is still low. To some extent, this reflects the tradition in the field of methods-oriented organic synthesis.

Recommendations

Organic synthesis in a method-development perspective is important for organic chemistry and related disciplines in Finland, including the pharmaceutical and biotechnological industry. For enhanced viability of this direction in Finland and within AU, opportunities for novel themes that increase diversity by complementing the current main direction should be supported.

In addition, the panel recommends elements of applied organic chemistry, with in-house or dedicated external collaborative projects for screening and developing applications for the products. However, this should not be implemented at the expense of the core themes of fundamental organic chemistry. Such a development of the unit will be particularly important in order to keep the "technology" label visible in the new AU structure.

4.7 Aalto University, Physical Chemistry

Overview

The unit is a small unit within the Department of Chemistry, consisting of one professor and a total of roughly 15 persons of which ten are PhD students. A new chair within the group was filled in 2010, which will open a new research direction within computational chemistry. The external funding of the unit amounts to 60 per

cent of the budget and it is obtained from a broad range of sources and includes participation in graduate schools.

Research profile

In general, the unit's work is focused on electrochemistry, but in a broad and diverse range of applications, from fuel cells, lithium batteries, ionic liquids and oscillating chemical reactions to pharmaceutical applications of electrochemistry. As electrochemistry traditionally plays a key role in the education of chemists and chemical engineers, the unit is actively engaged in teaching, in particular experimental courses. The unit also contributes with (award-winning) textbooks in electrochemistry, emphasising the importance of a strong mathematical background.

Research quality

The research output from this unit is of a high quality. The core of the unit's research is within electrochemistry and the group has over the last 35 years established itself as the leading electrochemistry group in Finland and has simultaneously built up a strong international reputation. The profound insight in electrochemistry has enabled the group to continuously make high-quality contributions to a number of fields.

The unit is very productive in terms of international scientific publications and is well-recognised for its work. Several of the unit's highly cited papers are from within the last ten years, indicative of the vitality of the unit.

The evaluation panel also lauds the addition of the new chair in computational chemistry, which will broaden the group's research base significantly. This is a testimony of an open and curiosity-driven scientific environment of high standards.

Compared to the majority of units in Finland, this unit is very successful in obtaining research grants from the EU. The unit could serve as a role model for other smaller units in how to make good use of the possibilities of EU funding and make the administrative load of projects manageable even for a small unit.

Research environment

The research environment of the unit is excellent. There seems to be an open and frank attitude towards science and engineering, and the younger members of the unit are given opportunity to pursue their own ideas, thereby establishing independent research profiles.

As the newly formed Aalto University gradually finds its form, the evaluation panel hopes and expects that this can foster an even stronger research environment.

Research networking and interaction

Given its many years of existence, the unit has trained numerous chemists now active in Finnish industry and academia, and it actively uses this network when engaging in scientific collaborations. There is a strong and important international tradition in the unit and many of its significant contributions or new research directions were developed during research visits to other institutions.

Recommendations

Within the next five years, the chair in physical chemistry will become vacant. The evaluation panel recommends that a new professor be hired to ensure the future

presence of core competencies in electrochemistry in Finland. Given the profile of Finnish industry, it is of great importance that this knowledge is maintained both for future research and education. This more macroscopic/thermodynamic approach to physical chemistry will thus nicely supplement the more microscopic/spectroscopic approach to physical chemistry present at UJ and UH.

However, the panel expects that it can be difficult to find a pure electrochemist for the professorship, and the unit may have to search for a strong candidate with a unique research profile, encompassing electrochemistry as a primary research tool.

The unit's successful track record with EU funding should serve as a model for other smaller Finnish laboratories.

4.8 Aalto University, Polymer Technology

Overview

The Polymer Technology Unit at AU School of Science and Technology is part of the Department of Biotechnology and Chemical Technology. The unit includes one professor and three senior scientists or postdoctoral researchers and, on average in the evaluation period, a little more than ten PhD students. The external funding of the unit amounts to one-third core funding and two-thirds external funding. The unit has been able to attract some of the most prestigious funding in Finland over the last years, including a research post as Academy Professor for 2011–2015 by the Academy of Finland.

Research profile

The unit works in the border area between pure and applied chemistry of modern biopolymer materials and applications. In addition to a strong basic research profile, the unit has very active and wide industrial collaboration. Key topics include polymer synthesis, polymer reaction engineering and catalysis, and central properties of polymers. Polymers include olefins, functional polyolefins, clay and cellulose (nano) composites, and the unit is increasingly working on the synthesis of biopolymers and the study of bioactive and biodegradable materials with medical applications. A broad range of experimental equipment from small- to medium-scale polymerisation reactors and state-of-the-art analytical tools is available. This also includes the capabilities of making 3D structures of bioactive materials that can be used as growth matrices in medical applications.

Research quality

The research quality of the unit is excellent, as indicated by the unit directing a Centre of Excellence during the evaluation period. Furthermore, the unit has a strong publication record in international scientific journals and the publications are well cited. The unit is also very active in securing the rights to their innovative research, and several national and international patents have been granted during the evaluation period.

Research environment

The research environment of the unit is excellent. There is a tradition of combining basic chemical research with direct applications. The unit thus manages to maintain

the delicate balance between, on the one hand, direct industrial corporation and, on the other hand, the research and teaching opportunities of a university laboratory. There is a strong focus on PhD education with participation in several graduate schools and an active policy to reduce completion times and ensure the quality of theses produced. As the unit expresses an ambition to contribute more towards basic research, it is important that it keeps focusing on both creativity and independence, ensuring that new generations of researchers and projects keep evolving from the unit. The location of the unit offers a research environment that is an important contribution to their activities thanks to project collaborations and the unique analytical instrumentation available.

Research networking and interaction

Networking and interaction seem to be the rule rather than the exception in the unit. At all levels, from national research collaborations and industrial projects to activities within the international scientific society, the unit is very well represented. However, the panel notes that there is a tendency primarily to hire senior researchers educated within the group, as is common for many of the Finnish units visited, and that the number of visiting researchers is low.

Recommendations

The unit has in the evaluation period gradually focused more and more on biomedical applications of polymer materials and technology. The evaluation panel strongly supports this focus. There is strong Finnish research activity in materials research, primarily in wood chemistry and thin films, and by focusing on biomedical application of polymers the unit secures itself a unique position in Finland. In order to be successful, it is likely that the unit must secure a longer time perspective in its funding base. It is uncertain whether the more short-term Tekes funding or funding through Strategic Centres of Science, Technology and Innovation will be ideal for these activities.

The panel strongly encourages the unit to realise the increased level of mobility, exchange and internationalisation discussed in the self-evaluation. To ensure a sustainable growth of innovation and research, the panel also recommends that independent research opportunities for younger and senior researchers be encouraged.

4.9 Lappeenranta University of Technology, Chemical Technology (not interviewed)

Overview

Of the seven laboratories at the LUT Department of Chemical Technology, four were selected by the Academy of Finland for the present evaluation: Chemistry; Membrane Technology and Technical Polymer Chemistry; Product and Process Technology; and Separation Technology). These four laboratories have been evaluated as a single unit, despite the diverse nature of their research activities.

On average, for the four units taken together, there have been a total of five professors, six senior researchers, nine postdoctoral researchers, 20 PhD students and four technicians. However, the distribution of the personnel varies quite

considerably between the individual groups. One of the group leaders held an Academy Professor post until the end of 2009. An average of 4.6 PhD theses are completed each year.

A little less than half of the budget comes from the core funding of the units, the external funding being fairly evenly split between funding from the Academy of Finland and Tekes. The units also have some industrial funding, and EU-funded projects as well.

Research profile

The research profile in the evaluated units covers a broad scope of chemistry, with an emphasis on technology and process-related chemical research. The Laboratory of Chemistry has since 2008 two research directions: "Separation and Environmental Chemistry" (with an emphasis on electrophoresis) and "Chemometrics". The Laboratory of Membrane Technology and Technical Polymer Chemistry works mainly on polymer membrane separation technologies, in particular nanofiltration and osmosis. The Laboratory of Product and Process Technology is divided into two groups: "Process Development" and "Process Intensification". Recently, multiscale modelling of reactors was added as a seminal topic. Other fields are also considered, such as heap leaching, ozonation kinetics, reactive distillation, and modelling of bubble columns. The Laboratory of Separation Technology works mainly in the field of crystallisation, grinding and filtration engineering on the one hand, and water treatment engineering on the other hand.

Research quality

Overall, the quality of the publications that originate from the evaluated units is good, and the publications are published in the relevant journals in their field. The number of articles produced is somewhat low, in particular considering the number of PhD students and postdoctoral researchers in the groups. An exception is the chemometrics group, which in the evaluation period has produced an impressive number of high-quality publications considering the low number of graduate students. This group is also well-recognised internationally in the field of chemometrics.

The groups appear in general to be fairly well connected to relevant industry, despite the somewhat low amount of funding obtained directly from industry.

The work of the Laboratory of Separation Technology is well known in the European crystallisation engineering community (in particular in the Working Party on Crystallisation of the European Federation of Chemical Engineering). A further testimony to the Laboratory's international standing is the observation that it has a double PhD degree with a renowned Chinese university.

The reports provided to the panel claim that LUT was the originator of process intensification in Finland, and that it is leading in this field, especially concerning microprocess technology. This is in some contradiction with the titles of the articles published (of 15 articles from the relevant unit, only two are concerned with microreactors or intensification), and with the relatively small amount of funding from industry and from Tekes, even if reactive distillation certainly belongs in the field of process intensification. It may be that this field of process intensification is treated in other parts of the Department not covered by the evaluation, or that this direction of research is still recent.

Research environment

From the evaluation reports, there seem to be ongoing collaborations in the Department between the different units, with the exception of the Laboratory of Product and Process Technology, for which no direct collaborations with other units at the Department are mentioned. Infrastructure appears to be adequate relative to the needs of the different units.

A possibility that may lead to improved infrastructure and increased collaborations is the creation of the LUT Centre of Separation Technology, which was mentioned but not elaborated on in the self-evaluations. As such, it is difficult for the panel to evaluate the possible impact of this initiative should it materialise.

Research networking and interactions

Although differing somewhat, the laboratories have quite good international contacts, and, in particular for the membrane technology and chemometrics, contacts with a number of relevant European centres have been established. While some incoming international visits are noted, this opportunity appears underutilised.

Little or no interactions with research groups working on related topics at other Finnish universities are documented.

Recommendations

Overall, the panel feels that there are too many units of subcritical size at the LUT Department of Chemical Technology. In addition, despite their small size, these various units seem to cover several different research fields. The panel is of the opinion that the potential of the units could be better utilised if the different laboratories were to be merged and if a clear strategy for the development of the Department as a whole, building on available competence and expertise, were to be developed.

In general, the units appear to be isolated from related scientific activities in Finland, and they should seek to strengthen collaborations with other relevant Finnish chemistry units, in particular with respect to the activity at ÅA.

The Department also needs to develop a clear strategy for increasing international collaborations. This should applied both to sending staff abroad and to an active programme for inviting leading scientists within relevant fields to the Department, with the purpose of initiating strategic alliances and collaborative projects.

4.10 Tampere University of Technology, Chemistry

Overview

The TUT Laboratory of Chemistry is part of the Department of Chemistry and Bioengineering. The research staff included two professors for the whole evaluation period and a third professor as from 2008, giving a 2.4 FTE average. In addition, the unit included 5.7 FTE senior and postdoctoral researchers and approximately twelve FTE PhD students. Over the five-year period, the unit included an average FTE research staff of 21.

The funding for the unit is approximately two-fifths core funding and three-fifths external funding, of which the Academy of Finland contributes nearly 60 per cent and Tekes nearly 40 per cent. The unit participates in national graduate schools.

The unit is responsible for teaching all branches of chemistry at all levels, from introductory to advanced levels, despite the fact that not all chemistry topics are within the core competencies of the unit. Senior staff engage in teaching to approximately 25 per cent, PhD students to about 5 per cent.

Examinations of MScs in the evaluation period were at 13 a year and PhDs at 1–2 a year.

Research profile

The unit is divided into two groups of non-equal size. The larger group consists of several teams, which together constitute a quite complete set of competencies for physical chemistry applied to supramolecular photochemistry. The topics of the teams span from target-oriented organic synthesis of molecular donor-acceptor systems to advanced time-resolved spectroscopy (femto- and nanosecond range). Target applications are, for example, organic films for photovoltaic applications. The more newly established organic group focuses on methods-oriented organic synthesis, in particular organic and organometallic methods, with bioactive compounds for pharmaceutical applications as prime targets.

Research quality

The unit's publication output is at a very good level considering the resources available. However, the number of patents is quite low (considering TUT is a technical university) but consistent with the self-assessment statement, which said that the unit's research is 95 per cent fundamental. The applied physical chemistry group is well established in the international photochemistry community and has delivered very good research during the evaluation period. The professors have given numerous invited talks at international meetings and the selected publications are placed in specialised journals relevant to the field. The more recently established organic chemistry group has not yet gained sufficient momentum for an international take-off. The selected publications are good, but placed in quite topic-specific or very regional journals with limited international recognition.

Research environment

The available instrumental infrastructure is excellent and fulfils the needs of the current research. However, laboratory space limits further expansion of the unit and hampers daily interaction, especially between the new organic synthesis group and the organic synthesis service of the physical chemistry group.

Research networking and interaction

The applied physical chemistry unit has, mainly thanks to the group leader, strong collaborations with several internationally well-recognised groups in the field of supramolecular photochemistry. As a result, the proportion of papers with international co-authors is very high. The organic group, founded in the evaluation period, is building on contacts with China, Japan and other methods-oriented organic chemistry groups in Finland. It has still not achieved as strong an international recognition as the physical chemistry group.

The unit has, through the physical chemistry group, been active within COST actions, and the proportion of internationally recruited PhD students is high. The

unit regularly receives senior scientists on stays of 1–3 months, mainly from Russia, Romania and Japan. As seems to be the common practice in Finland, the senior or postdoctoral researchers hired are mainly educated within the unit.

Recommendations

The physical chemistry group's shift from studies of assemblies in solutions to studies of the assemblies deposited on surfaces is timely and should be actively pursued. The organic chemistry group should focus on topics where it is likely that the available resources are sufficient to create international impact and promote the group towards higher visibility. The target-oriented organic synthesis subunit of the physical chemistry group and the new methods-oriented organic chemistry group would both benefit from closer interaction. If local geography is the main obstacle for collaboration, not only on analysis instruments, it needs to be constructively discussed at TUT.

The retirement of the most senior professor in the near future calls for strategic discussions at department and faculty level in order to further develop the chemistry unit and the university. Since chemistry is a key topic in several of the priority areas of TUT and a key element in several educational programmes, the panel strongly advises engaging competence in chemistry disciplines other than physical and organic chemistry (analytical and industrial chemistry currently not being covered at all according to the self-evaluation). Expanding the disciplinary versatility will strengthen the chemistry unit both at the research level and at the undergraduate teaching level.

The presently active groups at TUT are advised to seek collaborations not only in easterly directions. The "People" calls of the EU framework programmes could be pursued in order to increase the number of postdoctoral researchers on stays longer than a few months.

4.11 University of Eastern Finland, Chemistry (not interviewed)

Overview

The Laboratory of Chemistry at UEF is placed within the recently established Department of Biosciences on the Kuopio Campus. The unit has two professors, 3–4 senior researchers and postdoctoral researchers and around ten FTE PhD students. During the evaluated period the unit was the Department of Chemistry at the University of Kuopio and is, as of January 2010, the Laboratory of Chemistry at the Department of Biosciences, University of Eastern Finland, Kuopio Campus.

The unit's core funding covers 45 per cent and the external funding contains equal shares from the EU (17%), the Academy of Finland and graduate schools (16%), and Tekes and industry (16%).

Research profile

The unit is evenly devoted to basic and applied research and works in the border area between chemistry and biology: "the problems of biology investigated with the tools and concepts of chemistry". The chemical biology/biological chemistry research at the unit is focused on two main themes: (i) Synthetic biomolecular chemistry and analytical chemistry, with synthesis of various bioactive molecules, phosphonates,

peptides, polyamines for anti-cancer drug development, imaging, and radiochemistry as core topics, and (ii) Computerised NMR and NMR metabolomics, with a long tradition of working with analysis and predictions of NMR spectra of biomolecules using libraries and models taking into account (intra-/inter-) molecular motion. The activities in metabolomics are part of the national group for computational medicine and mainly focused on NMR spectroscopy of new potential drug molecules.

Research quality

The research output is at a very high level considering the size of the unit. The unit is publishing in good international journals and the papers are well cited. In particular the groups on synthetic chemistry have produced a high number of well-cited papers in the evaluation period. They also have productive collaborations with other departments at the Kuopio Campus and elsewhere. The most cited work from the NMR group is on integrator transforms and dates back 15 years. This work also formed the basis of the spin-off company that was founded in 2002 and presently attracts independent external funding to the tune of about €500,000 a year.

Research environment

The instrumental and laboratory infrastructure is well suited for the present research profile, and the unit has recently invested in new NMR equipment essential for the metabolomics projects. The unit is however rather critical in its own assessment of the research environment at the Kuopio Campus. Following the formation of UEF in 2009, the Department of Chemistry was enrolled under the Department of Biosciences, and the chemistry unit expresses concerns of the future of the research on biological chemistry at the Kuopio Campus. They are seeing the merger of the University of Kuopio and the University of Joensuu both as an opportunity and a threat, sensing that chemistry is not being prioritised within the human biosciences strategic topic in Kuopio.

Research networking and interaction

In spite of the good research carried out, the unit appears isolated, with limited international collaborative projects. From their publications, it is evident that the unit interacts productively with other groups, but, judging from the self-assessment, visitors, guest professors or postdoctoral researchers from other institutions are not common. Longer visits abroad for members of the unit are not frequent enough, and invited presentations at international conferences are at a very low level.

Recommendations

Based on the self-assessment alone, the panel cannot give precise recommendations on research strategies. Still, a number of key issues are recommended to be urgently addressed by the relevant parties:

1. UEF should formulate and communicate a clear strategy concerning the future of chemistry at the Joensuu and Kuopio Campuses, taking into account current collaborations (within and between campuses) and potential research synergies from future closer collaborations (within and between campuses) as well as the needs for quality chemistry teaching in the undergraduate programmes in Joensuu and Kuopio, respectively, and the local chemical industry in the regions.

A transparent discussion leading to a well-communicated strategy will obviously be essential to ensure good and inspiring working conditions for the chemistry researchers in Kuopio.

2. Any small unit with extensive teaching obligations at a university with delocalised campuses is prone to become isolated from the international research community. Given the interesting and productive work in both NMR and synthetic biomolecular chemistry, the evaluation panel strongly recommends strengthening the networking efforts of the unit, with participation in the appropriate initiatives at national and European level. A more active staff mobility policy is also recommended, both concerning short-term stays abroad for the current researchers (including PhD students) and in future recruitments.
3. One of the professors is retiring in the near future. It is thus essential that the long-term strategic issues (item 1 above) be settled at university level as soon as possible. It should also be decided whether the successful activities relying on the advanced NMR facility in Kuopio should be continued at UEF, in which case recruitment of a new professor in an international call is recommended.

4.12 University of Eastern Finland, Materials Chemistry

Overview

The Laboratory of Materials Chemistry is a combination of three smaller units in inorganic, physical and materials chemistry. As a whole, the unit consists of three professors, six senior scientists, ten postdoctoral fellows and 29 PhD students. Together, the unit and the Laboratory of Organic Chemistry (two professors) constitute the Department of Chemistry at the UEF Joensuu Campus. Of the unit's funding, 34 per cent was core funding and 66 per cent external funding, the main sources of the external funding being the Academy of Finland and graduate schools (21% of total funding), Tekes (16%), industry (11%) and the EU (12%).

Research profile

The unit is working in the general area of new materials and new materials technologies in accordance with the overall strategy of UEF. Specifically, the group is presently involved in work on intermolecular coordination metal compounds, crystal engineering, catalysis, composites/polymer materials, and functional micro-/nanomaterials. In addition to these experimental activities, the group has high-quality activity in theoretically predicting and numerically modelling nanomaterials. In general, the group works on problems in materials chemistry with long-term applications in sight, but is mainly concerned with the basic scientific questions pertaining to the systems under study. The unit is well organised and its funding strategies have been very successful over the evaluation period. This has enabled the financing of a relative large number of PhD students in the unit and has also helped in acquiring and maintaining a broad range of high-level analytical instruments that are shared among the activities. In addition to an excellent research profile, the evaluation panel notes that the unit has an outstanding educational profile, educating many PhDs per professor and most importantly ensuring that the PhDs graduate with an average age under 30. This sets an example to be followed by other chemistry departments in Finland.

Research quality

Despite the fact that the UEF Department of Chemistry is not among the biggest in Finland, it is doing very well. Not only is the productivity in terms of journal articles very high, many of the papers have over the evaluation period been published in the best international chemistry journals with the highest impact (Angewandte Chemie/ Journal of American Chemical Society JACS). In addition, the success in obtaining competitive grants from the Academy of Finland, Tekes and the EU bears evidence of the research quality of the unit. The unit is also able to participate in and contribute to international collaborative efforts with some of the leading groups in the world.

Research environment

The evaluation panel considers the research environment to be very good: there is a tradition of high-level basic research in materials chemistry and a broad range of excellent equipment available for the researchers. The research environment is perhaps somewhat limited by the fact that mobility among young Finnish researchers is rather low, leading to a very large proportion of the postdoctoral fellows in the group being UEF graduates. The unit is trying to compensate for this by sending students abroad, but it could also be refreshing for the research environment to have students or postdoctoral fellows come to Joensuu. The addition of an international Master's programme and the opportunity for Bachelor's students to work in the research laboratories during their first years are also great initiatives in efforts to increase and broaden the recruitment base.

The spokesman for the unit very nicely formulated a "moving platform" strategy for the groups, where the present research capabilities can be used as a stepping stone for the foreseeable change in research personnel that will occur in the next five years.

Research networking and interaction

There appears to be a constructive and productive collaboration between the units in Joensuu and there are also good relations and collaborations with similar units in Finland. The unit is responsible for the largest graduate school in Finland and is consequently very well integrated and coordinated with the research environment in Finland. The list of international collaborators also includes key institutions in both Europe and overseas.

Recommendations

The evaluation panel recommends that the future profile of the materials chemistry group in Joensuu be secured through the establishment of a new professorship in materials chemistry that can both represent scientific excellence and leadership.

The evaluation panel was given a unified presentation from the groups in inorganic, physical and materials chemistry, and the panel strongly encourages the units to continue this collaboration by forming a larger unit, possibly also including the organic department, to ensure a continued professional and modern handling of the many administrative challenges the groups are facing.

In the near future, the Department will have access to a unique research instrument, the 12 Tesla FT-ICR (Fourier-Transform Ion Cyclotron Resonance) mass spectrometer. The panel suggests that the Department consider how to take full advantage of the unique research potential of this machine.

4.13 University of Eastern Finland, Organic Chemistry

Overview

The Laboratory of Organic Chemistry has two professors (one professor retired at the end of 2009 and was replaced by a young colleague in 2010), six postdoctoral researchers and approximately seven PhD students. The funding of the unit amounts to about two-thirds core funding and one-third external funding and is reasonable for a small unit. The facilities are very good (see below) and the unit is involved in undergraduate and graduate teaching in the field of organic chemistry.

Research profile

The unit has an interdisciplinary research profile between chemistry and biology. There are two main topics: macromolecular crystallography of biomolecules, especially proteins; and high-resolution mass spectrometry using a new FTICR-MS (Fourier-Transform Ion Cyclotron Resonance Mass Spectrometer). The unit is interested in the quaternary structure of enzymes, molecular self-assembly, macromolecules and carbohydrate processing enzymes. The combination of X-ray techniques and mass spectrometry is an ideal analytical tool for such structure elucidations and especially dynamic processes in nature. The young and lively unit has a clear strategy for the next years, adapted to a smaller university such as UEF.

Research quality

The research of the unit as a whole is of a high quality and the unit is also well cited in the international literature. However, the impact and publication record of the FTICR-MS activities are not yet at the level of the activities in crystallography. Overall, this is an active and young research unit and the combination of X-ray analysis and FTICR-MS could hold a large research potential for the future.

Research environment

The research environment and the instrumentation is very good and a highlight for the unit. The in-house protein diffractometer is essential for the X-ray studies and one of the few instruments in Finland. More sophisticated measurements are conducted at synchrotrons in Hamburg or Grenoble. The mass spectrometry group is equipped with various high-resolution machines, and especially the recently installed 12 Tesla FT-ICR is unique in Finland. In Europe, it is only the fifth such instrument. Other units at UEF, VTT and chemical companies profit from this outstanding equipment.

Research networking and interaction

The unit's collaborations are good and other groups seek its analytical expertise. The unit has good funding from a graduate school and is involved in one COST action. However, as the panel has also seen at other universities, the recruitment of professors, senior researchers, and postdoctoral researchers is solely from the University of Joensuu. Interactions and collaborations with international groups are not very strong.

Recommendations

The unit should continue its interesting research and it has very good perspectives by combining X-ray analysis and mass spectroscopy in the study of dynamic processes of bio- and supramolecular interactions. With the new FTICR-MS instrument, the unit is extremely well placed to do frontline research. The unit must to a larger extent collaborate nationally and internationally with other groups in order to take full advantage of the unique instrument. The evaluation panel sees a large potential for obtaining funding for research projects that are more applied. Such funding could, and should, also be used to ensure a much more diverse staff by recruiting from other universities in Finland and abroad.

4.14 University of Eastern Finland, Pharmaceutical Chemistry (not interviewed)

Overview

The Department of Pharmaceutical Chemistry was combined in early 2010 with three other pharmaceutical units into the School of Pharmacy at the UEF Faculty of Health Sciences. The chemistry research at the unit is multidisciplinary with mainly 30 per cent analytical chemistry, 30 per cent theoretical chemistry, 10 per cent organic chemistry and 30 per cent medicinal chemistry. Over the reviewed period, the unit had an average research staff of four professors, 14 senior or postdoctoral researchers, 24 postgraduate students and two graduate students, three technicians and one part-time administrative officer. External funding, most importantly from Tekes and the Academy of Finland, represents more than one-third of the total budget.

Research profile

The research profile of the unit covers a rather broad spectrum of activities, including analytical chemistry with an emphasis on mass spectrometry, biotechnology-based medicines with an emphasis on medicines with anti-infectious and immunological responses, oligonucleotide-based medicines, medicinal chemistry using molecular modelling and drug synthesis, chemical drug delivery using cyclodextrins, and pharmaceutical excipients for drug formulations. The unit has a focus on promoting local pharmaceutical industry and supporting the local economy.

Research quality

During the period of evaluation, the unit published 188 articles in refereed scientific journals and was granted one national patent and two international patents. The unit's activities are thus at a good level, considering the size of the unit. The papers are published in relevant journals and have good impact. The focus on furthering local business ventures and local pharmaceutical companies appears to work well, and several spin-off companies have resulted from research in the unit. Overall, the quality of the work in the unit is very good.

Research environment

The unit is well equipped with state-of-the-art research equipment needed for the research activity. During the review period, 18 doctorate degrees and 29 Master's degrees were completed. The students graduating from the group readily obtain relevant positions in pharmaceutical industry as well as postdoctoral positions. It is

noteworthy that the graduates also get positions in international pharmaceutical companies outside Finland.

Research networking and interaction

More than 80 per cent of the papers produced by the unit involve domestic co-authoring and 30 per cent involve foreign co-authors.

Networking with units within the University of Kuopio and other Finnish universities as well as with three European universities is reported. Six staff members and two postgraduate students visited foreign research groups.

Recommendations

Based on the documents provided, the unit appears to have a very good research activity that leads to strong interactions with local industry, and this activity should be maintained. The unit is also providing highly relevant graduate student training, which should be maintained at its present level. While the graduate training and teaching in general have a strategic basis, the research strategy of the unit appears less developed, even though there is a strong strategic focus at the Department. The panel recommends that a long-term strategy be drafted for the unit, which would ensure the level of research and education in the unit also after the retirement of current faculty members, even though such retirements are not imminent.

4.15 University of Helsinki, Analytical Chemistry

Overview

Over the reviewed period the unit's staff included on average two professors, six senior or postdoctoral researchers, 14 postgraduate students, one technician, one laboratory engineer and one administrative officer. A total of eleven PhD degrees and 97 Master's degrees were completed. External funding represents more than half of the total funding budget, the largest external source being the Academy of Finland (21%).

Research profile

The research of the Laboratory of Analytical Chemistry is fully dedicated to analytical chemistry and in particular to the development of instrumental techniques such as chromatographic and capillary electrophoretic techniques, mass spectrometry, and miniaturised and multidimensional techniques. The unit's activities cover a wide spectrum, from basic studies including theoretical, methodological and technical issues to applied studies. The goal is to provide a unit of analytical chemistry where chemistry-relevant questions can be addressed.

The development of analytical tools is directed at two main targets: environmental research and bioanalytical research. In particular, novel analytical tools are developed for the analysis of aerosols and for use in relation to lipoprotein nanoparticles.

Research quality

The unit has internationally recognised expertise in separation techniques. The publication rate is high and most papers are published in highly ranked journals in the field. The impact of the research is evidently based on a high number of invited

presentations at scientific conferences and on memberships of researchers in editorial boards of scientific journals and international scientific boards.

The unit has a very clear strategy and plans in a broad area of research. In order to fulfil its objectives in developing analytical methods, the research is based on constant innovation. In order to understand the basic mechanisms of molecular recognition so that the analytical tools can be optimised, the unit extends its knowledge through effective and active collaborations to relevant topics such as the modelling of adsorption processes in chromatography separations, ionic liquids and molecular dynamics.

The unit's present work is directed at developing new functional materials for the stationary phases of chromatographic techniques, new biomimicking instrumental techniques and the miniaturisation of analytical techniques.

Research environment

The unit has achieved a critical mass. The teaching and research tasks are well distributed among the unit members, including the specialised technician who is also involved in teaching.

The equipment (commercial and self-constructed instruments) available in the unit is impressive. The good technical support is an asset for the group. Moreover, thanks to its high-quality work, the unit has good collaborations with equipment providers so that it also benefits from some support to maintain the equipment.

The research environment has managed to attract postdoctoral researchers and postgraduate students from abroad.

The unit also attracts a large number of undergraduate students and is involved in five graduate schools in the training of PhD students.

Research networking and interaction

The unit has much active collaboration both nationally and internationally. The unit receives many contacts from a number of parties but selects the topics it wants to pursue through collaborations, and bases the selection on its research strategy. The unit was a partner in the Nordic Centre of Excellence Biosphere, Aerosol, Cloud and Climate Interactions (BACCI) in 2003–2008 and is presently a partner in the Finnish Centre of Excellence in Physics, Chemistry, Biology and Meteorology of Atmospheric Composition and Climate Change (2008–2013). Networking is also provided through the unit's participation in five different graduate schools.

Recommendations

The unit should maintain its research activities at a high level. Negotiating special agreements would be beneficial in the use of specialised equipment only available outside the unit in order to ensure good access to such modern equipment. This applies in particular to the use of the FT-ICR (Fourier-Transform Ion Cyclotron Resonance) MS equipment that is only available in Eastern Finland. The unit should also be more proactive in sending people abroad, even if the working conditions within the unit are good for the researchers. Finally, the unit should continue to maintain a healthy balance between the number of staff members at different levels, in order to maintain the unit's competence and focus on long-term fundamental research issues.

4.16 University of Helsinki, Chemistry and Biochemistry

Overview

The chemistry unit, which is part of the Division of Chemistry and Biochemistry, belongs to the Department of Food and Environmental Sciences at the UH Faculty of Agriculture and Forestry. The current Department was formed after a merger of the Department of Applied Chemistry and Microbiology and the Department of Food Technology. The unit is responsible for teaching chemistry mainly to Bachelor's students in the Department and Faculty. This is a very special situation with respect to teaching and PhD recruitment. The unit has one professor (moved from VTT to UH in 2002), three lecturers, some three postdoctoral researchers and four PhD students. The unit's funding is approximately 50 per cent core funding and 50 per cent external funding, a good proportion for the mainly basic research-oriented activity of the unit. Additionally, the external funding has increased remarkably during the last few years as a result of the merger.

Research profile

The main research of the unit is focused on polysaccharide chemistry, especially on hemicelluloses. Such carbohydrates have been isolated, analysed and structurally modified with possible applications as thin films and the stabilisation of emulsions. The unit is also interested in the enzymatic production and *in vitro* fermentation of oligosaccharides. A clear strategy for future projects is provided. The unit also engages in research on analysis of minerals and trace elements. This topic, quite far from the current main activities of the unit, is pursued by only one university lecturer.

Research quality

The research is of good quality and the output in terms of publications has increased steadily during the last few years. At the same time, the number of PhD students and fundraising increased remarkably after the recruitment of the group leader from VTT to UH in 2002. The unit's results have been published in good but rather specialised journals. However, the research output of the trace element analysis is not visible.

Research environment

The research environment at the Viikki Campus is very good. The unit has all necessary facilities for preparative work with various instruments such as HPLC, GC-MS, HPSEC (high-performance liquid chromatography, gas chromatography mass spectrometry, high-pressure size exclusion chromatography). High-field NMR is available in the core unit at the Campus. A clear disadvantage is the separation of the unit into three different buildings.

Research networking and interaction

The unit has strong collaborations both within Finland and in Europe. The PhD students of the unit are involved in two national graduate schools. The unit's participation in four COST actions is very important, allowing for international exchange and transfer of knowledge. Collaboration within the unit, between the carbohydrate and trace element researchers, is not significant.

Recommendations

The carbohydrate unit is doing well and should continue in the directions indicated. The application of modified oligosaccharides as renewable raw materials in material sciences might be an attractive additional research field. The fundraising and number of publications should increase steadily during the next years. Publication in non-specialist journals should also be considered. The situation of the trace element group is not satisfactory, since it is quite isolated within the unit.

4.17 University of Helsinki, Inorganic Chemistry

Overview

The Laboratory of Inorganic Chemistry is a large unit of around 47 researchers consisting, on average, of three professors, eight senior researchers, eleven postdoctoral researchers and 25 PhD students. On average, three PhD students and five MSc students graduate each year. Of the funding, 56 per cent is external, the largest source being the Academy of Finland and graduate schools (30%).

Research profile

The unit's research effort is highly integrated with close collaboration between the three leading teams. The research is focused on two main areas of modern inorganic chemistry. The materials work is concerned with the production of thin films with a specialisation in atomic layer deposition (ALD). The thin film research covers the whole area from precursor design and preparation to functional characterisation of the films. The research is both fundamental and applied. Work on Li-ion batteries is directed towards the production of microbatteries.

The green chemistry is based on organometallic homogenous catalysis, which is directed towards the activation of small molecules, such as H2, O2 and CO2, synthetic biopolymers and inorganic-organic composites and the catalytic decomposition of wood.

All areas are experimental in nature and are supported by organometallic synthesis of catalysts and ALD precursors and X-ray characterisation of coordination compounds. The theoretical and computational needs are fulfilled by collaboration both within and outside UH.

Research quality

The unit is at the international cutting edge in ALD and innovative in its precursor design. One notable achievement is that Intel has based its 45 nm MOSFET (metal-oxide-semiconductor field-effect transistor), in production since 2007, on a material made by the unit some 14 years ago. New processes have been developed for ultrahigh-k and ferroelectric oxide films.

Highly effective catalysts have been developed for aerobic oxidation of alcohols, and frustrated Lewis acid-base pairs are used to activate molecular hydrogen. Combinatorial methods have been used to aid catalyst design. The level of innovation in the unit is impressive. Its publication record is very strong, with a high hit rate in leading journals. The graduated PhD students readily find relevant employment.

Research environment

The unit's research environment is excellent. It has extensive equipment, with nine ALD units. Technical support is limited, with students carrying out most of the maintenance. This has advantages in that the students learn the fundamental principles of the experimental equipment they use in the graduate studies. More conventional equipment (NMR, MS) is shared in the department as a whole, but access is not a problem. The acquisition of equipment has been considerably assisted by a policy of allowing groups to retain a proportion of the overheads on the grants raised. The level of funding is in general high, and only the salaries of tenured staff are paid from the budget. There is a good supply of PhD students and postdoctoral researchers.

Research networking and interaction

The unit's networking is strong and extensive. Similarly, there are very good contacts with industry. ASM, a Dutch company, relocated a R&D unit within the lab with an emphasis on bringing new scientific discoveries to a scale that makes them of relevance to industry. Collaboration within UH is also valued. Though anxiety exists as to the popularity of science among young people, steps have been taken to remedy this. The establishment of a laboratory for schools within the department has encouraged interest in science and chemistry at an early age.

Recommendations

The impressive performance of this unit and the effective way in which the various research areas support each other leave little to be desired. This outstanding group should be strongly supported. A decrease in the demands of bureaucracy would enable the unit to work more efficiently.

4.18 University of Helsinki, Laboratory for Instruction in Swedish

Overview

The Laboratory for Instruction in Swedish at the UH Department of Chemistry has the responsibility for BSc teaching in the Swedish language, and the teaching at this level covers inorganic, organic and physical chemistry. In addition, the unit offers graduate and postgraduate courses as well as supervision of MSc theses within the unit's research profile, that is, theoretical and computational chemistry. Graduate courses and MSc thesis supervision are offered also in organic chemistry. The unit is rather small, with one professor and 3–4 senior researchers and lecturers. In addition, the unit has on average had 1–2 postdoctoral researchers and four postgraduate students. The small size of the unit combined with the diversity of topics that need to be covered in the curriculum gives the unit challenges in terms of staff to keep an active and homogeneous research profile. The funding of the unit has been fairly evenly divided between core and external funding, where the Academy of Finland and graduate schools cover 30 per cent of the total funding.

Research profile

Although the chair in the Laboratory for Instructions in Swedish could historically be in any field of chemistry research, UH has recently decided that the research profile of the unit should continue to be in the field of theoretical and computational

chemistry, as has been the profile since 1984. The unit has been focusing on and pioneering in the fields of relativistic effects in chemistry and the chemistry of gold and gold nanoparticles. Related to the latter activity is also the unit's interest in quantum dots. Other computational activities involve the study of photoabsorption processes in biomolecules and silicon clusters. The unit is also actively involved in a variety of method development projects, such as the calculation of magnetic (ring) currents in open- and closed-shell molecules, finite-element methods and strongly correlated systems, as well as novel methods for studying protein folding.

Research quality

The research quality ranges from very good to excellent. The group is recognised as an internationally leading group in heavy-element chemistry, and gold chemistry in particular, but the unit is also internationally well recognised in other topics such as accurate spectroscopic quantities, finite-element methods and strongly correlated systems. The unit would like to continue to pursue photoabsorption studies with an emphasis on excited states and dynamics, as well as electron transfer processes, with a focus on photovoltaic cells. The unit also wants to continue its work on studying magnetic currents and exploring different areas where this may provide new chemical insights.

Research environment

The unit is well equipped in terms of access to supercomputing resources provided by the CSC. The unit has also its own computer cluster that allows for non-standard calculations and experimentation. This computer cluster is now getting fairly old. The unit will invest in new hardware in order to explore the potential of using GPUs in computational chemistry. The unit has been fairly well funded, in particular through the involvement in a Centre of Excellence and a graduate school. The unit has also been involved in various Nordic and EU-level networks and projects. The amount of external funding in the unit has been unevenly distributed between the research-active members of the unit. The recruitment of graduate and postgraduate students is good. The unit has the capacity to support a larger number of postdoctoral and senior researchers, the level of staff currently being restricted by the amount of available funding. Some of the senior staff members do not have an active research programme, and have the responsibility of teaching in different areas of chemistry, including experimental chemistry. Most of the administrative work appears to be done by the chair of the unit, and administrative support does not appear to be sufficient.

Research networking and interaction

Due to its international recognition, the unit has an extensive international network that is actively used. The unit also has very important and good contacts with experimental research groups. These propose research topics to the unit and the unit is also able to push these experimental collaborators to experimentally seek to verify their theoretical predictions. The winter school the unit organises every year is an important asset in increasing the unit's international awareness, not only through students attending the school, but also since this allows the unit to invite leading international researchers across a wide range of chemistry topics.

Recommendations

With the appointment of a new professor, the unit should continue its focus on high-quality science within the broad field of theoretical and computational chemistry. To maintain its international standing, the unit should consider a slightly more narrow focus, by selecting a few core research themes that will form the main thrust for the activities in the unit. When replacing staff with experimental teaching responsibilities, the possibility of creating research synergies with potential experimental research activities should be considered, but new openings should be widely announced. The unit should consider a more even distribution of administrative responsibilities among its senior staff members.

4.19 University of Helsinki, Organic Chemistry

Overview

The Laboratory of Organic Chemistry is part of the UH Department of Chemistry. The average personnel resources have been three FTE professors (four in the second half of the evaluation period), eight senior and postdoctoral researchers and 15 FTE graduate students. The total yearly average research staff FTE of the unit was about 27.

Financial support was with a close on 1:1 proportion of core to external funding, the external sources being the Academy of Finland (1/3), Tekes (1/3) and industry (1/3). EU funding accounts for only a minor part of the funding. The unit participates in several national graduate schools.

The unit is involved in teaching basic and advanced courses at BSc and MSc levels; all seniors and PhD students participate in this teaching to some extent (PhD students at the unit to about 25%). The unit is active in Erasmus student exchange programmes. Examinations of MScs in the evaluation period was at 15 a year and PhDs at three a year. Some PhD students have been external (e.g. VTT), with no time spent at the unit. The administrative duties, including task as head of unit, rotate between the professors.

Research profile

The research spans a broad range of topics, differing in classes of starting materials and target applications. The unifying themes for the five subgroups are natural products/bioactive compounds and the methods for synthesis and characterisation. Themes in the evaluation period have been various aspects of covalent and non-covalent chemistry of biomolecules/natural products, including nucleic acids and wood-derived natural products, as well as organic chemistry in the drug discovery area. The unit is also active in research on chemistry teaching.

Research quality

The quality of the research is good to excellent. Publications are in journals relevant to the fields and have been noted in the scientific community. The output, considering the size and funding level of the unit, is fairly low on the scale. The unit also identified this issue. Applied research, funded mainly by Tekes, has been very successful, with results being commercialised in collaboration with industry.

Researchers from the unit actively participate in international conferences, and most PhD students attend several conferences during their studies. The international

visibility, as reflected in conference invitations and international postdoctoral researchers on 1–2 year contracts, is satisfactory.

Research environment

The facilities available for synthesis and basic characterization are adequate, and the level of more advanced instrumental infrastructure is excellent. The unit expresses concerns about means for replacements of low- and medium-price instruments required in the near future.

Research networking and interaction

At the national level, the unit participates in national graduate schools. National research collaborations have been established with various university units as well as with a number of companies and VTT. Also in-house collaborations are well-established and productive, which enhances the output from the core themes of the unit. The in-house collaborations comprise research issues, shared instrumentation and administrative staff. The international collaborations, where the focus is on the EU and the US, are widespread and productive.

The unit has been represented in European and EU initiatives for chemical education, including participation in an Erasmus Mundus programme.

Recommendations

The unit is well placed within historically strong Finnish research themes relating to wood components. Such activities are still important, as is the structure elucidation work. Still, the panel recommends that the scope be broadened, strengthening activities on more fundamental methods-oriented organic synthesis rather than moving towards chemical biology (a theme already well ahead and strong elsewhere).

The panel agrees with the unit's self-assessment that the publication output needs to be improved. For enhanced international visibility and the long-term viability of the unit, it will be essential to ensure that all seniors actively engage in international research networking.

The well-developed custom of sharing and rotating administrative tasks among the more senior researchers seems to be a good solution to decrease individual administrative workload and is a model to be recommended for other units.

4.20 University of Helsinki, Pharmaceutical Chemistry (not interviewed)

Overview

The Division of Pharmaceutical Chemistry belongs to the UH Faculty of Pharmacy. The chemistry research at the unit is 65 per cent analytical chemistry and 35 per cent medicinal chemistry. The unit has a research staff of three professors and, on average over the reviewed period, six senior or postdoctoral researchers, 14 postgraduate students and one graduate student, as well as two technicians. Basic research represents 60 per cent of the unit's activities. External funding accounts for 50 per cent of the total funding budget and comes mainly from the Academy of Finland, the EU and Tekes.

The unit consists of two main groups: analytical chemistry and medicinal chemistry, with largely similar human resources. The medicinal chemistry research team was established in 2004 as a research group in the Division of Pharmaceutical Chemistry.

Research profile

The research of the unit aims at developing new biologically active compounds and key technologies that foster the drug discovery process. Specific research topics are (i) development of atmospheric pressure ionization methods, (ii) microchip-based analytics, and (iii) multi-disciplinary UDP (uridine diphosphate) glucuronosyltransferase research. Other current activities include the analysis of neurotransmitters and their metabolites in the brain; metabolomics; and medicinal chemistry in general, and the development of lead molecules based on naturally occurring terpenes and peptidomimetics.

Research quality

The unit performs high-quality research at the international level in mass spectrometry, miniaturisation of analytical techniques and drug metabolism. During the period of evaluation, the unit published about 50 articles per year in refereed scientific journals and produced 25 talks or conference publications. Domestic co-authoring represents about 60 per cent of the unit publication record, of which 15 per cent involves foreign co-authors. Several national and international patents were applied for but were not granted yet. The impact of the research is evident based on the high number of invited presentations at scientific conferences, the memberships of researchers in editorial boards of scientific journals as well as in international scientific boards.

Research environment

The unit provides an excellent learning environment for postdoctoral fellows and postgraduate and undergraduate students. During the reviewed period, twelve doctorate degrees and 30 Master's degrees were completed. The Master's and doctoral degree holders trained by the unit have been successful in the labour market. The unit participates in three graduate schools: the Graduate School in Pharmaceutical Research, the Finnish National Graduate School in Nanoscience, and the Graduate School of Chemical Sensors and Microanalytical Systems. All principal investigators of the unit have spent several years in leading research groups in prestigious universities in the US and Europe and promote open collaborative scientific work.

The analytical chemistry, medicinal chemistry and synthesis laboratories of the Division of Pharmaceutical Chemistry are modern and well-equipped. The micro- and nanotechnology laboratory at the Division is also very well equipped and unique, both in the Viikki Campus and in Finland. The unit has convenient access to many facilities in the Viikki Campus via the Joint Instrument Centre, several Core Facilities and other cooperation laboratories of UH.

Improvement of research infrastructures is an important challenge. Currently, there is a need for improved instrumentation, for example an FTMS (Fourier transform mass spectrometer), a high-field NMR instrument and a robust HPLC-MS (High-Performance Liquid Chromatography Mass Spectrometer).

The continuously increasing workload in terms of project, faculty and university bureaucracy, administration and teaching tasks in both the BSc and MSc programmes depletes human resources for research.

Research networking and interaction

The unit has much active collaboration within UH, as well as with other Finnish universities and institutes. Numerous industrial collaborations with companies in Finland are effective through Tekes projects. The unit has succeeded in internationalisation, as evidenced by the presence of postdoctoral researchers and postgraduate students from abroad. The unit also participates in international research programmes (e.g. EU-funded ProKinase, MAREX and FORESTSPECS), COST actions (Combinatorial chemistry; New drugs for neglected diseases), and the Paul Ehrlich MedChem Euro-PhD Network.

Recommendations

The unit should maintain its research direction and level of achievement, which is of high quality in an important societal area. The panel recognises and supports the efforts of the unit that aim at promoting cooperation with national and international research groups, encouraging international researcher exchange, and preparing advanced courses in English to attract undergraduate and postgraduate students from international exchange programmes to the unit.

UH should consider supporting this active unit by providing technical staff and better facilities for instrument modification and instrument building.

4.21 University of Helsinki, Physical Chemistry

Overview

The Laboratory of Physical Chemistry has two professors and two university lecturers. The unit also has 13 docents. One of the professors also acts as chair of the UH Department of Chemistry and his experimental activities are supported by an externally financed senior scientist (a docent). In the evaluation period there were about six postdoctoral researchers per year and about eight PhD students. Of the unit's funding, 40 per cent was external, including 31 per cent from the Academy of Finland and graduate schools.

Research profile

The unit is working in molecular spectroscopy with emphasis on high-sensitivity techniques and low-temperature matrix studies of rare gas compounds. In addition, the unit is also actively involved in the development of new laser systems for both infrared and far-infrared (THz) systems, in both cases based on optical parametric processes. Parallel to its experimental efforts, the unit is also developing and applying theoretical methods for small molecular systems. The unit has been active at UH for more than 25 years and is known throughout the physical chemistry community for its work. There is also a smaller activity in gas-phase photochemistry aimed at correlating chemical reactivity with simple molecular parameters (electronegativity etc.). Recent additions to the research profile are the studies of optical gain in Si-nanoparticles and the use of cavity ring-down (CRD) spectroscopy in breath analysis.

Research quality

The unit is part of the National Centre of Excellence in Computational Molecular Science (2006–2011) funded by the Academy of Finland. One of the professors has led this centre since 2009.

The research output of the unit is very good. In general, results are published in key international journals. The impact of the research is quite high and the unit is well known worldwide for its work on overtone spectroscopy and matrix isolation spectroscopy. The matrix isolation work of the unit received the George Pimentel price in 2009 for one of the professors.

The work on gas-phase chemical kinetics does not seem to have had as large an impact, and both the problems investigated and the techniques used are perhaps not competitive with the leading groups in this field. Similarly, the activities in laser development and breath analysis using CRD spectroscopy is quite new and the impact cannot yet be judged.

Research environment

The unit is co-localised with the other groups in the Department of Chemistry and thus part of the strong interdisciplinary chemistry environment at UH. Together with the Centre of Excellence in Computational Molecular Science, this has created a strong research environment for experimental physical chemistry. The unit has access to a number of experimental laboratories that specialise in rare-gas chemistry and ultra-sensitive molecular spectroscopy, and there is a strong experimental tradition both in maintaining and developing advanced optical and cryogenic laboratories. The unit is strongly committed to remaining an experimental laboratory, despite increasing efforts in computational chemistry.

Research networking and interaction

The matrix isolation activity and the activities in laser spectroscopy are very well integrated with international communities. Several shorter or longer visits to key academic institutions, numerous conference presentations and services to the scientific community are indicative of the high international level of the unit's research.

Recommendations

A key challenge for this unit is to maintain the high level of experimental research while gradually moving into new research areas in the coming years. New activities in applied spectroscopy and participation in the Si-nanophotonics consortium must be supported by creating attractive career opportunities for younger researchers. When a future research profile becomes more defined, it is important that the experimental infrastructure of the unit is renewed to keep it at a high international level. Given the increasing administrative burdens in applying for and administrating external funds, the unit could consider teaming up with some of the other units at the Department of Chemistry in order to make the handling of these matters more professional.

4.22 University of Helsinki, Polymer Chemistry

Overview

The UH Laboratory of Polymer Chemistry has personnel resources of about 22 researchers (2 professors, 2 university lecturers, some 3 postdoctoral researchers and 15 full-time PhDs). The funding of the unit amounts to approximately one-third core funding and two-thirds external funding. This proportion of external funding is mostly due to support by Tekes and industry, indicating the applied research profile of the unit. The unit is also involved in undergraduate and graduate teaching.

Research profile

The unit is interested in various fields of polymer chemistry. One topic is the synthesis and characterisation of water-soluble amphiphilic polymers with focus on stimuli-responsive materials. The unit applies modern methods of radical polymerisations, for example, atom transfer radical polymerisation (ATRP) or reversible addition-fragmentation chain transfer (RAFT) polymerisation. Nanocomposites have been investigated with the aim of crafting gold particles with polymers. More recently, the unit has analysed water-dispersible conducting polymers such as polyaniline. One of the professors in the unit is interested in cellulose derivatisation and the application of solid-state NMR. All research topics are up-to-date but quite diverse.

Research quality

The research is of a very high quality and the unit is part of a Centre of Excellence (in Functional Materials). The strong research impact is evidenced by the external funding, which is at a very good level, especially from Tekes and industry. Results have been published in good but specialised journals, with reasonable to high impact. However, the international visibility of the unit could be better, since the number of citations is quite low.

Research environment

The research environment is excellent. The essential equipment for polymer chemistry is available in-house. The facilities, including a 300 MHz NMR, light scattering, fluorescence spectrometer, scanning calorimeters, dynamic mechanical analysis (DMA) and a rheometer, are suitable although some instruments are quite old. Special instrumentation, such as atomic force microscope (AFM), MS, field-emission scanning electron microscope (FESEM), and ZetaSizer, is shared with other groups. A new 500 MHz NMR spectrometer was installed very recently. There is good collaboration between the groups in the Department, and the PhD students can share various instruments. The planned renovation of the Department will increase the safety and working conditions in the labs.

Research networking and interaction

The unit has very strong collaborations. There are many common projects and publications with other groups in Finland and Europe. Various industrial

collaborations in the field of applied research are evident, and the excellent external funding demonstrates the success of this strategy. The unit participates in three national graduate schools, but participation in international student exchange programmes would improve the external recruitment of PhD students.

Recommendations

The unit should continue its excellent research in polymer chemistry and its very successful fundraising efforts. However, a focus on a smaller number of projects would increase the visibility in terms of publications and citations. Furthermore, this would allow for more concrete applications of new materials. Recruitment of PhDs should be vigorously pursued through international student exchange programmes. The unit also should consider strategies for mutually beneficial collaboration between all senior researchers within the unit.

4.23 University of Helsinki, Radiochemistry

Overview

The UH Laboratory of Radiochemistry has, on average, one professor, seven senior researchers, two postdoctoral researchers and five PhD students. It is the only comprehensive radiochemistry group in Finnish universities and is also large in size in a European context. From the overall budget, core funding accounts for 25 per cent; this provides salaries for seven staff members. Other funding comes from a wide variety of sources.

Research profile

Research in the unit covers a number of areas of radiochemistry. The majority of the work is application-oriented with the approach of establishing a deep knowledge and understanding of radioactive elements and radiation.

Specific areas include migration and retention of radionuclides in the geosphere and the development of inorganic ion exchangers for the removal of radionucleids from nuclear waste effluents. The unit also studies radiopharmaceutical chemistry, environmental radioactivity and radiation chemistry and develops analytical methods for radionuclides in the environment and in nuclear waste.

The Master's course and the PhD programme are a valuable source of radiochemists for Finnish industry.

Research quality

The unit has a long history of high-quality work, and has gained much expertise in radiochemistry. It is uniquely placed in Finland and is noted within Europe for its size and breadth. There appears to be excellent integration within the unit and a clear sense of future directions. Support from both industry and government is strong; for both partners, the unit appears to be a vital resource.

Radiopharmaceutical research is a relatively new area for the unit. However, given the increasing importance of nuclear medicine, it is an excellent development.

Given the level of funding and available resources, the publication rate is rather low but has been increasing of late.

Research environment

The senior research staff have wide experience and a good age profile. The unit currently has ten PhD students but would benefit from more postdoctoral and PhD students. Active steps are being taken to recruit more students to both the MSc and doctoral programme.

The specialised laboratories and equipment required for radiochemistry are available. There is a wide range of modern instrumentation and both a cyclotron (1998 vintage, though recently upgraded) and a 60Co gamma irradiation source. The cyclotron will need replacement in the future. More conventional chemical measurements are carried out in the Laboratory of Inorganic Chemistry and other institutes in Finland and abroad.

A recent development is a small animal laboratory for preclinical studies by the radiopharmaceutical group.

Research networking and interaction

The unit has extensive collaborations both within Finland and throughout Europe. These are with universities, technical institutes and industry. Networking with past students is evident. The recently formed radiopharmaceutical group has established collaborations with the Turku PET Centre, the University of Kuopio and other units within UH. A significant proportion of the unit's funding comes from industry. The actual and potential benefits to Finnish society are noteworthy.

Recommendations

The group has a good vision for the future, which it should pursue actively.

A strategy should be evolved for replacement of the synchrotron, possibly within a university-wide programme for drug discovery. Publication rates should be increased, thereby enhancing visibility.

There is a need to establish international contacts with groups worldwide, beyond the European sphere.

It is important to maintain and enhance the international MSc programme in radiochemistry for Finnish society at large, and this should be strongly supported.

4.24 University of Jyväskylä, Applied Chemistry

Overview

The Laboratory of Applied Chemistry was founded in 1993 for the development of applied natural sciences. The main mission of the unit was to promote the sustainable and versatile use of wood as valuable products in cooperation with the Finnish forest cluster. The unit has a staff of two professors, one lecturer, three graduates and three laboratory technicians. No administrative support is available. The unit produces a significant number of Master's students who readily find employment. During the period of evaluation (2005–2009), two doctorate degrees were completed together with 13 licentiate degrees. The unit's budget consists of core funding (43%) and funding from Tekes and industry.

Research profile

The main expertise of the unit is related to the versatile utilisation of wood and its components for the Finnish forest cluster. The projects related to the area of wood processing chemistry have been more recently concentrated on the analysis of wood and non-wood raw materials, the characterisation of various process liquors from cooking, bleaching and papermaking as well as the chemistry of delignification and papermaking processes. The research initially on process optimisation is also extended to the utilisation of biomass for the production of new chemicals and energy and environmental chemistry.

Research quality

The research is essentially driven by industrial needs and is concentrated on chemical issues rather than engineering aspects. The unit has developed analytical methods and has gained good expertise in the analysis of biomass main components. The publication record is rather poor in terms of number and journal ranking. Moreover, no foreign co-authoring is noted.

Research environment

The experimental infrastructure is very good. A wide range of modern analytical instrumentation for organic and inorganic analysis is available in the unit. The unit also benefits from the expertise of three technicians. No administrative support is available. Recruitment of PhD students is difficult; there is a lack of interest by students in the topic of the applied chemistry unit despite its relevance to the Finnish chemical industry. Many students also complete a licentiate and go into industry.

Research networking and interaction

The unit has to fulfil teaching duties within the UJ Department of Chemistry. In terms of the research activities, the unit does not appear to be well integrated into the dynamic environment of the other units at the Department. Collaboration with local industry is very good, whereas contacts with domestic laboratories are limited. International collaborations are scarce and their impact is not measurable.

Recommendations

The unit needs to reconsider its contract terms with industries in order to achieve a more up-to-date academic publication record. If the unit is considered important for the university, the university needs to act proactively in order to ensure the unit's scientific survival. The future of the unit relies on strong, focused, yet modern, leadership committed to scientific excellence beyond the local arena. A stronger commitment to scientific excellence and publication may also lead to an increased interest among students in the current or future topics of the unit, and may ensure that more graduate students continue their studies to a full PhD degree. The younger staff members should be given the opportunity to pursue their scientific ideas and develop an independent research profile.

4.25 University of Jyväskylä, Inorganic and Analytical Chemistry

Overview

The UJ Laboratory of Inorganic and Analytical Chemistry is part of the Department of Chemistry. The average research staff over the reviewed period comprised two professors, five senior or postdoctoral researchers, eight postgraduate students and three graduate students. External funding, mainly from the Academy of Finland and graduate schools, represents 25 per cent of the total funding budget. The research at the unit is multidisciplinary, with inorganic chemistry accounting for 40 per cent, analytical chemistry for 20 per cent, computational and theoretical chemistry for 20 per cent, and organic and materials chemistry both for 10 per cent.

Research profile

Research at the unit is focused on three primary fields: inorganic chemistry, inorganic analytical chemistry and computational chemistry. The topics of inorganic chemistry include design, synthesis and characterisation of novel inorganic and organometallic compounds with useful physicochemical properties such as metal complexes of new amine bisphenolate ligands or ionic liquids. Theoretical and computational studies are conducted on main group radicals and fundamentals of chemical structure and bonding in order to assist the design of molecules with sought properties. The research in analytical chemistry is motivated by industrial needs and is aimed at developing new analytical methods for the identification, quantification and separation of different analytes, in particular metals, from a variety of matrices including industrial by-products and waste waters.

Research quality

The research is overall of a very high quality. The strategy is very well founded by unifying in the same unit the multidisciplinary aspects of the research relative to the development and analysis of new inorganic compounds. The combination of fundamental and applied studies, in particular for the analytical part, has a positive impact on all of the unit's activities. The publication record is impressive, with on average 40 peer-reviewed papers per year mostly in leading scientific journals in the field and some in very highly ranked scientific journals.

Research environment

The experimental infrastructure is excellent. The laboratory is up-to date and well-equipped with both small-scale and large-scale instruments for X-ray diffraction and spectroscopic equipments covering all standard techniques. The unit benefits from the support of two technicians and one administrative officer. Within the Department, the unit also shares human resources (staff in electronic and machine shops) for the maintenance or creation of custom-designed equipment. The teaching load of the faculty members is high and mainly involves courses in first-year chemical education. On average, nine Master's students graduate each year. In addition, six PhDs were completed during the evaluation period.

Research networking and interaction

Networking with relevant Finnish research laboratories and industries is important. The unit's very active international collaborations have resulted in many publications; more than 60 per cent of the papers of the unit involve foreign co-authors. The unit is a member of the COST working group Chemistry in High-Energy Micro-Environments, which consists of eleven analytical laboratories from seven European countries. Within the COST action, the unit has also been involved in the organisation of short-term missions for postgraduate students and a workshop.

Recommendations

The unit is doing very well and should be able to maintain its multidisciplinary approach to perform high-quality research and attract good students. Closer interaction with theoreticians from the physical chemistry group at UJ could be beneficial. The panel encourages the unit to further promote the national and international mobility of researchers and their searching of external funding for their research. More full-time funded postgraduate students would certainly support competitiveness and attract students.

The panel recommends that strategic planning for the near-future replacement of faculty members be immediately initiated in order to keep up the dynamics and competence of the unit.

4.26 University of Jyväskylä, Organic Chemistry

Overview

The Laboratory of Organic Chemistry is part of the UJ Department of Chemistry. The unit is affiliated both with the Department and with the UJ Nanoscience Center (NSC). During the evaluation period, the unit had an average of three professors, about ten other senior researchers, including almost 20 individuals as international postdoctoral research fellows for 1–2 years each. In addition, about 15 PhD students (quite constant number of persons) have been active in the unit. On average, the total number of active research staff amounts to 29 FTE. In addition, the unit has two assistants, three technical staff and one research-active professor emeritus.

Financial support was with a near 1:1 proportion of core to external funding (mainly the Academy of Finland, Tekes and industry contributing to a minor extent). The unit participates in national graduate schools.

The unit engages in teaching at BSc and MSc levels, with students participating in ongoing research throughout their BSc and MSc thesis work. The teaching load is evenly distributed among the senior staff. In the evaluation period, examinations of MScs were at 11–12 a year and PhDs at two a year. The unit has also recruited a professor from another Finnish university and promoted a senior researcher (a former Academy Research Fellow) to professor.

Research profile

The unit covers a wide range of topics, with three main themes collected under a wide-sense supramolecular heading: (i) Structural general supramolecular chemistry,

structural host-guest chemistry, (ii) applications of bile acids and steroids, and (iii) total synthesis and methods-oriented organic chemistry (catalysis). Themes (i) and (ii) involve more than one independent/semi-independent subgroup. The three themes benefit mutually from each other. Researchers meet on the issues related to the characterisation of molecules and assemblies. The unit is very active in the Nanoscience Center (NSC), and one group is located in the NSC building.

Research quality

The research at the unit is efficient and of excellent to outstanding quality, with a very high output of internationally recognised papers in a wide range of journals, from general science through general chemistry to more specialist journals.

A current direction in supramolecular research is the connection to the "nano" field. This has rendered the area internationally even more competitive, but the unit still manages to maintain its international visibility. A unique competence for the unit is attracting national and international collaborators, which is reflected in the quite high proportion of papers with co-authors affiliated outside the unit. Also, in the evaluation period, almost 20 international postdoctoral fellows have been active within the unit for 1–2 FTEs each.

Research environment

The infrastructure is at an international top level and is very well suited for the current and planned research directions. Instrumentation is available both within the Department and at the NSC (located 100 m from the Chemistry building). The climate at the Department and in particular within the NSC is highly collaborative. The NSC brings together researchers and students from traditionally separate branches of science.

Research networking and interaction

Local collaborations are mainly within the NSC on analysis methods, and involve the majority of the unit. The infrastructure available via the NSC also attracts national and international collaborations, mainly to the more senior professors.

The unit's national and international contacts are numerous and often productive. Although most of the senior researchers are active in networking activities, the level of activity varies.

Recommendations

The facilities and the performance of the unit are outstanding, and the evaluation panel encourages the unit to keep up the good work. The strategies for future research directions are well phrased, but to some extent lacking in synthesis development. The unit also agrees that this is not an issue to be neglected. The aim is to become a leading unit in organic and supramolecular chemistry in Northern Europe. If this vision is to be realised, the proportion of external funding needs a substantial increase.

The unit should also explore the "People" part of the EU funding schemes. Since the international visibility is very high and the unit already is multinational, it should be possible to attract top postdoctoral candidates with Marie Curie EU funding.

For the long-term viability of the unit, it will be essential to ensure that all seniors actively engage in independent international networking. Also of fundamental importance is to keep significant elements of topical diversity, in particular highlighting the synthetic aspects of organic chemistry, in order to meet yet unforeseen challenges.

4.27 University of Jyväskylä, Physical Chemistry

Overview

The UJ Laboratory of Physical Chemistry is moderately sized, consisting of 2.5 professors, as one professor is shared with the Department of Physics, and a total of approximately 25 other staff members. On average, the unit graduates 3–4 MSc students and one PhD student each year. External funding covers 57 per cent of the total funding. Of this, more than half (30%) comes from the Academy of Finland and 8 per cent from graduate schools, while the combined share of Tekes and industry funding is 10 per cent.

Research profile

The unit encompasses experimental activity in optical spectroscopy, multidimensional vibrational spectroscopy, femtosecond dynamics, higher-order Raman scattering processes and Raman microscopy, optical control of molecular alignment as well as theoretical modelling on various aspects of gold nanostructures and interactions with gold nanoparticles. In the future, the unit will focus on fewer application areas with molecule-surface interactions at the nanoscale, studied by optical spectroscopy and theory as the uniting theme. The unit is fully committed to this research profile, but will maintain its mode of operation of phasing out activities when key competence leaves the unit or when new exciting research directions emerge. An extensive network of collaborations exists both within the unit and with the inorganic and organic chemistry units.

Research quality

The unit does excellent research both in its experimental and theoretical activities, leading to internationally recognised papers in both theoretical and experimental activity, and the activity in optical spectroscopy is unique in Finland. Recent theoretical work has had an impressive impact in the community. The unit is internationally recognised and able to attract leading international researchers. It does an excellent job in enabling a research environment that combines building on core competencies with identifying new opportunities and pursuing these. The unit also phases out activity where it does not expect to be able to remain competitive due to a lack of personnel or key competence. Despite the highly competitive nature of nanoscience, the unit has a unique profile and competence that will ensure impact on the field.

Research environment

The unit has access to state-of-the-art experimental equipment and is located in the modern facilities offered by the UJ Nanoscience Center (NSC). To a large extent, the

unit develops its own instrumentation, and has been able to take advantage of national and regional infrastructure funding initiatives to develop a versatile optical laboratory suited for the study of real-time dynamics. The building of new equipment and maintenance are to a large extent handled by PhD students, providing valuable training and making the unit less dependent on highly specialised technical assistance. There is, however, a lack of local funding to cover everyday expenses for very small laboratory equipment.

The unit has the senior staff capacity to engage more students and postdoctoral researchers in the research. The unit recognises the need to ensure that all students complete their PhD studies. The PhD students are able to get relevant jobs both in industry and academia. The panel strongly encourages that PhD students active in the unit who are aiming for an academic career spend time also outside the unit during their studies. The age profile of the permanent staff is very broad, which, together with well-developed collaborations, makes the unit's activity viable even if some key staff members would leave the group. The unit is well equipped with computational resources from local computer clusters as well as from the CSC, the IT Center for Science.

Research networking and interaction

The researchers act as an integrated unit with skills that complement each other in their efforts towards their common goals of studying molecule-surface interactions at the nanoscale. The unit also maintains strong interaction and collaboration with relevant Finnish research groups that complement its own expertise. The unit has an active international network and the members at all levels travel to internationally leading groups on a regular basis and participate in relevant international meetings. The unit is able to attract leading international researchers to come for longer research visits to UJ, creating a stimulating environment locally for the younger unit members. The researchers would like to be able to offer a higher number of visiting postdoctoral researchers and PhD students the possibility to stay for longer periods. The unit has been involved in a graduate school, although the courses offered have not necessarily been relevant for all PhD students of the unit. Although the unit has been engaged in EU projects, the current good funding situation does not motivate the group to engage in the often rather administrative EU projects.

Recommendations

This is an excellent research unit that should continue to do research with a focus on molecule-surface interactions at the nanoscale using optics and theoretical modelling, a field in which the unit has a unique profile that will enable making an international impact even in a highly competitive field such as nanoscience. The replacement of the most senior member of the unit calls for strategic discussions in order to maintain the dynamic competence of the unit. The unit should explore the "People" part of the EU funding scheme. The Department should consider its budget policy to allow for some day-to-day costs to be covered from the core funding of the unit.

4.28 University of Oulu, Chemical Process Engineering (not interviewed)

Overview

The Laboratory of Chemical Process Engineering is one of seven laboratories of the Department of Process and Environmental Engineering at UO.

The unit has a staff of one professor, no senior researchers, one university lecturer, no postdoctoral researchers before 2008, although this number increased to two in 2009, 6–9 postgraduate students, of which an average of five full-time PhD students, an average of less than one graduate student and one technician. The supervised Master's students all completed their Master's degree for industry.

Of the overall funding, 60 per cent is core funding and the rest comes mainly from graduate schools (some 20%) and industry (some 10%). Funding from the Academy of Finland is very limited (some 5%), and there is no Tekes funding.

Research profile

The unit claims that only 5 per cent of its research activity belongs to chemistry, the main topic being chemical engineering (75% basic research and only 25% applied research). According to the documents available, there was an in-depth change in the scientific strategy when the head of the Laboratory changed in 2006, and a slight refining of the new research and strategy of the unit is still underway, according to the unit's self-evaluation. Computer-aided techniques and tools for the process synthesis and analysis continue to be the scientific challenge of the basic research done in chemical process engineering. In addition to the process design tools, deterministic modelling of processes (mass and energy balance, phase equilibria, transport equations and reaction kinetics) for process design purposes offers the connection to the applied research of the unit. The unit used to specialise in "theoretical process design", and is now in the process of getting nearer to application, which in this case is wastewater treatment and "non-wood" biorefineries (intense collaboration with a company specialising in this field).

Research quality

The number of publications (11 during the whole period and 3 granted international patents) is too small, considering the number of PhD students in the unit. As stated in the self-assessment, a publication policy has yet to be implemented. This corroborates the fact that only one single PhD thesis was completed in the evaluation period.

The panel supports the strategy of getting nearer to application. The unit's efforts to move towards more internationally oriented research are also convincing (all of the international collaborations indicated are recent).

Research environment

The unit is one of seven laboratories of the Department of Process and Environmental Engineering. Contacts with the laboratories of the Department of Chemistry are not mentioned.

Recommendations

Considering the documents available, this unit was in a lethargic state at the end of the mandate of its former director: concentration was on a few basic topics in quite

theoretical chemical engineering with very limited contacts to either industry or international science. Since this period, the unit has evolved in a positive way, and the efforts made by UO to strengthen it may hopefully lead to success. However, the unit has to work intensely in order to get better known abroad by adopting a more aggressive publication policy. It could also work with neighbouring colleagues to define applications in which the unit's know-how can be applied.

4.29 University of Oulu, Inorganic and Analytical Chemistry

Overview

The Laboratory of Inorganic and Analytical Chemistry belongs to the UO Department of Chemistry. The personnel average over the review period was two professors, two senior researchers, one postdoctoral researcher and seven PhD students. The unit consists of two distinct groups, one synthetic and one analytical. Budget funding, which on average accounts for four-fifths of all funding, has decreased over the review period but external funding has held up well. The unit produces a good stream of PhDs who readily find employment.

Research profile

The majority of the research is in inorganic main group chemistry with a particular focus on the synthesis and characterisation of chalcogen-nitrogen compounds. This is fundamental in nature and mainly carried out along classical lines for preparation and investigation of molecular species. However, their use as precursors in film formation is one benefit. Also related applied problems such as the study of exhaust catalytic systems and polysulfides in the oil field industry are investigated. Other applied areas are biofuel and bioash analysis and water purification chemicals.

The inorganic analytical group develops methods to tackle challenging analytical problems involving the determination of trace and ultra-trace elements in, for example, ice cores and the environment. The expertise of the group is in atomic spectroscopy and is directed towards sample preparation, which is a particular and crucially important step in the analysis. Work is commencing on speciation of metals, which is an intended future development.

Research quality

The non-metal group operates strongly in a niche area. Given its size, the group is productive in terms of publications, which are published in good-quality journals. In the specialised area of chalcogen chemistry, the research is internationally leading.

The analytical group is small but nationally leading. It is particularly focused on national environmental needs.

The unit is also unusually productive in terms of the number of graduated PhDs and Master's students. Many of the PhDs continue in academic science, others proceed to industrial jobs.

Research environment

There is presently a good balance between the number of research students and senior academic staff.

The instrumentation for molecular synthesis and characterisation is satisfactory. The new nuclear magnetic resonance (NMR) facilities are particularly welcome. It is important that these instruments be kept up to date. Electron paramagnetic resonance (EPR) and cyclic voltammetry (CV) are carried out in collaboration with Canadian colleagues, so the group should consider bringing these techniques in-house. A new Raman spectrometer is also needed.

There is a desire to acquire further analytical instrumentation, but this will require cooperation with other institutes.

Research networking and interaction

The non-metal group has particularly fruitful collaboration with Canadian scientists, which has involved prolonged stays by both staff and PhD students and has resulted in a significant number of joint publications. A research consortium has been formed with the UJ Laboratory of Inorganic and Analytical Chemistry, involving joint supervision and shared courses and instrumentation.

The analytical group is a member of the international consortium Measurement Science in Chemistry, which delivers a high-quality MSc programme.

Both groups have industrial collaborations appropriate to their interests. Industry has hosted many MSc projects.

Recommendations

The synthetic group, while maintaining its development of chalcogen chemistry, should extend its research to a broader range of elements. The analytical group would benefit from more collaboration at an international level. The instrumentation should be maintained and enhanced.

4.30 University of Oulu, Organic Chemistry

Overview

The Division of Organic Chemistry belongs to the UO Department of Chemistry. The unit has a staff of two professors (one professor only temporarily assigned since about 10 years), one lecturer, one senior assistant and no postdoctoral researchers. On average, there have been 4–5 postgraduate students a year, which increased to 7–8 towards the end of the review period. The funding of the unit amounts to approximately 75 per cent core funding and 25 per cent external funding. The proportion of external funding is quite small. The unit is involved in a substantial amount of undergraduate teaching to chemistry students, a majority of whom later switch to study medicine.

Research profile

The unit is subdivided into an analytical and two synthetic research groups. One research topic is the chemistry of light- and electroactive compounds, with possible future applications as printed electronics. Another focus is on water-soluble carbon nanotubes, which is quite an established research field. The analytical group is interested in the structural elucidation of biomolecules such as proteins by NMR and mass spectroscopy. The basic research profile of the unit is visible, but applications

have to be proven. There is no clear strategy for new research topics; the unit wants to continue and extend existing projects.

Research quality

The research output of the unit is reasonable, and results are published in good but specialised journals. In general, the unit's recognition in the scientific community is low. This may be due to the fact that the unit's PhD students are involved in industrial/VTT projects and the results cannot be published. The unit produces a relatively large number of MSc graduates, but the number of PhD students is low and, in addition, the time spent on doctoral studies is quite long.

Research environment

There appears to be limited interaction and communication between the groups within the unit as well as between the unit and the department. The unit was, for example, not aware of the Dean's plans to restructure the Department as these had not entered the official process yet. The instrumentation with four NMR and mass spectrometers is satisfactory; however, the instruments are quite old and should be renewed. European Regional Development Funding (ERDF) is strongly recommended. Although the educational and administrative load is high, it is comparable with other units in Finland. The new graduate school is a very good instrument for doctoral training, recruiting more PhD students and decreasing the time used to complete a PhD thesis.

Research networking and interaction

There is good collaboration with other universities in Finland concerning the efforts in printed electronics. In particular, the joint project with VTT will pave the way for more applied research. In the field of carbon nanotubes, the unit has international research collaboration with the University of Arizona. The unit also has some common papers with groups at Rensselaer Polytechnic Institute in the US.

Recommendations

The unit is small and thus very vulnerable when it comes to staffing and funding. The panel recommends that the Department quickly decide on the number of permanent professors in the unit, and that it together with the unit formulate a scientific strategy for the unit in an effort to increase the scientific overlap between units. This process should also address the foreseeable generation change in the unit.

Compared to other units, the unit has a relatively modest funding contribution from external sources. This must also be a point of focus in the new strategy for the unit. More external funding should be used to train more PhD students and to ensure a much younger graduation age for the PhDs.

The activities in both photo- and electroactive chemical compounds are relevant and interesting, and since they are both heavily dependent on research collaboration, these connections should be strengthened and expanded on.

Although it is clear that the instrumentation of the analytical group is insufficient for a serious research effort in metabolomics, the panel assesses that such investment must await a formulation of a research strategy for the Department.

4.31 University of Oulu, Physical Chemistry

Overview

The unit belongs to the UO Department of Chemistry. During the period of evaluation, the unit had an average permanent staff of three professors and one senior researcher. The unit also had 1–2 postdoctoral researchers and eleven postgraduate students. The unit currently consists of two full professors and one senior scientist. One of the professors is funded by industry and has a dual appointment between Oulu and Kokkola. In the evaluation period, the unit also had one professor who recently transferred to AU. No replacement for this key scientific staff member has yet been found. One of the members of the unit has during the review period served as Dean of the Faculty of Science, and another member has served as Head of the Department of Chemistry. Of the unit's funding, 28 per cent is external, representing a variety of sources.

Research profile

In the evaluation period, the research has spanned a very broad field of physical chemistry, including computational chemistry and experimental homogeneous and heterogeneous catalysis. Some of the activity in catalysis has strong links to local industry, and several research projects involve industry.

Research quality

Considering the significant administrative responsibilities of key scientific members of the unit, the number of publications is at an acceptable level, and part of the work of the unit receives a reasonable amount of international recognition. The more applied research is, however, less visible at the international level, and this activity needs to consider channels for disseminating scientific achievements. Industrial contacts appear to be very good, and there are a large number of industry-driven projects (or projects with strong industry involvement). However, this activity is still too young to enable an assessment of the impact on local industry.

The unit does not appear as a single unit, neither in terms of research methods nor in terms of research goals. Even if physical chemistry in a wide sense is considered as a uniting theme, the research topics are very diverse with significant elements of research outside the traditional scope of physical chemistry (organic and inorganic chemistry) and with limited internal collaboration.

Despite the opportunities offered by the recent vacancy of a professor position, there appears to be no clear strategy for developing the unit into a high-quality research unit.

Research environment

The unit has been heavily engaged in administrative responsibilities, but it appears that with these exceptions, the amount of teaching and administrative duties leave ample opportunities for research. The level of funding provided by the university does not support as large and diverse an activity as is currently performed in the unit, and it would appear that a more focused research activity would lead to a better utilisation of the limited resources available.

The UO Faculty of Science has since 2009 had an active policy for renewal of scientific equipment, and the panel strongly supports this policy. The unit, in collaboration with the other units at the Department of Chemistry, is well equipped with infrastructure.

The introduction of a graduate school programme has decreased PhD completion times, and the panel supports a further expansion of the programme. This will also help reduce the number of PhD students who do not complete their doctoral studies.

The alarming information provided by the Dean of Faculty regarding the quality of the buildings needs to be addressed by the Faculty of Science.

Research networking and interaction

The unit appears to be rather isolated, with limited internal, departmental and national collaboration and interaction. The unit has been participating in (and coordinating) some EU projects.

The unit has good contacts with local industry. However, due to the lack of integration of the basic and applied aspects of the research activity in the unit, the longevity of these collaborations is not properly secured.

Recommendations

The unit needs to define a research strategy that clearly states the ambitions of the unit and the means for achieving them. In particular, the unit needs to focus its scientific attention on a few key areas where it can have international impact. In recruiting new permanent staff members, recruitment should support the strategic goals of the unit and should not broaden the profile of the unit any further. Theoretical and computational chemistry is very strong in Finland, both in volume and in quality, and it is not obvious that the unit will be able to make an impact on this field in the future, even though computational sciences are a strategic priority for the university. The importance of lithium-battery research is unquestionable, but it is not clear whether the unit's size would enable it to have considerable impact in this field. The unit should seek to integrate better the basic and applied aspects of their research, with the aim of increasing the scientific quality and impact of the applied research, and securing the more basic research in local industry.

The unit should develop a clear strategy for increasing its international visibility and collaboration. The unit also needs to promote its scientific activity more aggressively, by participating at international meetings and through networks, for instance.

The panel acknowledges the strong involvement of the unit in time-consuming administrative positions, but recommends that the unit limit the number of staff members engaged in such duties at any given time.

4.32 University of Turku, Materials Chemistry and Chemical Analysis

Overview

The Laboratory of Materials Chemistry and Chemical Analysis belongs to the UTU Department of Chemistry. The unit was formed in 2005 as a result of a reorganisation within the Department. On average, the unit has four professors, six senior researchers,

two postdoctoral researchers and five postgraduate students. The funding is predominantly budget funding, with less than 30 per cent coming from other sources. Of these other sources, funding from the Academy of Finland accounts for 13 per cent.

Research profile

There are four main, largely independent areas of research in the unit: functional materials and thin films, luminescent and solid state materials, analytical applications of electrogenerated chemiluminescence, and organometallic catalysis. The focus is on basic research directed at obtaining a fundamental understanding of chemical principles. Increased collaboration and concentration of research areas are considered as the keys to competitive success.

The unit is currently led by four professors, leading the four main research areas with expertise in analytical, inorganic, materials and physical chemistry.

Research in the area of functional materials has a focus on materials at the nanoscale and the thin films prepared from them. The classes of materials considered are broad, ranging from carbon nanotubes to biological polyelectrolytes. Luminescence studies deal with persistent luminescence, up-conversion materials and electrogenerated luminescence, though work in this last area has moved elsewhere. Although the research is basic, applications, in particular medical ones, are an actual and potential outcome. Olefin metathesis by new Mo and W catalysts is the active research area of the organometallic chemistry group. The unit also has a tradition of instrument construction, which broadens the range of available experimental techniques.

Research quality

At present, the unit appears to be an administrative structure rather than a focused research unit. Although a well-defined strategy for the scientific development of the unit exists, it does not seem to be firmly secured in the staff members.

The number of publications by the unit has historically been rather low but has recently shown a sharp increase. The majority of publications have been in high-quality journals, in accordance with the strategy of the unit: to focus on fewer papers, but of higher quality, and to publish these in high-impact journals. The research quality varies strongly between the different research directions, and is in general not of a very high level, nor with a significant international impact (despite the publications in high-impact journals).

Research environment

The unit is very well equipped with respect to research infrastructure and also has access to relevant shared facilities both at ÅA and at Turku Science Park. The proximity makes any experimental measurements readily accessible. The unit also develops its own instrumentation and is supported in this by an excellent workshop.

The number of postgraduates and postdoctoral researchers is very low. This is due to funding difficulties rather than a lack of potential interest. A recent new appointment anticipates an increase in funding, resulting from more project-oriented work, which may lead to a desired increase in the number of researchers in the unit.

Research networking and interaction

There is good collaboration at the local level (MatSurf and ÅA) for research and instrumentation purposes. At national and international levels, the focus of the unit is on active networks. The graduate school has been an important factor. Surprisingly, for a materials unit, there is little contact with industry. However, the international connections seem to be unevenly distributed in the unit.

Recommendations

The research directions are appropriate. More synergy between the various activities is desirable. The unit needs to actively implement its strategy, and use opportunities that arise when hiring new faculty members to strengthen activities at the interface between different unit members. In this way, the unit can grow to a size and have a focus that allows it to have strong international impact, in particular considering the low number of postdoctoral researchers and postgraduate students in the unit. Language should not be used to limit the search for good applicants, also at the faculty staff level. A more focused research profile may lead to a need to revise and focus also the courses offered to undergraduate students.

The unit needs to be more aggressive in seeking to secure external funding in order to allow for an increase in the number of postdoctoral and postgraduate researchers, which is badly needed in order to increase the research activity in the unit.

The materials chemistry research should develop closer collaborations with relevant national and international industry.

4.33 University of Turku, Organic Chemistry and Chemical Biology

Overview

The Laboratory of Organic Chemistry and Chemical Biology belongs to the UTU Department of Chemistry. The unit has a staff of three professors (bioorganic chemistry, natural products recruited in 2009, radiochemistry), some eight other senior researchers, five postdoctoral researchers and 15 full-time PhDs. The funding of the unit amounts to approximately two-thirds core funding and one-third external funding. The facilities are excellent and the unit is coordinating a national graduate school.

Research profile

The unit has two main research topics: bioorganic chemistry (nucleic acids, natural products) and radiochemistry. The organic chemistry fits well into three of the six profiling areas of UTU. The focus of the nucleic acid research is on chemical models of ribozymes, oligonucleotide conjugates, pro-drug strategies and large-scale synthesis of oligonucleotides. Natural product chemistry has been established with a new professorship very recently. The radiochemistry group is vitally integrated within the Turku PET (positron emission tomography) Centre with an excellent research environment. As for the nucleic acid chemistry, applications towards medicinal chemistry are very attractive.

Research quality

The research of the unit is of a high quality, indicated by a large number of well-cited publications in journals with high impact. The two main topics (nucleic acids and PET radiochemistry) are here by far the strongest in Finland and offer various possibilities for collaborations with biological, physical and medical research groups. Due to the very recent establishment of the natural product chemistry group, its international visibility is so far less pronounced. The future research strategy of the nucleic acid group is not very clear and has to be substantiated, especially in view of the imminent replacement of the professorship.

Research environment

The research environment is very good. Two modern NMR spectrometers are available in-house. The radiochemistry group has access to three cyclotrons, six PET scanners and one magnetic resonance imaging (MRI) machine, thanks to the excellent Turku PET Centre. The unit is equipped with various UPLC and HPLC (Ultra/High-Performance Liquid Chromatography) systems for modern and efficient separations, as well as LC/MS and GC/MS (liquid and gas chromatography MS) with detectors for positron emitting radionuclides. Additionally, thanks to the proximity of ÅA, further special instrumentation (e.g. 600 MHz NMR) can be shared with other groups.

Research networking and interaction

Collaborations are essential for the unit, especially because the research profile is unique in Finland. There are joint projects with groups in other European countries, but the unit's visibility could be further enhanced. The establishment of a national graduate school is a great merit for the unit and supports the mobility of PhD students. However, the recruitment of senior researchers, lecturers and postdoctoral researchers still shows a strong preference to stay at the same university.

Recommendations

The unit should continue its interesting research on nucleic acids and radiochemistry. The pro-drug strategy for nucleotide phosphoesters is attractive, but should be directed more at pharmaceutical and medical applications. The radiochemistry group is an essential and vital partner for the PET Centre at UTU. Synergies with similar research at UH should be highlighted. The perspective of the personnel structure of the nucleic acid unit should be discussed within the next months. The panel strongly recommends open calls for all senior positions, which should be published internationally.

4.34 University of Turku, Synthetic Drug Chemistry (not interviewed)

Overview

The Laboratory of Synthetic Drug Chemistry is part of the Department of Pharmacology, Drug Development and Therapeutics at the UTU Institute of Biomedicine. It has a staff of one professor, approximately two senior researchers and one postdoctoral researcher and some five PhD students. The funding of the unit is about two-fifths core funding and three-fifths external funding. The unit is involved in two national graduate schools.

Research profile

The unit works in the field of synthetic organic chemistry with the aim of producing biologically active pharmaceuticals and fine chemicals. The research is focused on enzyme-catalyzed reactions with the application of hydrolases, oxynitrilases and peroxidases in kinetic resolutions. This methodology allows for the asymmetric formation of C–C, C–N and C–O bonds and is of current interest in organic chemistry.

Research quality

The research of the unit is of a good quality, and the number of articles in refereed journals increased remarkably in 2009 and is reasonable for the personnel resources. Importantly, publications appear in journals visible for the general readership in organic chemistry, for example in Tetrahedron and Organic Letters. Enzyme-catalyzed reactions are not investigated by other groups in Finland, giving the unit a unique research profile.

Research environment

The unit is well equipped with state-of-the-art instrumentation for preparative work and analytics, such as a microwave reactor, a polarimeter, gas chromatography, and HPLC (high-performance liquid chromatography). NMR (400–600 MHz) and liquid chromatography-mass spectrometry (LC-MS) is only available at the UTU Department of Chemistry, which might be a logistic problem.

Research networking and interaction

The unit has some national collaboration, mainly with groups from ÅA and UTU. Participation in two COST actions is very important and allows for student exchange with Milano, Italy. However, the number of visiting researchers decreased remarkably during the last two years in the review period, and all senior researchers, lecturers and postdoctoral researchers graduated from the UTU.

Recommendations

The unit should continue its research on biocatalysis, especially enzyme-catalyzed reactions, which is an attractive field in organic chemistry. This gives the unit a unique research profile in Finland. Testing of compounds towards their biological activities should be pursued, ideally in collaboration with pharmaceutical companies. Recruitment of PhDs and postdoctoral researchers from other places is strongly recommended. The perspective of the personnel structure of the unit should urgently be discussed, since the head of the unit will soon retire.

4.35 VTT Technical Research Centre of Finland, Process Chemistry

Overview

VTT is a large government organisation with the aim of providing applied research and bridging the gap between academic research and industrial development. It has experienced several reorganisations during its history, the latest being the introduction of VTT group structure in 2010. Before that, VTT changed into a matrix organisation in 2006 and this assessment therefore covers only the period 2006–2009. The Process Chemistry Knowledge Centre was one of the 46 Knowledge Centres of that

organisation. Another organisational change relevant here is that part of KCL (Oy Keskuslaboratorio – Centrallaboratorium Ab, a major pulp and paper research institute) was integrated into VTT in 2009.

The average personnel resources of the unit during the period were in total slightly less than 50 FTE, of which four were chief researchers, 32 research scientists, four research engineers, and eight technical personnel. About 27 per cent of the researchers had a PhD degree. The merger with KCL increased these numbers with some 15 FTE.

Of the total funding resources during the evaluation period, one-third was core funding and two-thirds external funding. The latter includes funding from industry (40% of total funding), Tekes funding (18%) and EU funding (5%), the remaining sources being marginal. However, funding from the Academy of Finland increased from 1 per cent to 2 per cent during the period.

Research profile

Process chemistry research covers the whole value chain from raw material characterisation, fractionation of target raw materials and further processing to applications. It covers the following set of technological competencies: polymer and chemical products, chemical processes and models, natural materials and their processing, and biomass fractionation, which also includes agricultural raw materials. In 2009, some 30 per cent of the research was contract research for different customers, while joint projects funded mainly by Tekes and the EU but also by the Academy of Finland accounted for 55 per cent. Of the projects, 15 per cent are self-financed when jointly funded projects are included, whereas only a minor fraction of the projects are totally self-financed (using VTT budget funding). The amount of basic research conducted by the unit has increased, especially the number of applications to the Academy of Finland. Also, the VTT Graduate School, started in 2009, will enhance the scientific – and in that sense the more basic – research portfolio.

Research quality

The quality of the work is quite satisfactory. The publication output would be small for a university unit of comparable size, but given the number of patents applied for, the research activity and publication output are good. The quality of articles published in international journals is good and they are published in respected journals in their field. The increased focus of VTT on basic research has both positive and negative sides: the organisation is in this way building a more solid scientific base for its application-driven research, but is also to an increasing extent competing with other research units, making the division of roles between the VTT and university research units less clear.

The panel noted that the patenting strategy has changed, and that now the unit is concentrating on fewer but "heavier" patents, putting more emphasis on quality than quantity. The panel supports this shift in focus.

Research environment

The infrastructure is very good and the costs for maintaining, running and renewing the infrastructure are covered by external funding. There is a general positive feeling about this. There is also good administrative and technical support.

Education is not the primary task of this unit, but recently a VTT graduate school has been founded: VTT pays full-time PhD students who perform their research at VTT under the supervision of a VTT researcher with a PhD degree and in collaboration with a university professor (since VTT does not give any degrees). Nearly half of the researchers with PhD degrees are also adjunct university professors. It might be advisable to push for more professor appointments to strengthen the link to the academic environments, in particular for the sake of the students.

Research networking and interaction

The national networking is good, and many chemistry units collaborate with VTT. Some of the national collaboration is realised in the form of the Centre of Excellence on White Biotechnology-Green Chemistry. International networking is not as good, despite a very active involvement in EU programmes. There is good interaction with (mainly domestic) industry. However, mobility is a challenge; this is also due to the Centre structure with classified research versus non-classified research.

Recommendations

The unit tackles a large number of fields. This can give the impression that there is a great deal of fields with the prefixes "bio" or "green". The unit needs to develop a focused research strategy and define core competency areas. The interaction with universities (especially through the presence of VTT members as adjunct professors) should be encouraged. VTT needs to define a clear dissemination strategy for communicating scientific quality, since 30 per cent of the organisation's funding comes from public sources (including Tekes).

4.36 Åbo Akademi University, Analytical Chemistry

Overview

The Laboratory of Analytical Chemistry belongs to the ÅA Department of Chemical Engineering. It is one of the four units that constitute the Process Chemistry Centre (PCC) of ÅA, a Centre of Excellence of the Academy of Finland in 2000–2005 and 2006–2011 (in the second period within the framework of "Sustainable Chemistry in Production of Pulp and Paper, Fuels and Energy, and Functional Materials").

In the evaluation period the unit has had an average staff of 2–4 professors, two senior researchers and about three postdoctoral researchers, as well as ten PhD students. The unit is supported by a part-time (75%) administrative staff member and two technicians.

Of the unit's annual budget, less than one-third comes from core funding. The main portion of external funding is split fairly evenly between the Academy of Finland/graduate schools and Tekes funding. In recent years, there has been a substantial increase in funding from industry.

Research

The research in the unit is concerned with basic studies of chemical sensors applied in process analytical chemistry and environmental, online and healthcare applications. One of the aims is to develop methods that allow for in situ spectroelectrochemical measurements.

Research quality

The research quality of the unit is excellent. The unit produces a large number of high-quality scientific papers each year, and these papers have an impressive impact on research in the field of analytical chemistry.

The different units of the PCC work well together and have a number of joint projects. The panel got the impression that the PCC is a truly collaborative effort between excellent research teams supported by a jointly shared administrative level. The scientific productivity of the PCC is overall quite high and the different senior researchers have a good international reputation.

Research environment

The research infrastructure is very good, especially considering the opportunities of the joint UTU and ÅA campus as well as the opportunities offered through Turku Science Park. The unit largely has access to all of the state-of-the-art equipment it needs. The panel was particularly impressed by the commitment of the City of Turku to developing a strong scientific research environment in Southwest Finland through its investment in and support for Turku Science Park.

Research networking and interaction

The collaborations inside Finland are good, although some potential collaborative partners are limited due to the competition for the same funding opportunities within their own specialised fields. The international relations are very good. The recruitment of senior researchers seems to have a preference for people with a background from ÅA. The faculty members actively use opportunities for sabbaticals, although the possibilities for funding the sabbaticals are considered too limited. The panel notes that many different motivations prevent PhD/postdoctoral mobility, to some extent hampering the exchange of internal PhD students/postdoctoral researchers.

Recommendations

This is an excellent unit that should maintain its strategy and high standard of research. The panel encourages the unit to more strongly recruit senior staff members from outside ÅA and also from outside Finland.

4.37 Åbo Akademi University, Industrial Chemistry and Reaction Engineering

Overview

The Laboratory of Industrial Chemistry and Reaction engineering in the Department of Chemical Engineering is one of the four units that constitute the Process Chemistry Centre of ÅA, a Centre of Excellence of the Academy of Finland in 2000–2005 and 2006–2011 (in the second period within the framework of "Sustainable Chemistry in Production of Pulp and Paper, Fuels and Energy, and Functional Materials").

In the evaluation period, the unit had an average staff of two professors, five senior researchers and about eight postdoctoral researchers. The unit also had an impressive 25 PhD students. The unit is supported by a full-time administrative staff member, but no technicians.

Of the annual budget, little more than 20 per cent comes from core funding. The majority of the external funding comes from industry, accounting for roughly 40 per

cent of the total budget. Considering the large amount of industrial funding, the funding from Tekes is at a fairly low level, accounting for some 10 per cent. The remaining external funding comes from the Academy of Finland and the graduate school.

Research

Industrial Chemistry and Reaction Engineering is one of the largest groups in the PCC. One of the main topics is applied heterogeneous catalysis, but also chemical kinetics and chemical reactor modelling. The focus is increasingly on green chemistry and green process technology. This implies different means of intensification: micro- and millireactors, intensification through the use of ultrasounds or microwaves, and supported ionic liquid catalysis.

Research quality

The research quality of the unit is excellent. The unit produces a fairly high number of high-level publications each year, although there is only just over one publication produced per year if divided by the number of professors/senior researchers/ postdoctoral researchers/PhD students in the group, which is fair. The publications are in general highly cited, creating an international impact.

The different units of the PCC work well together and have a number of joint projects. The panel got the impression that the PCC is a truly collaborative effort between excellent research teams supported by a jointly shared administrative level. The scientific productivity of the PCC is overall quite high and the different senior researchers have a good international reputation.

Research environment

The research infrastructure is very good, especially considering the opportunities of the joint UTU and ÅA campus, as well as the opportunities offered through Turku Science Park. The unit largely has access to all of the state-of-the-art equipment it needs. The panel was particularly impressed by the commitment of the City of Turku to developing a strong scientific research environment in Southwest Finland through its investment in and support for Turku Science Park.

Research networking and interaction

The collaborations inside Finland are good, although some potential collaborative partners are limited due to the competition for the same funding opportunities within their own specialised fields. The international relations are very good. However, the recruitment of senior researchers seems to be almost exclusively from ÅA. The faculty members actively use opportunities for sabbaticals, although the possibilities for funding the sabbaticals are considered too limited. The panel notes that many different motives prevent PhD/postdoctoral mobility, to some extent hampering the exchange of internal PhD students/postdoctoral researchers.

Recommendations

This is an excellent unit that should maintain its strategy and high standard of research. The panel encourages the unit to more strongly recruit senior staff members from outside ÅA and also from outside Finland.

4.38 Åbo Akademi University, Inorganic Chemistry

Overview

The Laboratory of Inorganic Chemistry in the Department of Chemical Engineering is one of the four units that constitute the Process Chemistry Centre of ÅA, a Centre of Excellence of the Academy of Finland in 2000–2005 and 2006–2011 (in the second period within the framework of "Sustainable Chemistry in Production of Pulp and Paper, Fuels and Energy, and Functional Materials").

In the evaluation period, the unit had an average staff of one professor, about four senior researchers and eight postdoctoral researchers, as well as 17 PhD students. The unit is supported by three administrative staff members and seven technicians.

Of the annual budget, less than 15 per cent comes from core funding. The majority of the external funding comes from Tekes, followed very closely by industrial funding. The Academy of Finland and the graduate school programme account for some 15 per cent of the total budget of the unit.

Research

Inorganic chemistry includes two main activities: combustion and materials chemistry. Finland is well known in the design of large-scale biomass combustion units and has some of the leading companies in the field. The classical combustion reactors are fluidised beds. Beside the quite complex fluid mechanics, chemical kinetics is also quite complex, especially due to the mineral compounds included in the different biomaterials to be burned: salts and oxides produced may form a eutectic liquid under the prevalent temperature, which may induce severe fouling and corrosion. This team aims at including relatively detailed chemical kinetics in the CFD codes used to model industrial furnaces. Another part of the work concerns biocompatible materials, especially the chemistry and engineering of special kinds of glass useful in the regrowth of bone tissue.

Research quality

The quality of the research conducted in the unit is very good. However, considering the size of the unit, the number of articles published by the unit is only fair. Nevertheless, the papers are published in the relevant journals and have good international impact.

The different units in the PCC work well together and have a number of joint projects. The panel got the impression that the PCC is a truly collaborative effort between excellent research teams supported by a jointly shared administrative level. The scientific productivity in the PCC is overall quite high and the different senior researchers have a good international reputation.

Research environment

The research infrastructure is very good, especially considering the opportunities of the joint UTU and ÅA campus, as well as the opportunities offered through Turku Science Park. The unit largely has access to all of the state-of-the-art equipment it needs. The panel was particularly impressed by the commitment of the City of Turku to developing a strong scientific research environment in Southwest Finland through its investment in and support for Turku Science Park.

Research networking and interaction

The collaborations inside Finland are good, although some potential collaborative partners are limited due to the competition for the same funding opportunities within their own specialised fields. The international relations are very good. However, the recruitment of senior researchers seems to be almost exclusively from ÅA. The faculty members actively use opportunities for sabbaticals, although the possibilities for funding the sabbaticals are considered too limited. The panel notes that many different motives prevent PhD/postdoctoral mobility, to some extent hampering the exchange of internal PhD students/postdoctoral researchers.

Recommendations

This is an excellent unit that should maintain its strategy and high standard of research. The panel encourages the unit to more strongly recruit senior staff members from outside ÅA and also from outside Finland.

4.39 Åbo Akademi University, Organic Chemistry

Overview

The Laboratory of Organic Chemistry is placed within the Department of Natural Sciences at ÅA. In the evaluation period, the personnel resources have been two FTE professors, 3–4 senior researchers and postdoctoral researchers (of which several have been present as international postdoctoral research fellows for 1–2 years each), and ten FTE graduate students. The unit had a total annual average staff FTE of about 20.

The unit's funding was fairly evenly distributed between core funding and external funding, where the Academy of Finland's contribution was close to equal with that of Tekes and industry. The unit participates in several national graduate schools.

The unit is responsible for teaching organic chemistry to science and engineering students in courses at both BSc and MSc levels, with involvement of students in ongoing research. All seniors participate to some extent in the teaching activities, as do all PhD students. Examinations of MScs in the evaluation period were at three a year and PhDs were at 1–2 a year.

During the evaluation period, the unit has begun a generation change, with one professor retiring on a part-time pension. Moreover, one of the professors has been Rector of the University for the major part of the evaluation period.

Research

The research spans several timely topics: methods-oriented organic synthesis and catalysis, physical organic chemistry, derivatisation of natural products (lignans, monosaccharides) and applications thereof, as well as organic environmental chemistry with a strong component of structure determination. Despite this diversity, there is a strong common denominator in the molecular organic chemistry perspective, and collaborations between groups within the unit are active.

Research quality

The research output from the unit is outstanding, in particular considering the size of the unit and the resources available. Publications are in high-level journals with the highest impact factors for general chemistry, and they have received attention. Researchers and students from the unit participate regularly and actively in international conferences. PhDs from the unit are encouraged to work elsewhere after finishing their degree, and finding employment has not been difficult. As part of the ongoing generation change, the unit has carried out recruitment of staff graduated from the unit and with international postdoctoral experience.

The research strategy, with focused diversity in subtopics, collaborations nationally or internationally for access to additional competencies and close and productive interactions within the unit, is viable and has already resulted in good international visibility.

Research environment

The instrumental infrastructure available in the ÅA and UTU region is outstanding. The active strategy for quality in undergraduate teaching has resulted in an inflow of talented and interested students, which renders recruitment of good PhD students easier.

Research networking and interaction

PhD students are recruited from both Finland and abroad, the official teaching language of ÅA obviously not being a limiting factor at this stage. At the national level, the unit participates in four national graduate schools. Although the number of PhD students enrolled is limited, all ÅA organic PhD students benefit from all graduate schools.

The unit, by all research seniors, is actively collaborating with units in the ÅA/UTU region. At a national level, the unit is active within the organic synthesis network. Collaboration is also a means to get access to additional competencies and advanced characterisation methods. The unit's international contacts are mainly European. The unit has been and is active within COST actions as well as within the European funding network ERA-Chemistry. Several PhD students have spent a few months in a European laboratory during their studies. All research-active seniors have or have had commissions of trust at the national level or wider.

Recommendations

The unit should maintain its very high level of achievement and the focused diversity in research themes. In order to continue and improve the outstanding efficiency and quality in output achieved in the evaluation period, the amount of external funding should be secured at a substantially higher level than at present, and ideally with a higher proportion of long-term contracts. Strategies for this necessary increase should be developed and very actively pursued.

The unit could consider the "People" calls of the EU Framework Programmes, as well as other EU sources with lower administrative workloads.

4.40 Åbo Akademi University, Physical Chemistry

Overview

The Laboratory of Physical Chemistry in the ÅA Department of Natural Sciences consists of two chairs, one in the field of quantum chemistry and molecular spectroscopy, and the other in the field of chemistry, preferably physical chemistry. In the evaluation period, the unit also had an average of three senior researchers and two postdoctoral researchers, as well as 14 postgraduate students. The majority of the staff is involved in the activity of physical chemistry. Of the funding, two-thirds is external funding, coming mainly from industry, Tekes and the Academy of Finland.

Research profile

The unit has two distinct research profiles, one group focusing on theoretical and computational chemistry, working in close collaboration with a number of different experimental spectroscopy groups in Finland, and the other focusing on surface colloidal chemistry. In the latter group, the activity ranges from classical molecular modelling to macromolecular and nanosystem modelling. There is little overlap between the activities of the two groups. The physical chemistry group has strong connections to experimental activities related to synthesis, characterisation and applications of nanomaterials. Since 1995, the group holds the chair of the Graduate School of Materials Research and is a member in another graduate school. Since 2006, it also holds the chair in the Centre of Excellence for Functional Materials (FunMat). The chair in physical chemistry was announced in 2010 with an open call within the field of physical chemistry.

Research quality

The research in the unit is of mixed quality, with the physical chemistry group being very active and producing a large number of high-impact publications in the evaluation period. The group publishes both very good experimental work and more theoretical studies of relevance to its focus on colloid chemistry. The activity in the theoretical chemistry group is of a more routine nature, and is largely done based on demand from collaborating experimental groups.

A replacement for the chair in physical chemistry has recently been announced, inviting applications from all fields of physical chemistry. There is no strategy for the development or profile of the chair in physical chemistry, the decision being largely left to the international panel evaluating the applicants to the chair.

Research environment

The unit has been well equipped with supercomputing resources from the Finnish IT Centre for Science (CSC). Through Turku Science Park, the Centre of Excellence for Functional Materials and the Graduate School of Materials Research, the physical chemistry group enjoys excellent research infrastructure for its experimental activity in printing technology. As with other units in Turku, it is noteworthy that the City of Turku has helped support the establishment of Turku Science Park. The long-term funding of the unit seems stable, thanks to a healthy balance between fundamental and applied research, as well as the ongoing graduate schools and the Centre of Excellence.

Research networking and interaction

The unit has excellent national collaborations through the graduate schools that it coordinates or participates in, and locally in Turku through the leadership of the FunMat consortium. The physical chemistry group is internationally well connected. The unit has been involved in various EU projects and has also been active in establishing connections to China.

Recommendations

The panel commends the unit for announcing the position for the new chair in physical chemistry in a very open call. However, the unit should take a more active role in deciding the future profile of the chair in physical chemistry, which the panel believes should have a focus on experimental physical chemistry. In particular, the unit should consider hiring personnel with expertise that would complement the activity in the physical chemistry unit of UJ in such a manner that they together can form a strong team in the broad topic of molecule-surface interactions. The theoretical chemistry and spectroscopy group should develop a more active research programme in which they take the lead in joint theoretical/experimental investigations.

4.41 Åbo Akademi University, Wood and Paper Chemistry

Overview

The Laboratory of Wood and Paper Chemistry in the Department of Chemical Engineering is one of the four units that constitute the Process Chemistry Centre of ÅA, a Centre of Excellence of the Academy of Finland in 2000–2005 and 2006–2011 (in the second period within the framework of "Sustainable Chemistry in Production of Pulp and Paper, Fuels and Energy, and Functional Materials").

In the evaluation period, the unit has had an average staff of one professor, some three senior researchers and three postdoctoral researchers, as well as 14 PhD students. The group is supported by one administrative staff member and two technicians.

Of the unit's annual budget, about one-third comes from core funding. The majority of the external funding comes from Tekes and industry, the two funding sources contributing in total about 50 per cent of the unit's total funding. The Academy of Finland and the graduate school programme account for the remaining 20 per cent.

Research

The unit's research direction was changed two years ago, as a result of the appointment of a new professor replacing the former unit head. Analytical tools are very important, and the unit benefits from close collaboration with the ÅA Laboratory of Analytical Chemistry. The unit's work concerns the chemistry of components contained in wood, with particular attention paid to the whole value chain so that potentially valuable products in numerous parts of different kinds of biomass can be identified and their separation envisaged (e.g. lignans in the knots of spruce wood). There are also other teams in Finland focusing on this area of chemistry.

Research quality

The research quality of the unit is overall very good. The number of articles published by the unit is fair for its size, but the papers have a good impact in the relevant international scientific communities. The newly appointed professor is fairly young and has been taking over an extensive activity from his predecessor. This appears to have worked well, but it is important that the new professor can set his own research agenda. The panel noted that the research strategy for this unit appeared less consolidated than for the other units of the PCC.

The different units of the PCC work well together and have a number of joint projects. The panel got the impression that the PCC is a truly collaborative effort between excellent research teams supported by a jointly shared administrative level. The scientific productivity of the PCC is overall quite high and the different senior researchers have a good international reputation.

Research environment

The research infrastructure is very good, especially considering the opportunities of the joint UTU and ÅA campus, as well as the opportunities offered through Turku Science Park. The unit largely has access to all of the state-of-the-art equipment it needs. The panel was particularly impressed by the commitment of the City of Turku to developing a strong scientific research environment in Southwest Finland through its investment in and support for Turku Science Park.

Research networking and interaction

The collaborations inside Finland are good, although some potential collaborative partners are limited due to the competition for the same funding opportunities within their own specialised fields. The international relations are very good. However, the recruitment of senior researchers seems to be almost exclusively from ÅA. The faculty members actively use opportunities for sabbaticals, although the possibilities for funding the sabbaticals are considered too limited. The panel notes that many different motives prevent PhD/postdoctoral mobility, to some extent hampering the exchange of internal PhD students/postdoctoral researchers.

Recommendations

This is a very good unit. However, the unit is in a critical phase considering the recent change of the chair of the unit, and it is important that the unit develop a clear strategy for defining a research profile and securing the high standard of research for which the group is well known. The panel encourages the unit to more strongly recruit senior staff members from outside ÅA and also from outside Finland.

Appendices

A. Statistics on chemistry research in Finland 2005–2009

A1. Introduction

This Appendix is based on data from the evaluation forms sent to the units (Appendix D). The form consisted of two parts. Part I requested basic quantitative data from the evaluation period: personnel resources, funding, research output, education and collaboration. Part II was for the self-assessment: the units were asked to describe their research profile and strategy, provide a SWOT analysis, give a detailed description of infrastructure, collaboration and publication activity, and outline future prospects. Only Part I data are used in this Appendix; Part II was intended for evaluation purposes only.

Although included in the statistics, the VTT Process Chemistry Knowledge Centre is in many respects not directly comparable to the other units, which are all based at universities. The Centre was also able to provide the Part I statistics for the period 2006–2009 only.

A2. The research units and their host organisations

The units

The evaluated units are listed in Table 1. Several of the universities as well as VTT have undergone restructurings during the evaluation period and the names of the units have changed thereby. However, the names of the units that are research groups rather than administrative units are such with which the units preferred to identify themselves. These are often carried over from the era preceding the restructurings. The names for the more official, administrative levels of the organisations refer to the year 2010. Some further changes are due in 2011 and are indicated in the descriptions of the universities.

Aalto University (AU)

The university was established in 2010, when Helsinki University of Technology (TKK), Helsinki School of Economics, and the University of Art and Design Helsinki were merged. It has 20,000 students and a staff of 4500, of which 300 are professors. The Aalto University School of Science and Technology, the former TKK, has 15,000 students. The other two schools are the Aalto University School of Economics and the Aalto University School of Art and Design. As of 2011, the School of Science and Technology will be divided into four schools: School of Engineering, School of Chemical Technology, School of Science, and School of Electrical Engineering. This more or less corresponds to the faculty structure of 2010: Faculty of Engineering and Architecture, Faculty of Chemistry and Materials Sciences, Faculty of Information and Natural Sciences, and Faculty of Electronics, Communications and Automation.

Due to the restructurings, the names of subunits are somewhat unsettled. Until the end of 2007, TKK had twelve departments divided into more than 100 laboratories. Since 2008, there were four faculties, whose 25 subunits were called departments. In some cases, these corresponded roughly to the old departments, in other cases to new groupings of previous laboratories. Each department had a number of subunits, often termed 'research groups'. These more or less corresponded to the previous laboratories. The groups still often call themselves laboratories although this name has no official status. Few changes are expected at this level when the new schools are introduced in 2011.

Lappeenranta University of Technology (LUT)

LUT was founded in 1969 and presently has 5700 students and a staff of 930. As of 2007, the university has had three faculties. The Faculty of Technology has six departments, one of which is the Department of Chemical Technology. This Department is further divided into seven research subunits.

Tampere University of Technology (TUT)

TUT has some 12,000 students and a staff of 1800. It was founded as a branch of TKK in 1965 and gained full university status in 1972. Until the end of 2007, the university consisted of ten departments and 35 institutes. As of 2008, there are five faculties and 22 departments. In some cases, the new departments correspond partly to certain former institutes, while in other cases institutes have been combined or their profile otherwise changed. The Faculty of Science and Environmental Engineering contains five departments. The Department of Chemistry and Bioengineering combines the former institutes of Materials Chemistry and Environmental Engineering and Biotechnology.

University of Eastern Finland (UEF)

UEF has two main campuses in Joensuu and Kuopio and a smaller one in Savonlinna. The university was formed in 2010 by a merger of two previously independent universities in Joensuu and Kuopio. It has about 14,000 students and a staff of 1400. There are four faculties. The Department of Biosciences and the Department of Chemistry are among the seven departments of the Faculty of Science and Forestry, while the School of Pharmacy is one of the three departments in the Faculty of Health Sciences.

University of Helsinki (UH)

UH is the oldest and largest Finnish university and has 35,000 students and a staff of 7600. Its eleven faculties are hosted by four main campuses: City Center, Meilahti, Kumpula and Viikki. The Faculty of Science in Kumpula contains the Department of Chemistry. The Faculty of Agriculture and Forestry is located at the Viikki Campus and is divided into four departments, including the Department of Food and Environmental Sciences. This structure started in 2010 after the merger of the Department of Food Technology and the Department of Applied Chemistry and Microbiology. The Faculty of Pharmacy is located at the Viikki Campus and the Division of Pharmaceutical Chemistry is among its six divisions.

University of Jyväskylä (UJ)

UJ is arranged into three campuses in Jyväskylä and has more than 15,000 students and a staff of 2600. There are six faculties and a School of Business and Economics. The Department of Chemistry is one of the four departments in the Faculty of Mathematics and Science at the Mattilanniemi Campus.

University of Oulu (UO)

UO was founded in 1958 and is the third largest university in Finland with its 17,000 students and a staff of 3100. The Faculty of Science is one of the university's six faculties and is further divided into eight departments, including the Department of Chemistry. The Department of Process and Environmental Engineering belongs to the Faculty of Technology.

University of Turku (UTU)

UTU is the second largest university in Finland and has almost 19,000 students and a staff of 3000. There are seven faculties. The Faculty of Mathematics and Natural Sciences includes the Department of Chemistry and seven other departments, while the Faculty of Medicine is divided into four main institutes, including the Institute of Biomedicine, which hosts the Department of Pharmacology, Drug Development and Therapeutics.

VTT Technical Research Centre of Finland

VTT was founded in 1942. It is the largest multitechnological applied research institute in northern Europe and has facilities in ten Finnish cities. It produces technological research, development and testing services to the private and public sector. In 2007, the institute had a turnover of EUR 230 million and a staff of 2740. VTT has undergone several restructurings. In 1994, the 39 laboratories and four divisions were replaced by nine independently accountable research institutes. In 2002, the number of institutes was further reduced to six. The organisation was again changed in 2006 into a matrix organisation where the R&D work was carried out in 46 Knowledge Centres while the function of the seven Knowledge Clusters was to facilitate cross-organisational synergy. The accounting principles were also changed. The Process Chemistry Knowledge Centre was grouped first under the Energy and Pulp & Paper Cluster with six other centres and later moved to the Biotechnology Cluster. As of 2010, VTT has been organised as VTT Group, consisting of VTT Expert Services Ltd, VTT Ventures Ltd and VTT International Ltd, including some changes in the centres and clusters.

Åbo Akademi University (ÅA)

ÅA is a Swedish-language university in Turku and has about 8000 students and a staff of 2000. Before 2010, there were ten faculties and as of 2010 three divisions. The four departments of the Division of Natural Sciences and Technology include the Department of Chemical Engineering and the Department of Natural Sciences.

Table 1. The evaluated units and their abbreviations

Aalto University, School of Science and Technology		
1	AU/Analytical	Analytical Chemistry, Department of Chemistry, Faculty of Chemistry and Materials Sciences
2	AU/ChEng	Chemical Engineering Research Group, Department of Biotechnology and Chemical Technology, Faculty of Chemistry and Materials Sciences
3	AU/Industrial	Laboratory of Industrial Chemistry, Department of Biotechnology and Chemical Technology, Faculty of Chemistry and Materials Sciences
4	AU/ForestTech	Department of Forest Products Technology, Faculty of Chemistry and Materials Sciences
5	AU/Inorganic	Inorganic Chemistry Group, Department of Chemistry, Faculty of Chemistry and Materials Sciences
6	AU/Organic	Laboratory of Organic Chemistry, Department of Chemistry, Faculty of Chemistry and Materials Sciences
7	AU/Physical	Physical Chemistry and Electrochemistry Research Group, Department of Chemistry, Faculty of Chemistry and Materials Sciences
8	AU/PolymerTech	Polymer Technology Research Group, Department of Biotechnology and Chemical Technology, Faculty of Chemistry and Materials Sciences
Lappeenranta University of Technology		
9	LUT/ChemTech	Department of Chemical Technology, Faculty of Technology: Laboratory of Chemistry, Laboratory of Product and Process Technology, Laboratory of Separation Technology, Laboratory of Membrane Technology and Technical Polymer Chemistry
Tampere University of Technology, Faculty of Science and Environmental Engineering		
10	TUT/Chemistry	Laboratory of Chemistry, Department of Chemistry and Bioengineering
University of Eastern Finland		
11	UEF/Chemistry	Laboratory of Chemistry, Department of Biosciences, Faculty of Science and Forestry (Kuopio)
12	UEF/Materials	Materials Chemistry, Department of Chemistry, Faculty of Science and Forestry (Joensuu)
13	UEF/Organic	Laboratory of Organic Chemistry, Department of Chemistry, Faculty of Science and Forestry (Joensuu)
14	UEF/PharmCh	Department of Pharmaceutical Chemistry (presently School of Pharmacy, Kuopio), Faculty of Health Sciences
University of Helsinki		
15	UH/Analytical	Analytical Chemistry, Department of Chemistry, Faculty of Science
16	UH/Ch&Bioch	Division of Chemistry and Biochemistry, Department of Food and Environmental Sciences, Faculty of Agriculture and Forestry
17	UH/Inorganic	Laboratory of Inorganic Chemistry, Department of Chemistry, Faculty of Science
18	UH/ChSwedish	Laboratory for Instruction in Swedish, Department of Chemistry, Faculty of Science
19	UH/Organic	Laboratory of Organic Chemistry, Department of Chemistry, Faculty of Science

20	UH/PharmCh	Division of Pharmaceutical Chemistry, Faculty of Pharmacy
21	UH/Physical	Laboratory of Physical Chemistry, Department of Chemistry, Faculty of Science
22	UH/Polymer	Laboratory of Polymer Chemistry ,Department of Chemistry, Faculty of Science
23	UH/RadioCh	Laboratory of Radiochemistry, Department of Chemistry, Faculty of Science
University of Jyväskylä		
24	UJ/Applied	Laboratory of Applied Chemistry, Department of Chemistry, Faculty of Mathematics and Science
25	UJ/Inorg&Anal	Inorganic and Analytical Chemistry, Department of Chemistry, Faculty of Mathematics and Science
26	UJ/Organic	Laboratory of Organic Chemistry, Department of Chemistry, Faculty of Mathematics and Science
27	UJ/Physical	Physical Chemistry, Department of Chemistry, Faculty of Mathematics and Science
University of Oulu		
28	UO/ChProcEng	Chemical Process Engineering Laboratory, Department of Process and Environmental Engineering, Faculty of Technology
29	UO/Inorg&Anal	Inorganic and Analytic Chemistry, Department of Chemistry, Faculty of Science
30	UO/Organic	Organic Chemistry, Department of Chemistry, Faculty of Science
31	UO/Physical	Physical chemistry, Department of Chemistry, Faculty of Science
University of Turku		
32	UTU/Materials	Laboratory of Materials Chemistry and Chemical Analysis, Department of Chemistry, Faculty of Mathematics and Natural Sciences
33	UTU/Organic	Laboratory of Organic Chemistry and Chemical Biology, Department of Chemistry, Faculty of Mathematics and Natural Sciences
34	UTU/DrugCh	Laboratory of Synthetic Drug Chemistry, Department of Pharmacology, Drug Development and Therapeutics, Institute of Biomedicine, Faculty of Medicine
VTT Technical Research Centre of Finland		
35	VTT/ProcessCh	Process Chemistry Knowledge Centre
Åbo Akademi University		
36	ÅA/Analytical	Laboratory of Analytical Chemistry, Department of Chemical Engineering, Division of Natural Sciences and Technology
37	ÅA/Industrial	Laboratory of Industrial Chemistry and Reaction Engineering, Department of Chemical Engineering, Division of Natural Sciences and Technology
38	ÅA/Inorganic	Laboratory of Inorganic Chemistry, Department of Chemical Engineering, Division of Natural Sciences and Technology
39	ÅA/Organic	Laboratory of Organic Chemistry, Department of Natural Sciences, Division of Natural Sciences and Technology
40	ÅA/Physical	Physical Chemistry, Department of Natural Sciences, Division of Natural Sciences and Technology
41	ÅA/WoodCh	Laboratory of Wood and Paper Chemistry, Department of Chemical Engineering, Division of Natural Sciences and Technology

A3. Profile of chemistry research in Finland

The units were asked to specify the percentage accounted for by chemistry research of all research in the unit (Table 2). For ten units, the percentage is less than 100 per cent. The smallest percentages, 25 per cent for unit 2 and 5 per cent for unit 28, indicate that these units do not consider chemistry as their focus research field. The units were then asked to divide their chemistry research between eight research fields shown in Table 2. Nine units gave only one field, a few units have research in all or almost all fields, and twelve units used the opportunity to specify additional fields.

In its assessment of the subfields of chemistry research, the panel chose to define these somewhat differently so that they better correspond to the actual research.

- Analytical, organic, physical and theoretical chemistry are all in Table 2 and in the subfield evaluations.
- Inorganic and materials chemistry in Table 2 are combined in the evaluation to one subfield, which includes radiochemistry.
- Polymer chemistry in Table 2 is rephrased as polymers and organic materials.
- In addition to industrial chemistry in Table 2, the evaluation also includes the subfield of chemical engineering.

The percentages of subfields for all units taken together are shown in Figure 1. These are averages of values in Table 1, weighted by the total chemistry research funding of each unit. The division between fields is quite uniform, the largest field being organic chemistry with 16 per cent and the smallest field being theoretical chemistry with 7 per cent.

The units were also asked to estimate the percentages of total funding targeted at basic and applied research respectively. These are illustrated in Figure 2. The overall percentages are 52 per cent for basic and 48 per cent for applied research.

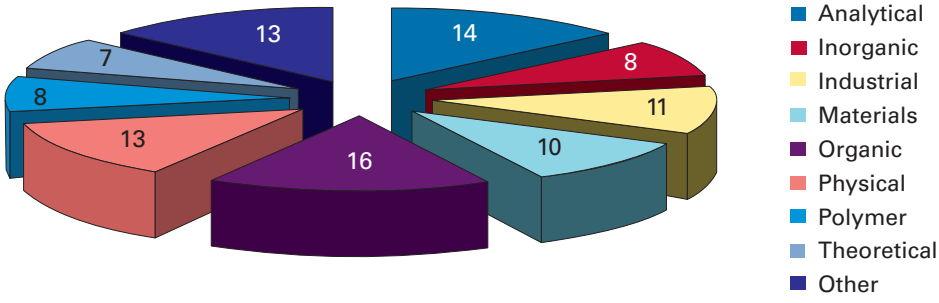


Figure 1. Profile of Finnish chemistry research, subfield percentages

Table 2. Research profiles of the evaluated units (largest percentage in bold)

		Chemistry research	Analytical chemistry	Inorganic chemistry	Industrial chemistry	Materials chemistry	Organic chemistry	Physical chemistry	Polymer chemistry	Theoretical chemistry	Other	Other, specification
1	AU/Analytical	100	**80**	0	0	20	0	0	0	0	0	
2	AU/ChEng	25	10	10	15	0	15	**50**	0	0	0	
3	AU/Industrial	100	0	0	**100**	0	0	0	0	0	0	
4	AU/ForestTech	50	5	5	20	20	5	**30**	15	0	0	
5	AU/Inorganic	100	0	**50**	0	**50**	0	0	0	0	0	
6	AU/Organic	100	0	0	0	0	**100**	0	0	0	0	
7	AU/Physical	100	0	0	0	20	0	20	0	0	**60**	Electrochemistry
8	AU/PolymerTech	100	10	0	0	0	20	0	**40**	0	30	Chemical eng.
9	LUT/ChemTech	87	**23**	11	11	1	8	19	8	3	16	Chemometrics, proc. tech.
10	TUT/Chemistry	100	0	10	0	10	20	**50**	5	5	0	
11	UEF/Chemistry	100	20	10	0	5	**40**	25	0	0	0	
12	UEF/Materials	100	2	12	0	**26**	4	18	20	18	0	
13	UEF/Organic	100	0	0	0	0	**60**	0	0	0	40	Biological Chemistry
14	UEF/PharmCh	100	**30**	0	0	0	10	0	0	**30**	**30**	Medicinal Chemistry
15	UH/Analytical	100	**95**	0	0	0	0	0	0	5	0	
16	UH/Ch&Bioch	50	20	5	0	25	10	0	40	0	0	
17	UH/Inorganic	100	0	**60**	0	40	0	0	0	0	0	
18	UH/ChSwedish	100	0	0	0	0	0	0	0	**100**	0	
19	UH/Organic	100	5	0	5	5	**80**	0	5	0	0	
20	UH/PharmCh	100	**65**	0	0	0	0	0	0	0	35	Medicinal Chemistry
21	UH/Physical	100	5	0	0	0	0	**65**	0	30	0	
22	UH/Polymer	100	0	0	0	10	0	0	**85**	5	0	
23	UH/RadioCh	90	0	0	0	0	0	0	0	0	**100**	Radiochemistry
24	UJ/Applied	90	**30**	5	10	5	20	0	5	10	15	Envir. chemistry
25	UJ/Inorg&Anal	100	20	**40**	0	10	10	0	0	5	15	Comput. chemistry
26	UJ/Organic	100	0	0	0	0	**50**	0	0	0	50	Supramol. chemistry
27	UJ/Physical	100	0	0	0	0	0	**100**	0	0	0	
28	UO/ChProcEng	5	10	**25**	20	0	20	**25**	0	0	0	
29	UO/Inorg&Anal	100	30	**50**	0	10	0	0	0	10	0	
30	UO/Organic	100	**30**	0	0	**30**	**30**	0	10	0	0	
31	UO/Physical	100	5	0	20	0	5	**35**	0	10	25	
32	UTU/Materials	100	15	**30**	0	**30**	0	20	0	5	0	
33	UTU/Organic	100	0	0	0	0	**92**	0	0	0	8	Radiochemistry
34	UTU/DrugCh	100	0	0	0	0	**100**	0	0	0	0	
35	VTT/ProcessCh	75	10	0	**35**	10	0	5	25	15	0	
36	ÅA/Analytical	100	**100**	0	0	0	0	0	0	0	0	
37	ÅA/Industrial	100	0	0	**100**	0	0	0	0	0	0	
38	ÅA/Inorganic	70	10	10	10	30	0	0	0	0	**40**	Ch. in energy tech.
39	ÅA/Organic	100	0	0	0	0	**100**	0	0	0	0	
40	ÅA/Physical	100	1	4	4	14	0	**71**	4	3	0	
41	ÅA/WoodCh	80	**35**	5	10	20	20	10	0	0	0	

How much each university or VTT represents from the whole volume of each research field is shown in Table 3. The 'Overall' line thus shows the share accounted for by each university or VTT of total chemistry research funding. The University of Helsinki and Aalto University dominate in most fields. They have also a wide spectrum with expected differences on the theoretical/industrial axis. On the other hand, the University of Eastern Finland and Åbo Akademi University have strong focus areas.

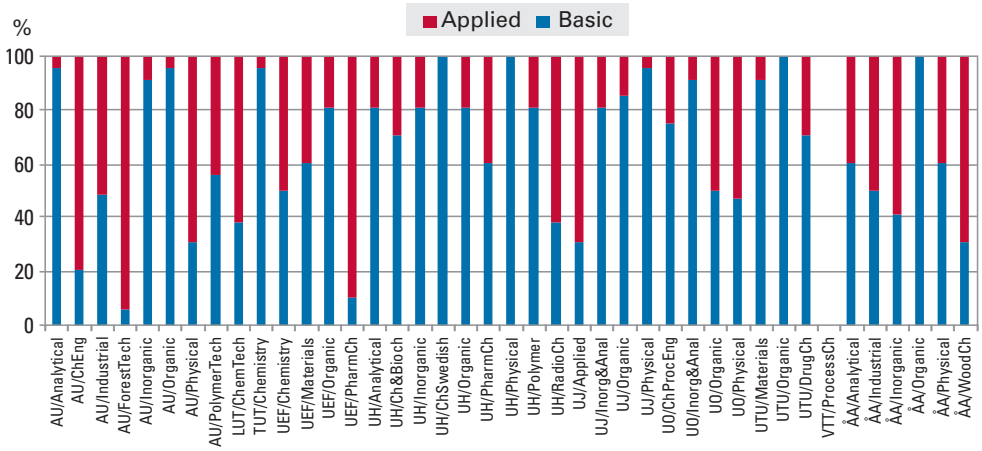


Figure 2. Distribution of research between applied and basic research, as estimated by the units

Table 3. Percentage of universities and VTT in each research field (largest value for each subfield in bold)

	AU	LUT	TUT	UEF	UH	UJ	UO	UTU	VTT	ÅA	
Analytical	8	7	0	18	**28**	5	10	2	5	16	100
Inorganic	16	6	2	10	**31**	8	14	6	0	7	100
Industrial	31	4	0	0	1	1	5	0	24	**33**	100
Materials	**22**	0	2	14	22	2	8	4	7	18	100
Organic	**20**	2	2	16	15	11	5	18	0	10	100
Physical	**23**	6	7	10	13	15	6	2	3	15	100
Polymer	20	5	1	13	**33**	1	3	0	23	1	100
Theoretical	0	2	1	**43**	28	3	5	1	15	1	100
Other	15	5	0	21	**29**	13	3	1	0	11	100
Overall	**18**	**4**	**2**	**15**	**21**	**7**	**7**	**5**	**7**	**13**	**100**

A4. Personnel resources

The units were asked to tabulate their personnel resources as person-months for different personnel categories. The average FTEs (full-time equivalents) calculated from the data are shown in Table 4. The total FTEs together with combined FTEs for research and assisting categories are in Figure 3. The total FTEs, or the size of the unit, depend partly on the choices of the evaluation, as the units may be research groups or laboratories or, in other cases, departments with several groups or laboratories. There are five units with a total FTE over 40. For four units the FTE number lies between 30 and 40, for 18 units between 20 and 30, and for 14 units below 20.

The research staff resources for the units are shown in Figure 4. The percentage of seniors of all researchers varies from 15 per cent to 90 per cent. For VTT, 'senior' is interpreted differently from the universities. The seniors are further divided to professors, postdoctoral researchers and other seniors in Figure 5. For professors, the percentage varies from 8 per cent to 70 per cent and for postdoctoral researchers from 0 per cent to 75 per cent.

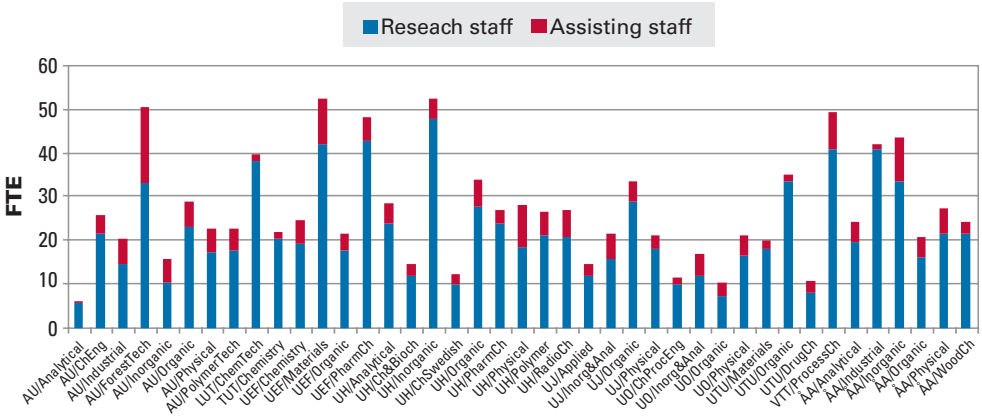


Figure 3. Total unit FTEs, divided between research and assisting staff

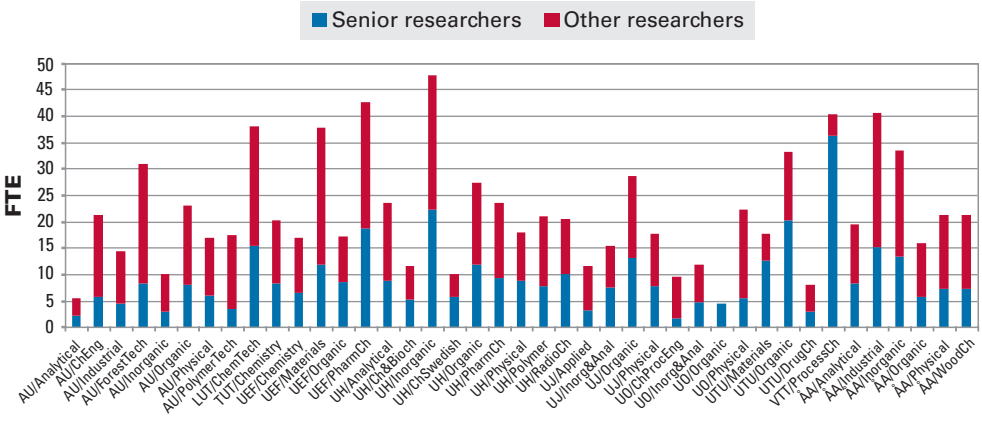


Figure 4. Research staff FTEs, divided between senior and non-senior researchers

Table 4. Average FTEs for research and assisting staff

		Professors	Other senior researchers	Postdoctoral researchers	Total senior and postdoctoral	Postgraduate students	Other graduated academic staff	Total postgrads and other	Total active research staff	Res. assist. and grad. students	Administrative personnel	Technical personnel	Total assist. admin. and techn.	TOTAL STAFF
1	AU/Analytical	1	1	0	**2**	2	1	**3**	**5**	0	0	0	0	**6**
2	AU/ChEng	1	1	4	**6**	14	1	**16**	**21**	2	1	1	**4**	**25**
3	AU/Industrial	1	0	3	**4**	10	0	**10**	**14**	4	1	1	**6**	**20**
4	AU/ForestTech	3	4	1	**8**	23	0	**23**	**33**	9	2	6	**17**	**50**
5	AU/Inorganic	2	0	1	**3**	7	0	**7**	**10**	3	1	1	**5**	**15**
6	AU/Organic	2	2	4	**8**	15	0	**15**	**23**	3	1	2	**6**	**28**
7	AU/Physical	1	2	3	**6**	10	1	**11**	**17**	3	1	2	**6**	**22**
8	AU/PolymerTech	1	1	2	**3**	14	0	**14**	**17**	3	1	1	**5**	**22**
9	LUT/ChemTech	4	5	8	**15**	19	3	**23**	**38**	1	1	0	**1**	**42**
10	TUT/Chemistry	2	3	3	**8**	12	0	**12**	**20**	0	1	0	**1**	**42**
11	UEF/Chemistry	2	3	1	**6**	10	1	**10**	**19**	0	1	4	**5**	**22**
12	UEF/Materials	4	3	9	**12**	24	2	**26**	**42**	5	1	5	**11**	**52**
13	UEF/Organic	2	0	6	**8**	7	1	**9**	**17**	0	1	3	**4**	**21**
14	UEF/PharmCh	4	10	4	**19**	22	2	**24**	**43**	2	0	3	**5**	**48**
15	UH/Analytical	2	3	4	**9**	14	1	**15**	**23**	2	1	2	**5**	**28**
16	UH/Ch&Bioch	1	3	1	**5**	4	3	**6**	**11**	1	0	2	**3**	**14**
17	UH/Inorganic	3	8	11	**22**	25	0	**25**	**47**	3	1	1	**5**	**52**
18	UH/ChSwedish	1	3	1	**6**	4	0	**4**	**10**	0	1	1	**2**	**12**
19	UH/Organic	4	2	7	**12**	15	0	**15**	**27**	0	2	4	**6**	**33**
20	UH/PharmCh	3	3	4	**9**	14	0	**14**	**24**	1	0	2	**3**	**27**
21	UH/Physical	2	2	5	**9**	9	0	**9**	**18**	7	1	2	**10**	**28**
22	UH/Polymer	2	2	4	**8**	12	2	**13**	**21**	3	1	2	**6**	**26**
23	UH/RadioCh	1	7	2	**10**	5	5	**10**	**20**	3	1	2	**6**	**26**
24	UJ/Applied	2	0	1	**3**	1	3	**8**	**11**	0	0	3	**3**	**14**
25	UJ/Inorg&Anal	2	4	2	**7**	8	0	**8**	**15**	3	1	2	**6**	**21**
26	UJ/Organic	3	4	6	**13**	15	1	**16**	**29**	2	0	3	**5**	**33**
27	UJ/Physical	2	2	4	**8**	10	0	**10**	**18**	2	0	1	**3**	**21**
28	UO/ChProcEng	1	0	0	**1**	7	1	**8**	**9**	1	0	1	**2**	**11**
29	UO/Inorg&Anal	2	2	1	**5**	7	0	**7**	**12**	0	1	4	**5**	**16**
30	UO/Organic	2	2	0	**4**	3	0	**0**	**7**	0	1	2	**3**	**10**
31	UO/Physical	2	1	2	**5**	11	1	**17**	**16**	0	1	4	**5**	**21**
32	UTU/Materials	4	6	2	**12**	5	0	**5**	**18**	1	0	1	**2**	**19**
33	UTU/Organic	4	9	8	**20**	13	0	**13**	**33**	1	0	1	**2**	**35**
34	UTU/DrugCh	1	2	0	**3**	5	0	**5**	**8**	2	0	0	**3**	**10**
35	VTT/ProcessCh	0	4	32	**36**	0	4	**4**	**0**	1	1	8	**85**	**85**
36	ÅA/Analytical	2	2	3	**8**	10	1	**11**	**19**	2	1	2	**5**	**24**
37	ÅA/Industrial	2	5	8	**15**	25	0	**25**	**41**	0	1	0	**1**	**42**
38	ÅA/Inorganic	1	4	8	**13**	17	3	**20**	**33**	0	3	7	**10**	**43**
39	ÅA/Organic	2	2	1	**6**	9	1	**10**	**16**	2	1	2	**5**	**20**
40	ÅA/Physical	2	3	2	**7**	14	0	**14**	**21**	3	1	2	**6**	**27**
41	ÅA/WoodCh	1	3	3	**7**	14	0	**14**	**21**	0	1	2	**3**	**24**
	TOTAL	**84**	**124**	**168**	**370**	**466**	**37**	**511**	**886**	**73**	**36**	**89**	**197**	**1 105**
	Per unit	**2,0**	**3,0**	**4,1**	**9,0**	**11,4**	**0,9**	**12,5**	**21,6**	**1,8**	**0,9**	**2,2**	**4,8**	**27,0**

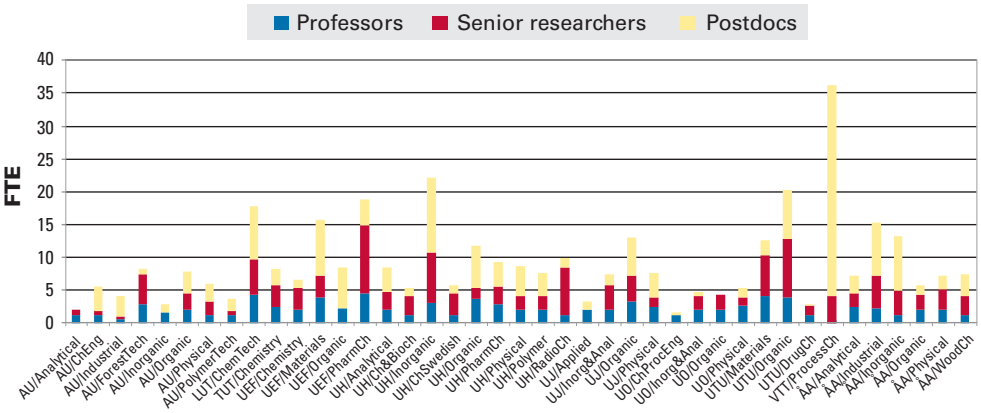


Figure 5. Senior researcher FTEs, divided between professors, postdoctoral researchers and other senior researchers

The total FTE number has changed very little during the five-year evaluation period (Figure 6). The change from 2005 to 2006 is mostly due to VTT, which did not report the 2005 figures. Figure 7 shows the FTEs for chemistry research in each university and VTT. UH has the largest resources, while AU, UEF and ÅA belong to the next size category. These four comprise about two-thirds of the total personnel resources.

The units were also asked to list senior researchers that have worked in the unit during the evaluation period (Table 5). The number of researchers listed was 616 in total (15 per unit on average), which, when compared to the total 370 FTEs of senior researchers, means that 1.7 researchers contribute to 1 FTE on average. The average stay in the units was 9.5 years.

Nearly all or 97 per cent of senior researchers have a PhD degree; the remaining 3 per cent is mainly due to VTT (70% PhDs), where senior staff are interpreted differently, and to process engineering-oriented units. The average age for obtaining a PhD is 34 years or about the same as the average age of obtaining a PhD degree

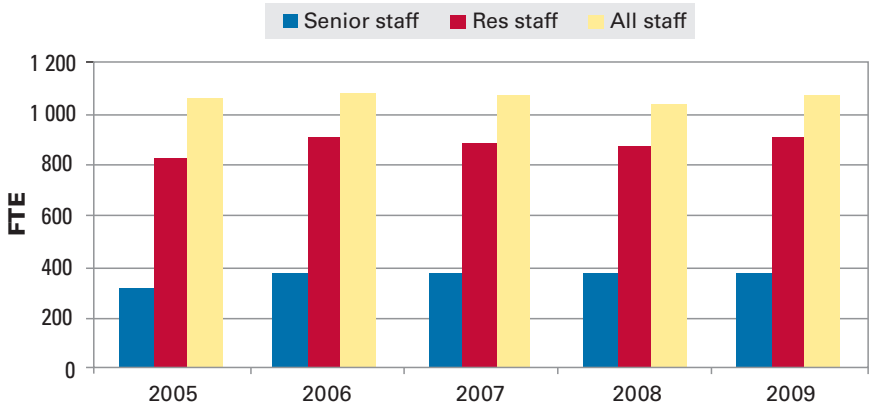


Figure 6. Changes in staff FTEs during the evaluation period

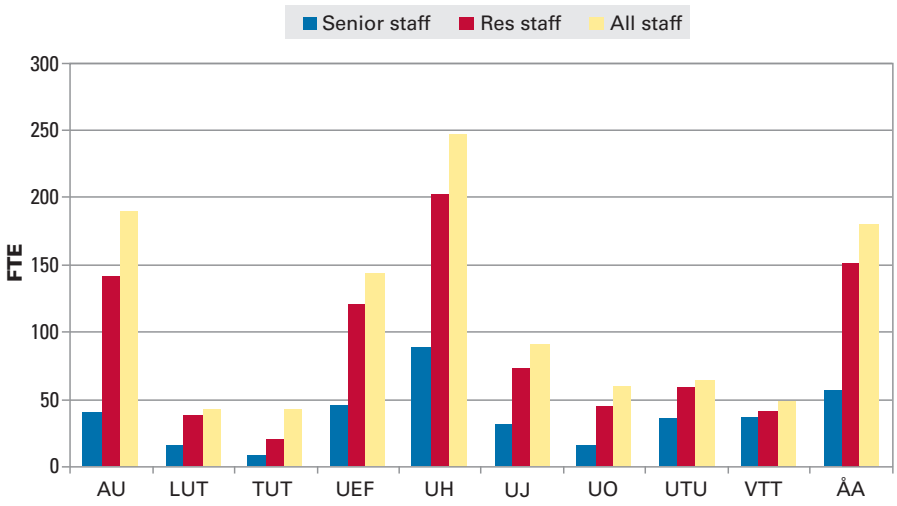


Figure 7. University and VTT FTEs

during the evaluation period (33 years, see Education). For 71 per cent, the degree was given by their present employing university and for four units this percentage was 100 per cent. For 18 per cent, the degree was awarded by a foreign university, of which 75 per cent by German, Russian, US, Indian or UK universities (Table 6).

Separating professors from the list of senior researches shows that there are 108 professors or 2.7 per unit (Table 7). The professors are on average six years older than the senior researchers overall. However, the age for obtaining a PhD is the same, 34. On the other hand, 59 per cent of the degrees are from the university of their present chair, which is somewhat less than for seniors, and 10 per cent are from foreign

Table 5. Statistics for senior researchers

Number of seniors	616
Percentage of men	66
Researchers per FTE	1.7
Average year of birth	1964
Degree awarded by same university, %	71
other Finnish university, %	11
foreign university, %	18
Year awarded, on average	1998
Stay in the unit	9.5
Age of obtaining PhD	34.1
% with PhD degree	97

universities (mainly Russia and the US), which is also less than for the seniors. This shows that there is mainly domestic mobility. On average, the professors have stayed for 13 years in their units (in any position during their careers), and have been 1.2 professors per 1 professor FTE during the five-year evaluation period.

The list of professors includes five Academy Professors and four professors emeritus. The FiDiPro Professors (visiting professors funded through the Academy of Finland and Tekes Finland Distinguished Professor Programme) are not included in the statistics. There are five FiDiPro Professors with a mean age of 58 years, with an age of obtaining a PhD at 32 years, and with an average stay of two years in the unit.

Table 6. Countries of foreign universities that have awarded PhD degree to senior researchers

GER	13
RUS	11
USA	10
UK, IND	9
ITA	5
CHI FRA POL	4
SWE CZE CAN	3
EST SPA HOL	2
CRO SLO DEN LT POR JAP AUS RO	1

Table 7. Professor statistics

Professors	108
Percentage of men	75
Professors per professor FTE	1,23
Average year of birth	1956
Degree awarded by same university, %	59
other Finnish, %	31
foreign university, %	10
Year awarded, on average	1990
Stay in the unit	13

A5. Funding

Table 8 and Figure 8 summarise the funding resources. The total overall funding to chemistry research during the evaluation period was EUR 311 million, or EUR 62 million per year. On average, the funding for one unit was EUR 7.6 million for the period and EUR 1.5 million per year. Core funding covered 45 per cent, while the external funding (55%) was distributed almost equally between the Academy of Finland, Tekes, industry and other sources. Academy funding stood at EUR 8.0 million per year and Tekes funding at EUR 8.8 million per year.

Table 8. Funding summary

K€	Period	Per year	%	Period per unit	Per unit per year
Budget	123 605	24 721	40	3 015	603
Other core	14 852	2 970	5	362	72
Total core	138 457	27 691	45	3 377	675
Academy	39 969	7 994	13	975	195
Min. Edu.	13 542	2 708	4	330	66
Tekes	44 195	8 839	14	1 078	216
Public	11 767	2 353	4	287	57
Industry	44 088	8 818	14	1 075	215
Foundations	3 641	728	1	89	18
EU	13 526	2 705	4	330	66
Other foreign	2 307	461	1	56	11
Total external	173 034	34 607	55	4 220	844
Overall	311 491	62 298	100	7 597	1 519

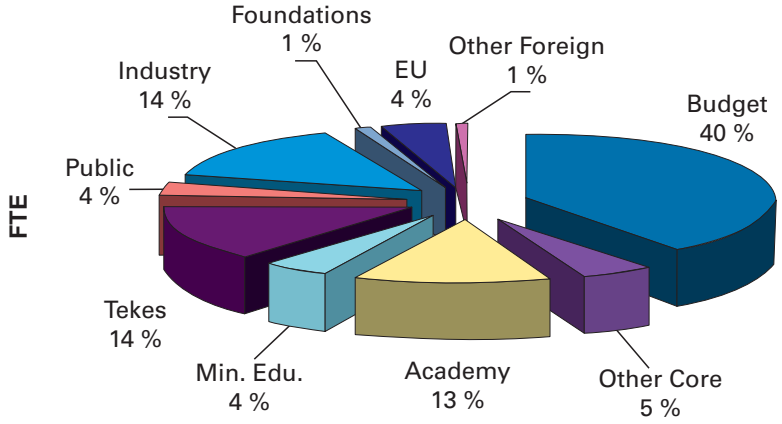


Figure 8. Overall funding structure

The funding for the units in Tables 9–11 is first illustrated in Figures 9–12, showing the annual total/core/external funding and the division of external funding between categories. The different funding structure of VTT is shown in Figure 9, as it has the largest total funding while its personnel resources are comparable to several university units. On the other hand, the external funding percentage (67%) is not especially high: there are seven university units with higher percentages (up to 87%). There are also five units with an external funding percentage lower than 30 per cent.

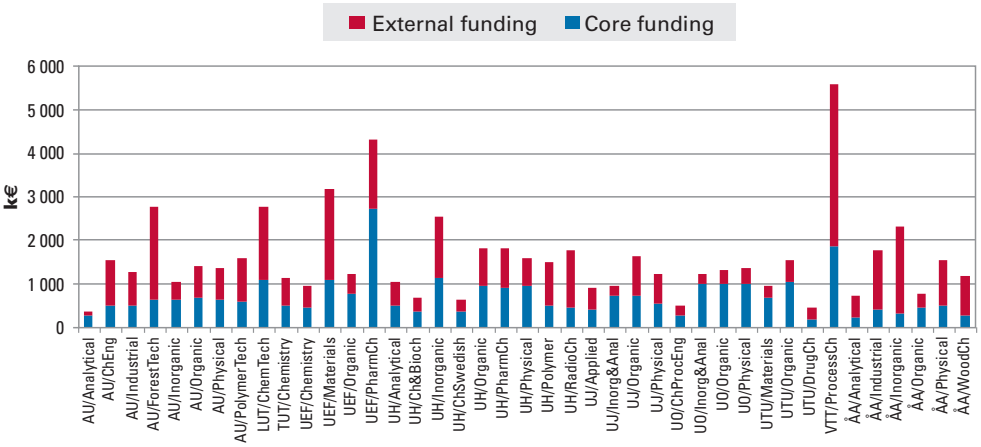


Figure 9. Average total, core and external funding per year for the evaluation period

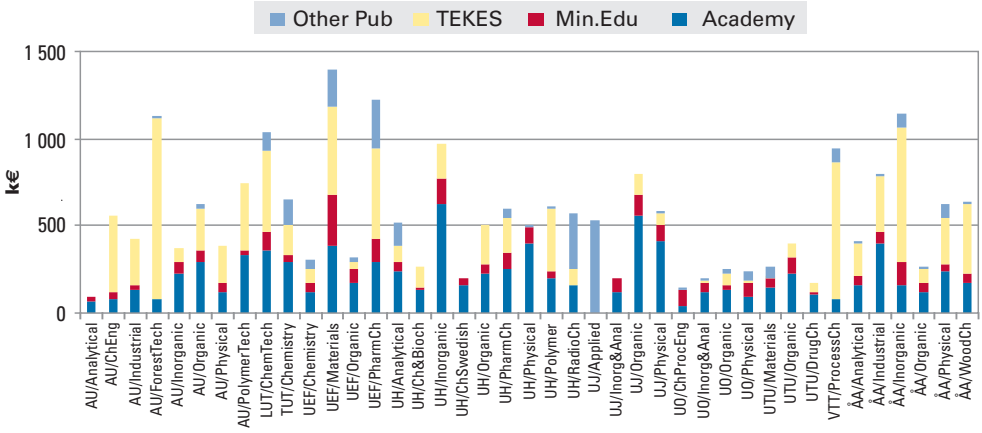


Figure 10. External funding sources, annual average (part I)

Academy of Finland funding for university units ranges from 2 per cent up to more than 30 per cent for two units and between 20 per cent and 30 per cent for eleven units. Tekes funding is more than 30 per cent for three units and 20–30 per cent for five units. Here, the units appear to fall into three categories: Academy-driven, Tekes-driven and units funded about equally by both the Academy and Tekes (Figure 12).

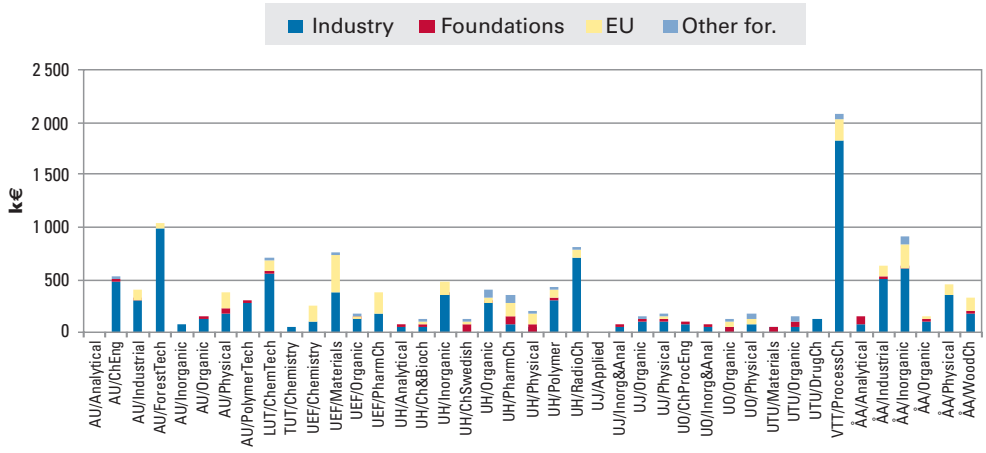


Figure 11. External funding sources, annual average (part II)

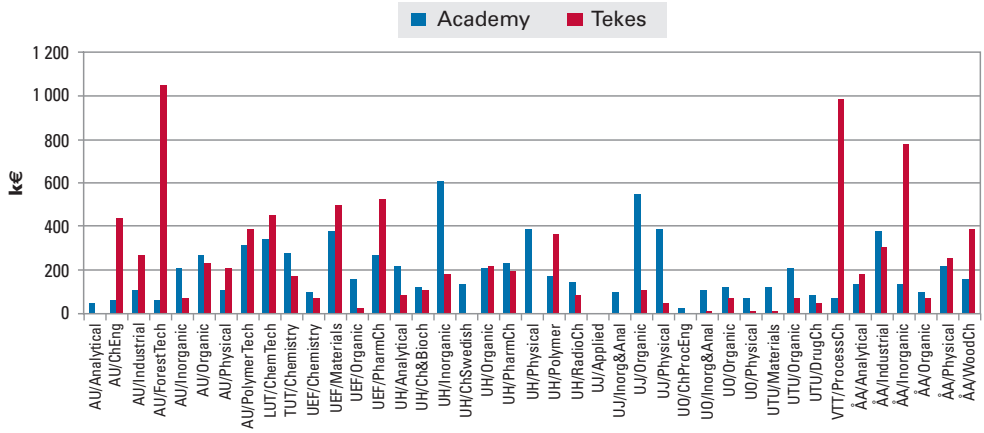


Figure 12. Funding from the Academy of Finland and Tekes

Table 9. Total, core and external funding for the units (annual average)

		Total core		Total external		Total overall
		k€	%	k€	%	k€
1	AU/Analytical	268	77	79	23	346
2	AU/ChEng	469	31	1 034	69	1 503
3	AU/Industrial	482	38	783	62	1 265
4	AU/ForestTech	627	23	2 113	77	2 740
5	AU/Inorganic	636	62	389	38	1 025
6	AU/Organic	666	49	703	51	1 369
7	AU/Physical	631	46	732	54	1 363
8	AU/PolymerTech	586	37	985	63	1 571
9	LUT/ChemTech	1 049	38	1 686	62	2 735
10	TUT/Chemistry	472	42	657	58	1 129
11	UEF/Chemistry	423	45	515	55	939
12	UEF/Materials	1 083	34	2 094	66	3 177
13	UEF/Organic	759	64	433	36	1 192
14	UEF/PharmCh	2 714	63	1 563	37	4 277
15	UH/Analytical	486	47	551	53	1 037
16	UH/Ch&Bioch	319	49	328	51	647
17	UH/Inorganic	1 106	44	1 401	56	2 507
18	UH/ChSwedish	332	55	271	45	603
19	UH/Organic	923	52	857	48	1 780
20	UH/PharmCh	895	50	901	50	1 796
21	UH/Physical	941	60	630	40	1 571
22	UH/Polymer	490	33	975	67	1 465
23	UH/RadioCh	441	25	1 317	75	1 758
24	UJ/Applied	388	43	520	57	908
25	UJ/Inorg&Anal	704	76	226	24	929
26	UJ/Organic	726	45	880	55	1 606
27	UJ/Physical	520	43	697	57	1 217
28	UO/ChProcEng	272	59	187	41	458
29	UO/Inorg&Anal	965	81	225	19	1 190
30	UO/Organic	965	75	321	25	1 286
31	UO/Physical	965	72	367	28	1 332
32	UTU/Materials	677	72	265	28	942
33	UTU/Organic	1 004	66	507	34	1 511
34	UTU/DrugCh	182	42	254	58	436
35	VTT/ProcessCh	1 836	33	3 726	67	5 562
36	ÅA/Analytical	206	28	520	72	726
37	ÅA/Industrial	378	22	1 374	78	1 752
38	ÅA/Inorganic	308	13	1 998	87	2 306
39	ÅA/Organic	412	54	347	46	758
40	ÅA/Physical	496	32	1 038	68	1 534
41	ÅA/WoodCh	260	22	902	78	1 162
	TOTAL	**28 059**	**44**	**35 352**	**56**	**63 410**

Table 10. External funding categories (annual average, part I)

		Academy		Ministry of Edu.		Tekes		Other public	
		k€	%	k€	%	k€	%	k€	%
1	AU/Analytical	52	15	27	8	0	0	0	0
2	AU/ChEng	67	4	45	3	435	29	0	0
3	AU/Industrial	115	9	31	2	269	21	0	0
4	AU/ForestTech	61	2	0	0	1 035	38	5	0
5	AU/Inorganic	208	20	72	7	71	7	0	0
6	AU/Organic	273	20	67	5	238	17	34	3
7	AU/Physical	111	8	53	4	212	16	0	0
8	AU/PolymerTech	313	20	31	2	386	25	0	0
9	LUT/ChemTech	340	12	116	4	454	17	109	4
10	TUT/Chemistry	279	25	35	3	169	15	150	13
11	UEF/Chemistry	104	11	48	5	82	9	59	6
12	UEF/Materials	375	12	284	9	502	16	215	7
13	UEF/Organic	163	14	79	7	33	3	23	2
14	UEF/PharmCh	271	6	143	3	516	12	272	6
15	UH/Analytical	220	21	64	6	88	9	125	12
16	UH/Ch&Bioch	123	19	11	2	118	18	0	0
17	UH/Inorganic	602	24	155	6	190	8	0	0
18	UH/ChSwedish	143	24	39	6	0	0	0	0
19	UH/Organic	214	12	54	3	223	13	0	0
20	UH/PharmCh	236	13	88	5	200	11	55	3
21	UH/Physical	389	25	87	6	0	0	9	1
22	UH/Polymer	179	12	43	3	365	25	2	0
23	UH/RadioCh	144	8	0	0	88	5	323	18
24	UJ/Applied	0	0	0	0	0	0	520	57
25	UJ/Inorg&Anal	105	11	85	9	0	0	0	0
26	UJ/Organic	542	34	115	7	117	7	0	0
27	UJ/Physical	392	32	102	8	57	5	10	1
28	UO/ChProcEng	27	6	86	19	0	0	24	5
29	UO/Inorg&Anal	108	9	54	5	7	1	4	0
30	UO/Organic	124	10	22	2	71	6	19	1
31	UO/Physical	74	6	81	6	10	1	61	5
32	UTU/Materials	127	13	63	7	0	0	64	7
33	UTU/Organic	205	14	98	6	75	5	0	0
34	UTU/DrugCh	92	21	11	3	55	13	0	0
35	VTT/ProcessCh	62	1	0	0	786	18	73	2
36	ÅA/Analytical	142	20	62	9	184	25	10	1
37	ÅA/Industrial	382	22	70	4	308	18	8	0
38	ÅA/Inorganic	140	6	136	6	772	33	76	3
39	ÅA/Organic	102	13	62	8	76	10	8	1
40	ÅA/Physical	226	15	44	3	254	17	90	6
41	ÅA/WoodCh	162	14	46	4	394	34	6	1
		7 994	13	2 708	4	8 839	14	2 353	4

Table 11. External funding categories (annual average, part II)

		Industry		Foundations		EU		Other foreign	
		k€	%	k€	%	k€	%	k€	%
1	AU/Analytical	0	0	0	0	0	0	0	0
2	AU/ChEng	462	31	25	2	0	0	0	0
3	AU/Industrial	261	21	8	1	99	8	0	0
4	AU/ForestTech	966	35	0	0	46	2	0	0
5	AU/Inorganic	38	4	0	0	0	0	0	0
6	AU/Organic	90	7	1	0	0	0	0	0
7	AU/Physical	150	11	55	4	151	11	0	0
8	AU/PolymerTech	243	15	12	1	0	0	0	0
9	LUT/ChemTech	524	19	18	1	116	4	10	0
10	TUT/Chemistry	23	2	0	0	0	0	0	0
11	UEF/Chemistry	67	7	0	0	155	17	0	0
12	UEF/Materials	347	11	0	0	370	12	1	0
13	UEF/Organic	91	8	13	1	29	2	3	0
14	UEF/PharmCh	142	3	0	0	219	5	0	0
15	UH/Analytical	15	1	39	4	0	0	0	0
16	UH/Ch&Bioch	23	4	30	5	14	2	9	1
17	UH/Inorganic	318	13	2	0	134	5	0	0
18	UH/ChSwedish	0	0	47	8	28	5	15	2
19	UH/Organic	237	13	22	1	36	2	71	4
20	UH/PharmCh	34	2	93	5	130	7	64	4
21	UH/Physical	1	0	40	3	100	6	4	0
22	UH/Polymer	284	19	8	1	86	6	8	1
23	UH/RadioCh	673	38	0	0	83	5	6	0
24	UJ/Applied	0	0	0	0	0	0	0	0
25	UJ/Inorg&Anal	26	3	10	1	0	0	0	0
26	UJ/Organic	75	5	10	1	0	0	22	1
27	UJ/Physical	58	5	38	3	35	3	5	0
28	UO/ChProcEng	47	10	3	1	0	0	0	0
29	UO/Inorg&Anal	7	1	45	4	0	0	0	0
30	UO/Organic	6	0	16	1	53	4	11	1
31	UO/Physical	50	4	0	0	49	4	41	3
32	UTU/Materials	1	0	10	1	0	0	0	0
33	UTU/Organic	31	2	41	3	0	0	56	4
34	UTU/DrugCh	96	22	0	0	0	0	0	0
35	VTT/ProcessCh	1 790	40	0	0	213	5	57	1
36	ÅA/Analytical	42	6	80	11	0	0	0	0
37	ÅA/Industrial	470	27	26	1	110	6	0	0
38	ÅA/Inorganic	574	25	6	0	216	9	78	3
39	ÅA/Organic	73	10	20	3	6	1	0	0
40	ÅA/Physical	328	21	0	0	96	6	0	0
41	ÅA/WoodCh	156	13	8	1	130	11	0	0
		8 818	14	728	1	2 705	4	461	1

Figure 13 shows the funding divided by personnel FTEs, for both total staff and research staff. The averages are EUR 51,000 per personnel FTE and EUR 71,000 per research staff FTE. At OU, the three latter units have shared their common core funding equally among themselves, which produces the spike for UO/Organic with a smaller staff. Taking this into account, the statistics show that the VTT resources per FTE are about twice those for university units.

Overall chemistry research funding increased by 26 per cent from 2005 to 2009 (Table 12, Figures 14–16). This is because external funding as the core funding fluctuates around a constant value. A clear trend in external funding is the increase in Academy funding. In other categories, however, no clear patterns can be discerned.

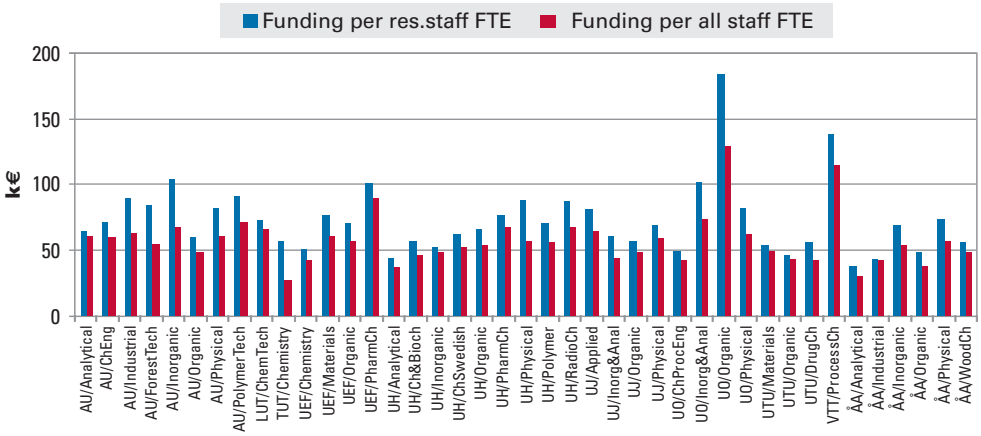


Figure 13. Funding per staff and research staff FTEs

Table 12. Changes in funding percentages during the evaluation period

	2005	2006	2007	2008	2009
Budget	42	42	40	38	37
Other core	5	6	4	5	4
Total core	47	49	44	43	41
Academy	12	10	13	14	15
Min. Edu.	4	4	4	5	4
Tekes	16	14	12	13	15
Public	3	3	5	4	4
Industry	12	14	15	15	14
Foundations	1	1	1	2	2
EU	4	4	5	4	4
Other foreign	1	1	1	1	1
Total external	53	51	56	57	59
Overall	100	100	100	100	100

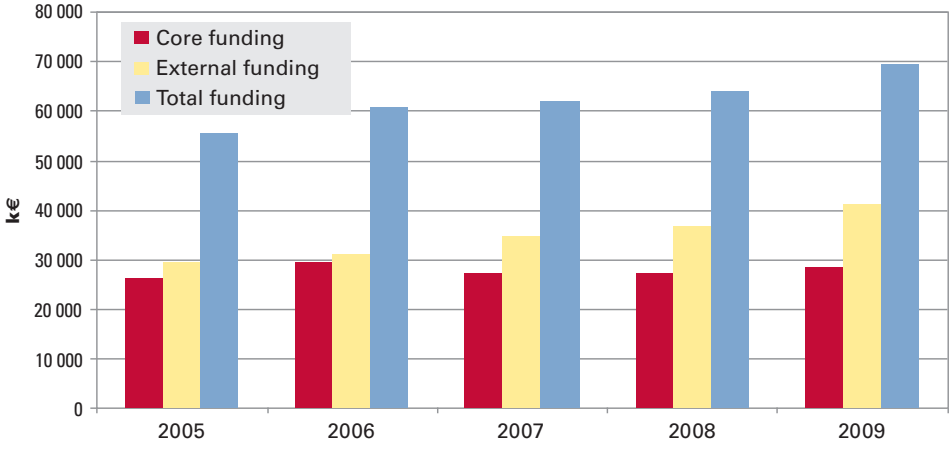


Figure 14. Total, core and external funding during the evaluation period

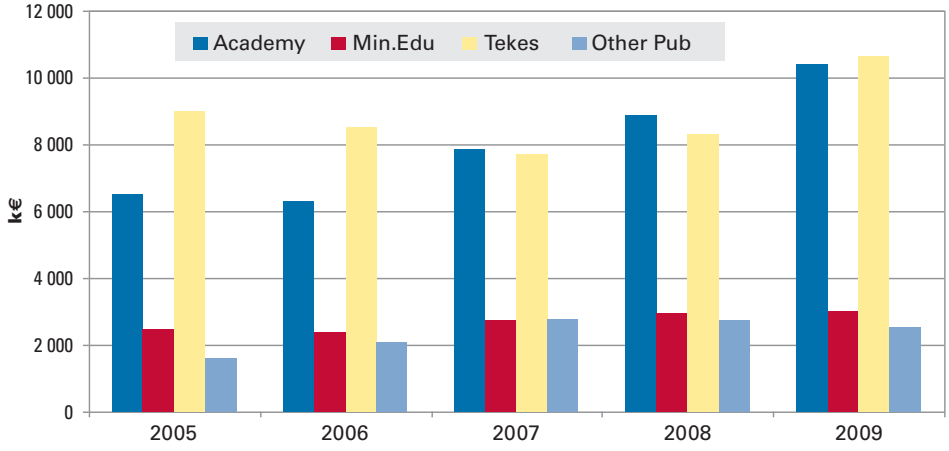


Figure 15. External funding during the evaluation period, part I

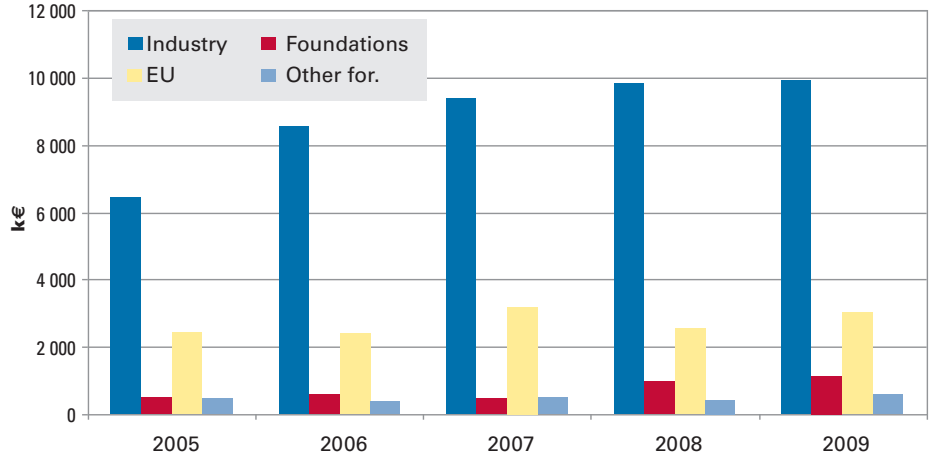


Figure 16. External funding during the evaluation period, part II

A6. Publications and other output

The units were asked to provide statistics on their publication activity for journal articles, proceeding articles and other publications, as well as statistics on patents (Table 13). In total, there were slightly fewer than 4700 articles or 23 per unit per year, and further 2.5 per senior FTE per year or 1.1 per research FTE per year. The units reported slightly more than 1000 proceedings articles. However, the distribution of this number between the units is very uneven, an apparent contributing reason being that the units have not considered this data worth collecting. The same applies even more to 'research reports' and 'other publications', for which the hundreds of publications for certain units is out of proportion in comparison with the general response. The journal and proceeding article numbers are shown in Figure 17, while the other publication numbers are too uncertain for statistical comparison.

The number of patents is quite small (Figure 18). Combining all four categories of Table 13 gives about 400 patents or two per unit per year. VTT's share is 176 patents, so the university units have one patent per year, either applied or granted.

Table 13. Publication statistics

		Journal articles	Proceeding articles	Mono-graphs	Other volumes	Research reports	Other publications	Granted nat. patents	Applied nat. patents	Granted int. patents	Applied int. patents	Other
1	AU/Analytical	26	0	0	1	0	0	1	3	3	0	1
2	AU/ChEng	65	30	0	0	9	0	0	0	0	0	0
3	AU/Industrial	46	49	0	1	0	4	0	0	0	0	0
4	AU/ForestTech	170	148	1	3	0	2	0	0	12	0	0
5	AU/Inorganic	114	3	0	0	0	1	0	0	8	0	0
6	AU/Organic	36	8	0	5	0	0	0	0	3	0	0
7	AU/Physical	81	56	0	6	0	2	0	1	0	1	0
8	AU/PolymerTech	70	56	0	1	75	3	1	7	6	7	0
9	LUT/ChemTech	206	143	6	5	82	41	1	1	5	6	22
10	TUT/Chemistry	96	1	0	1	0	0	1	0	0	1	0
11	UEF/Chemistry	137	1	4	1	3	33	1	4	0	3	0
12	UEF/Materials	243	5	0	0	0	0	0	0	0	0	0
13	UEF/Organic	69	5	0	0	0	0	0	0	0	3	0
14	UEF/PharmCh	188	0	3	0	0	0	1	1	3	0	0
15	UH/Analytical	145	30	0	6	0	0	1	0	1	11	0
16	UH/Ch&Bioch	40	14	0	1	0	2	0	0	0	0	0
17	UH/Inorganic	382	31	0	4	0	1	0	4	4	8	164
18	UH/ChSwedish	91	0	0	0	3	14	0	0	0	0	0
19	UH/Organic	114	127	0	6	0	10	1	1	0	6	0
20	UH/PharmCh	153	24	0	1	3	2	0	5	0	14	145
21	UH/Physical	121	0	0	0	0	2	0	1	0	0	0
22	UH/Polymer	92	19	0	2	0	0	1	0	0	5	10
23	UH/RadioCh	59	54	0	1	25	0	0	0	1	1	0
24	UJ/Applied	33	37	0	2	11	6	0	2	1	0	9
25	UJ/Inorg&Anal	194	4	0	11	81	1	0	0	0	0	89

Table 13. (continued)

		Journal articles	Proceeding articles	Mono-graphs	Other volumes	Research reports	Other publications	Granted nat. patents	Applied nat. patents	Granted int. patents	Applied int. patents	Other
26	UJ/Organic	210	1	11	2	3	3	0	2	0	4	1
27	UJ/Physical	106	8	0	1	1	1	1	1	2	0	0
28	UO/ChProcEng	11	15	0	1	3	3	1	0	3	0	0
29	UO/Inorg&Anal	74	10	0	4	1	7	0	0	0	0	0
30	UO/Organic	46	0	0	0	0	5	0	1	1	0	1
31	UO/Physical	79	21	0	0	2	29	1	2	0	0	0
32	UTU/Materials	84	2	0	0	13	1	2	0	2	1	0
33	UTU/Organic	200	26	0	1	0	3	0	0	2	0	0
34	UTU/DrugCh	24	1	0	1	11	0	0	0	0	0	0
35	VTT/ProcessCh	61	33	1	2	492	91	10	37	50	79	0
36	ÅA/Analytical	105	17	0	1	2	164	0	1	1	3	0
37	ÅA/Industrial	254	3	0	13	29	315	1	1	1	15	42
38	ÅA/Inorganic	106	47	0	12	23	118	0	0	1	8	35
39	ÅA/Organic	87	6	0	0	0	0	0	1	0	0	0
40	ÅA/Physical	152	3	0	2	64	0	0	1	1	1	142
41	ÅA/WoodCh	116	4	0	0	0	81	1	1	2	4	17
	TOTAL	4686	1042	26	98	936	945	26	78	113	181	678
	Per unit	114	25	1	2	23	23	1	2	3	4	17
	Per unit per year	22.9	5.1	0.1	0.5	4.6	4.6	0.1	0.4	0.6	0.9	3.3
	Per senior FTE year	2.53	0.56	0.01	0.05	0.51	0.51	0.01	0.04	0.06	0.10	0.37
	Per research FTE year	1.06	0.24	0.01	0.02	0.21	0.21	0.01	0.02	0.03	0.04	0.15

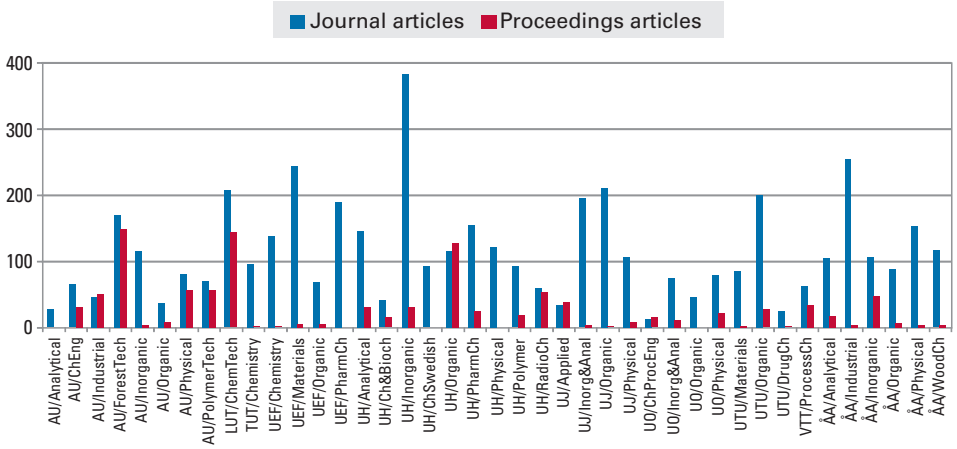


Figure 17. Journal and proceeding articles for the evaluation period

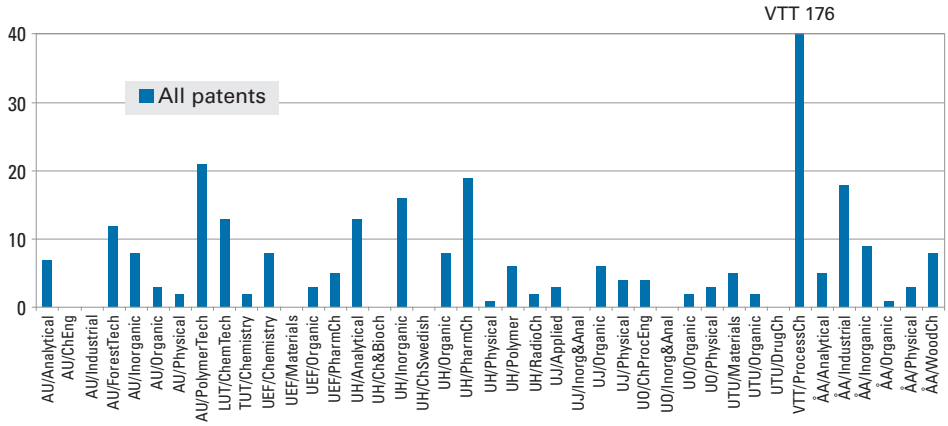


Figure 18. Patents during the evaluation period (national/international, applied/granted)

The statistics related to journal article production are shown in Table 14 and Figures 19–20. The maximum production is 8.4 articles per senior FTE per year. For one other unit this number is larger than 5 and for four units larger than 4. Dividing the total funding by the number of journal articles gives a 'k€/paper' descriptor that has an average value of 68. The lowest value is 24 and ten units have a value smaller than 50. VTT has a value of 456 while the largest numbers for university units are around 200.

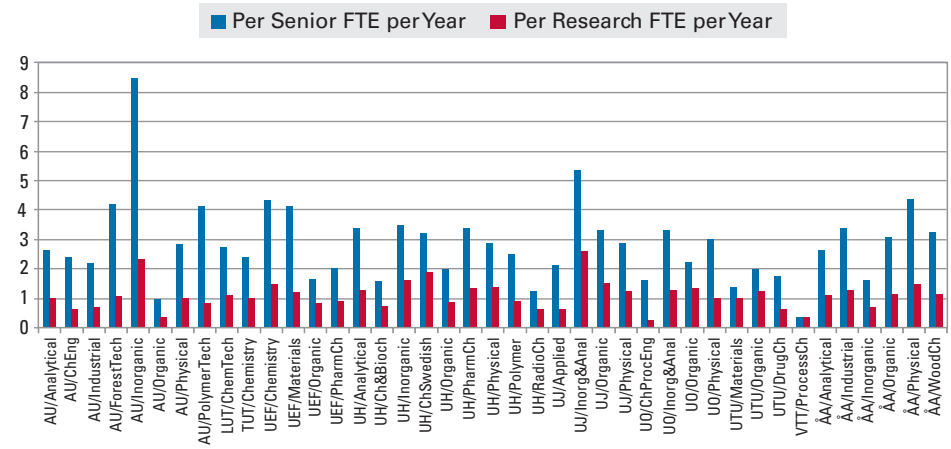


Figure 19. Production of journal articles per senior researcher FTE and research FTE

Table 14. Journal article production and efficiency

		Journal articles per year	Articles per senior FTE per year	Articles per research FTE per year	Funding per article k€
1	AU/Analytical	5.2	2.6	1.0	67
2	AU/ChEng	13	2.4	0.6	116
3	AU/Industrial	9.2	2.1	0.6	138
4	AU/ForestTech	34	4.1	1.0	81
5	AU/Inorganic	22.8	8.4	2.3	45
6	AU/Organic	7.2	0.9	0.3	190
7	AU/Physical	16.2	2.8	1.0	84
8	AU/PolymerTech	14	4.1	0.8	112
9	LUT/ChemTech	41.2	2.7	1.1	66
10	TUT/Chemistry	19.2	2.4	1.0	59
11	UEF/Chemistry	27.4	4.3	1.5	34
12	UEF/Materials	48.6	4.1	1.2	65
13	UEF/Organic	13.8	1.6	0.8	86
14	UEF/PharmCh	37.6	2.0	0.9	114
15	UH/Analytical	29	3.3	1.2	36
16	UH/Ch&Bioch	8	1.6	0.7	81
17	UH/Inorganic	76.4	3.5	1.6	33
18	UH/ChSwedish	18.2	3.2	1.9	33
19	UH/Organic	22.8	1.9	0.8	78
20	UH/PharmCh	30.6	3.4	1.3	59
21	UH/Physical	24.2	2.8	1.4	65
22	UH/Polymer	18.4	2.5	0.9	80
23	UH/RadioCh	11.8	1.2	0.6	149
24	UJ/Applied	6.6	2.1	0.6	138
25	UJ/Inorg&Anal	38.8	5.3	2.6	24
26	UJ/Organic	42	3.3	1.5	38
27	UJ/Physical	21.2	2.8	1.2	57
28	UO/ChProcEng	2.2	1.6	0.2	208
29	UO/Inorg&Anal	14.8	3.3	1.3	80
30	UO/Organic	9.2	2.2	1.3	140
31	UO/Physical	15.8	3.0	1.0	84
32	UTU/Materials	16.8	1.4	1.0	56
33	UTU/Organic	40	2.0	1.2	38
34	UTU/DrugCh	4.8	1.7	0.6	91
35	VTT/ProcessCh	15.3	0.3	0.3	456
36	ÅA/Analytical	21	2.6	1.1	35
37	ÅA/Industrial	50.8	3.4	1.3	34
38	ÅA/Inorganic	21.2	1.6	0.6	109
39	ÅA/Organic	17.4	3.1	1.1	44
40	ÅA/Physical	30.4	4.3	1.4	50
41	ÅA/WoodCh	23.2	3.2	1.1	50
	TOTAL or average	937.2	2.5	1.1	68

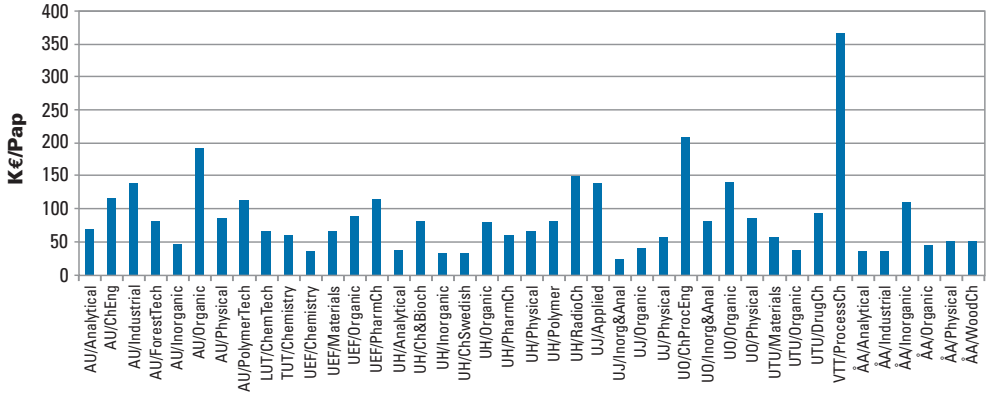


Figure 20. Funding divided by number of journal articles ('k€/paper')

The yearly numbers for journal articles are shown in Figure 21. As few changes have occurred in research staff, these numbers mirror the changes in publication efficiency. The increase after 2005 is followed by a two-year period with lesser activity; a possible reason can be the effort required by the restructuring of the universities. University patent numbers show no clear trends, while for VTT the number is decreasing.

The units were also asked to give percentages for co-authoring of journal articles, that is, for the following categories: no co-authoring outside unit, only domestic co-author outside unit, only foreign co-author, both domestic and foreign co-authors outside unit. The summarised results are shown in Figure 22. Of the journal articles, 58 per cent are domestic and a further 23 per cent from the unit only. Of the articles, 42 per cent have foreign co-authors and 11 per cent only foreign co-authors. There is a clear trend towards more international cooperation during the evaluation period.

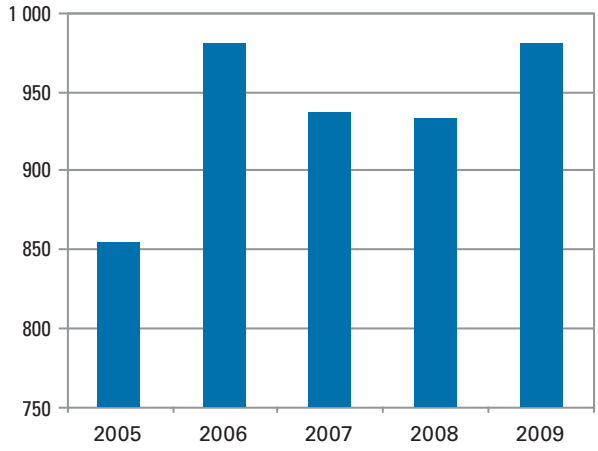


Figure 21. Journal article production during the evaluation period

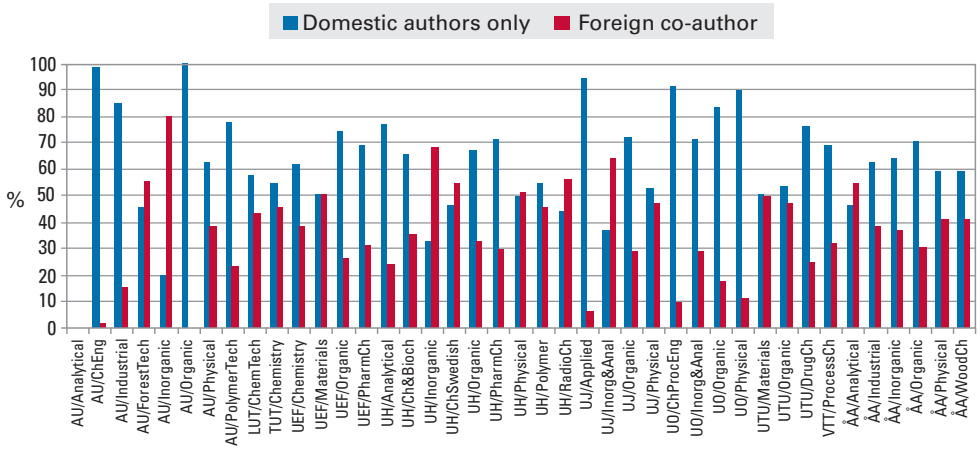


Figure 22. Percentages of journal articles with domestic authors only and with foreign co-authors

A7. Education

The units were asked to provide the number of completed MSc and PhD degrees as well as the number of postgraduate students. The completed PhD degrees were also listed with additional information such as gender, year of birth and study completion times. The units were asked whether the postgraduates are working full-time for their degree and how much those who have completed their PhD have worked in the unit.

Table 15 provides averages per year over the evaluation period: on average 6.2 MSc degrees and 1.7 PhD degrees per year per unit. For each PhD degree, there are 3.5 MSc degrees and eight students continuing with postgraduate studies. The numbers of MSc and PhD degrees and their ratio are shown in Figures 23.

The average year of birth for those who completed their PhD is 1974. The age has been about 33 years, which is about the same as for senior researchers and professors. The PhD completion time was seven years on average, which is in accordance with the postgraduates/PhD degrees ratio. Of this time, five years were unit stay. The completion times vary between 4 and 12 years among the units.

The education statistics for the evaluation period are in Table 16. There is a drop in the number of MSc degrees in the last year; it is possible that this is only due to incomplete statistics. The number of PhD degrees varies around a constant value without any trend, and the same applies to the number of postgraduate students.

The statistics show that there are 2.9 MSc degrees and 0.6 PhD degrees per one professor FTE. Dividing the total funding by degree production gives the average values EUR 236,000 per MSc degree and EUR 821,000 per PhD degree. The unit data is shown in Figure 24.

Table 15. Education statistics (number of degrees, averages per year)

		Master's degree	Postgraduate students	Full-time postgrads	PhD degree	MScs per one PhD	Postgrads per one PhD	PhD completion time	% of men of PhD degrees	Average YOB PhD degrees	PhD completion time, years	Years in unit during studies
1	AU/Analytical	0.8	2.6	1.6	0.4	2.0	6.5	5	0	1972	5	5
2	AU/ChEng	5.8	16.4	13.8	1.6	3.6	10.3	9	75	1971	9	6
3	AU/Industrial	5.4	11.4	9.2	2.2	2.5	5.2	10	45	1973	10	5
4	AU/ForestTech	8.6	33.0	23.6	2.6	3.3	12.7	7	46	1973	7	4
5	AU/Inorganic	3.4	9.0	9.0	0.8	4.3	11.3	6	75	1975	6	6
6	AU/Organic	5.4	14.2	14.2	1.6	3.4	8.9	0	50	1971	0	0
7	AU/Physical	4.4	10.0	10.0	1.4	3.1	7.1	7	57	1978	7	4
8	AU/PolymerTech	4.6	10.8	9.8	2.0	2.3	5.4	9	60	1971	9	8
9	LUT/ChemTech	13.4	28.8	19.5	4.6	2.9	6.3	7	35	1975	7	4
10	TUT/Chemistry	12.8	12.0	12.0	1.8	7.1	6.7	5	56	1974	5	4
11	UEF/Chemistry	3.6	8.2	2.4	0.8	4.5	10.3	7	75	1978	7	6
12	UEF/Materials	7.8	30.8	29.2	4.2	1.9	7.3	6	62	1977	6	5
13	UEF/Organic	4.6	0.0	0.0	1.6	2.9		5	43	1973	5	4
14	UEF/PharmCh	5.8	10.6	10.6	3.6	1.6	2.9	6	33	1976	6	5
15	UH/Analytical	19.4	25.2	11.8	2.2	8.8	11.5	9	27	1972	9	4
16	UH/Ch&Bioch	1.6	4.2	4.2	0.4	4.0	10.5	7	0	1965	7	9
17	UH/Inorganic	8.4	31.8	26.8	4.2	2.0	7.6	8	67	1972	8	6
18	UH/ChSwedish	2.0	4.8	3.4	1.0	2.0	4.8	4	80	1976	4	4
19	UH/Organic	14.6	26.8	20.0	2.8	5.2	9.6	9	38	1972	9	5
20	UH/PharmCh	6.0	32.4	22.6	2.4	2.5	13.5	7	33	1970	7	5
21	UH/Physical	5.4	0.0	0.0	1.4	3.9		8	67	1975	8	5
22	UH/Polymer	5.0	12.0	12.0	1.8	2.8	6.7	7	44	1973	7	5
23	UH/RadioCh	3.2	7.2	4.4	0.8	4.0	9.0	10	25	1966	10	9
24	UJ/Applied	9.0	22.6	13.0	0.4	22.5	56.5	7	0	1977	7	4
25	UJ/Inorg&Anal	8.8	8.8	8.0	1.2	7.3	7.3	5	50	1975	5	4
26	UJ/Organic	11.2	17.6	16.0	2.2	5.1	8.0	6	50	1974	6	4
27	UJ/Physical	4.2	12.6	9.0	0.8	5.3	15.8	6	75	1977	6	6
28	UO/ChProcEng	0.0	7.8	4.6	0.2		39.0	12	100	1968	12	11
29	UO/Inorg&Anal	11.8	13.0	8.4	3.0	3.9	4.3	7	43	1974	7	3
30	UO/Organic	7.0	7.0	7.0	0.8	8.8	8.8	7	75	1976	7	6
31	UO/Physical	5.6	13.4	11.0	0.8	7.0	16.8	6	50	1979	6	5
32	UTU/Materials	8.8	8.6	6.6	1.0	8.8	8.6	8	83	1973	8	6
33	UTU/Organic	15.8	24.0	15.8	3.2	4.9	7.5	7	50	1973	7	7
34	UTU/DrugCh	2.6	5.2	5.8	0.4	6.5	13.0	11	50	1971	11	10
35	VTT/ProcessCh											
36	ÅA/Analytical	3.2	15.6	11.8	1.4	2.3	11.1	8	38	1970	8	5
37	ÅA/Industrial	6.0	18.0	16.4	3.4	1.8	5.3	5	72	1975	5	4
38	ÅA/Inorganic	5.6	16.0	12.0	1.8	3.1	8.9	6	60	1972	6	5
39	ÅA/Organic	2.6	12.0	10.4	1.6	1.6	7.5	5	33	1977	5	5
40	ÅA/Physical	2.6	18.2	14.4	1.8	1.4	10.1	8	33	1974	8	5
41	ÅA/WoodCh	3.6	6.0	4.0	1.2	3.0	5.0	6	67	1975	6	5
	TOTAL or average	241	543	432	69	3.5	7.9	7	51	1974	7	5
	Per unit	6.2	15.1	11.4	1.7							

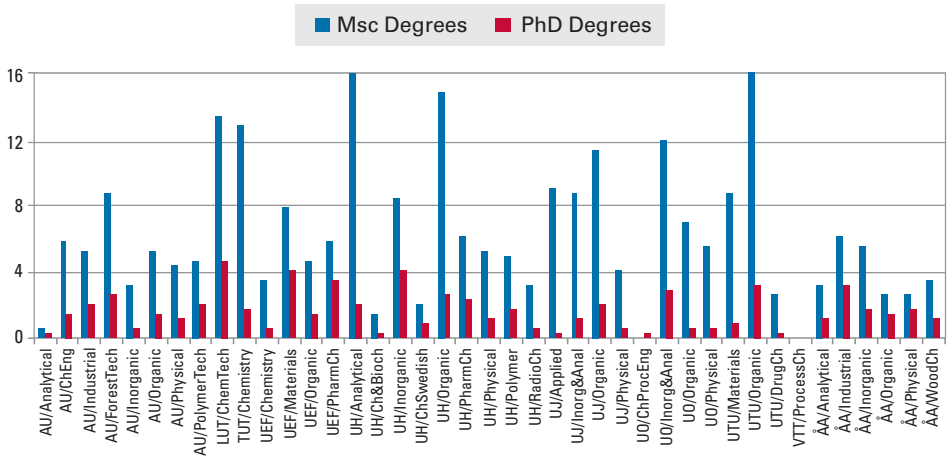


Figure 23. Degree production (averages per year)

Table 16. Annual education statistics

	2005	2006	2007	2008	2009	Total/ average
MSc degrees	234	209	254	344	167	1208
Postgraduates	551	550	531	539	548	2719
Full-time postgraduates	438	435	412	431	449	2164
PhD degrees	74	72	80	58	64	348
MSc/PhD	3.2	2.9	3.2	5.9	2.6	3.5
Postgraduates/PhDs	7.4	7.6	6.6	9.3	8.6	7.8

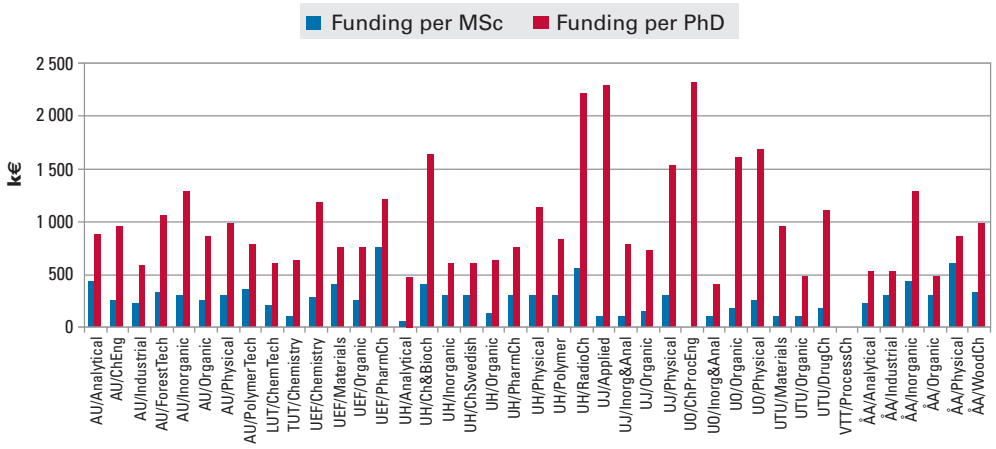


Figure 24. Funding divided by number of MSc and PhD degrees

A8. Gender issues

The average percentage of men among senior scientists is 66 per cent and among professors 75 per cent. In 21 of 41 units, there are only male professors, while in four units there are only female professors. However, no unit has a 100 per cent male or female dominance for senior scientists. Certain research fields seem to attract either men or women, but not strongly so.

The percentage of male seniors does not depend on the average year of birth of the seniors in the unit. Also, the percentage accounted for by men among senior staff does not correlate with the percentage of men among professors. There are thus no indications of gender bias, of favouring of one's own sex in staff decisions, or of old-generation gender prejudices.

Half of the completed PhD degrees are by women. This is a considerably higher percentage than the 34 per cent for senior researchers or 25 per cent for professors. There is a correlation between the percentages of men for senior scientists and PhD degrees (Figure 25). This indicates that the existing gender structure to some extent affects students' postgraduating considerations so that some units have an internal tendency to retain or strengthen male dominance while others are developing towards gender balance or female dominance.

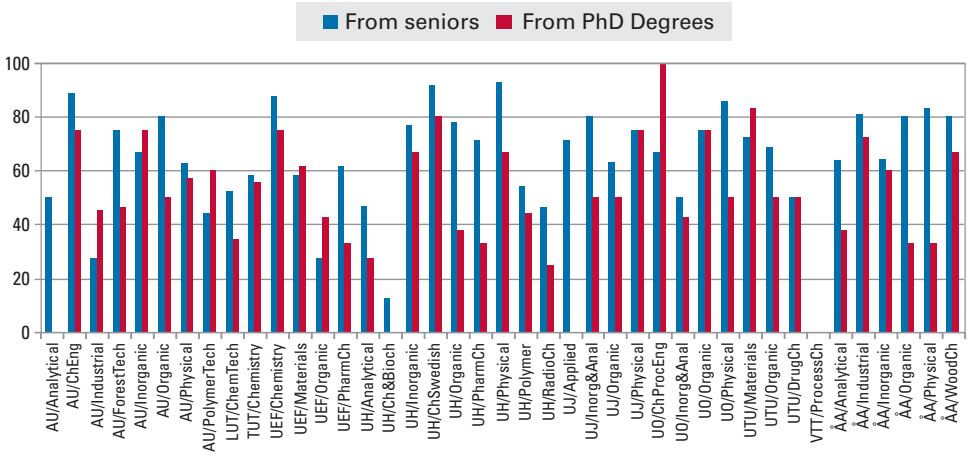


Figure 25. Proportion of men as a percentage of senior researchers and PhD degrees

A9. Scientific collaboration

The units reported more than 750 foreign collaborative partners or about 18 per unit. Five units had had more than 40 partners during the evaluation period (Figure 26). The units had an average of nine partners per professor and 4.5 partners per senior researcher. The countries for the collaborating partners were given in 702 cases (Table 17). There were in total 52 countries listed, of which the share for 28 countries is less than 1 per cent each and 13 countries are mentioned only once. Europe dominates

with 89 German and 74 Swedish partners, while the US comes in third place. The other Scandinavian countries Norway and Denmark follow the larger European countries, Russia and Japan.

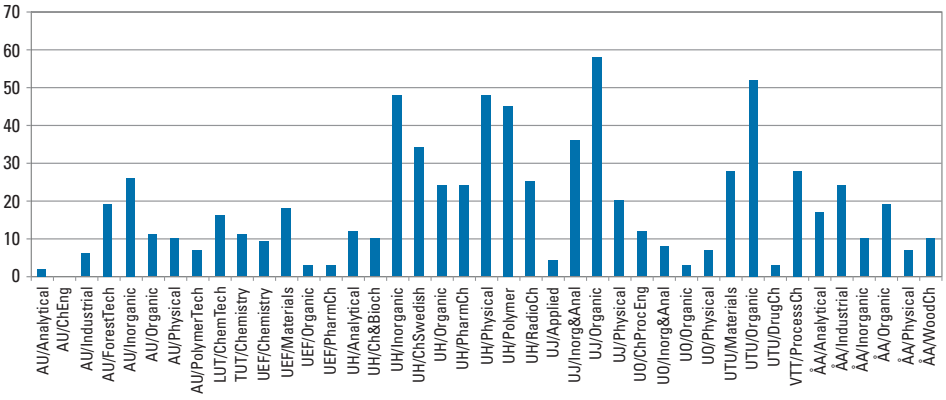


Figure 26. Number of foreign collaborative partners

Table 17. Number of partners from each country

Germany	89	Switzerland	11	South Africa	2
Sweden	74	Estonia	11	Israel	2
USA	64	Belgium	9	Egypt	2
France	36	Portugal	9	Venezuela	1
UK	34	China	8	New Zealand	1
Italy	33	Brazil	8	Pakistan	1
Russia	32	Greece	7	Uruguay	1
Spain	26	Australia	7	Belarus	1
Poland	25	Romania	4	Mexico	1
Japan	24	Ukraine	4	Iran	1
Czech Republic	24	Ireland	3	Kazakhstan	1
Netherlands	22	Slovenia	3	Croatia	1
Denmark	22	Turkey	3	Iceland	1
Norway	19	Taiwan	3	Argentina	1
Canada	17	Lithuania	3	Cuba	1
Hungary	16	Slovakia	3	Cyprus	1
Austria	13	Latvia	3		
India	12	Bulgaria	2		

The units listed 362 instances of collaboration with industrial companies and with senior researcher participation from the unit. Of these, 65 are foreign companies for which the countries are listed in Table 18. In all 19 units reported 77 cases where industrial collaboration has contributed essentially to completed postgraduate studies. This is slightly more than 20 per cent of all PhD degrees. Some non-reporting units can be assumed to have PhD degrees in this category as well, so the percentage of PhD degrees that have benefited essentially from industrial collaboration really lies between 20 and 40. The number of industrial partners was 37, of which five were from other countries. The most popular industrial partners are UPM (7), Kemira (6), VTT (6), Neste (5), Metso (4) and Stora Enso (4).

Table 18. Countries with which there has been industrial collaboration

USA	13	Switzerland	3
Sweden	12	Japan	2
Germany	8	Belgium	2
France	7	Spain	1
UK	6	Russia	1
Netherlands	5	Norway	1
Austria	3	Poland	1

The units reported 109 visits abroad (at least one month in duration) for senior researchers or about two visits per three seniors. The corresponding number for foreign visitors coming to the unit was 54 or somewhat more than one visit per unit on the average. Thus, there are two visits abroad for each countervisit to the unit. The numbers for visits abroad are shown in Figure 27. Six units have more than five visits. The statistics of the visited/visitor countries are in Table 19. The US is the most popular target country, followed by the European countries, Japan and Canada. The list of visitors' home countries looks somewhat different, Russia being number one while the countries dominating the collaboration and visits abroad lists have lower positions.

Table 19 shows visits made from and to the unit by postgraduate students (minimum stay one month). There are 124 students who have been abroad and 199 who have visited Finland. The ratio of these numbers is quite opposite to that of the senior scientists. There were 345 PhD degrees during the evaluation period, so it can be estimated that one in three postgraduate students make a longer visit abroad. However, this is an underestimate as there are probably cases among the 15 per cent of units with zero data where the visits have just been left unreported. Germany appears to dominate the international collaboration here, too. The postgraduate visits from the units correspond well to the political statistics of collaborative partners and senior visits abroad. Germany also sends the largest number of visitors, but the second place is held by Russia, which is not visited by the units at all, while the Czech Republic, Hungary and Poland have altogether 34 visits to the unit and only three visits from the unit. This indicates that a certain part of postgraduate visits are related to PhD studies only and are not based on existing scientific collaboration and do not help to generate such.

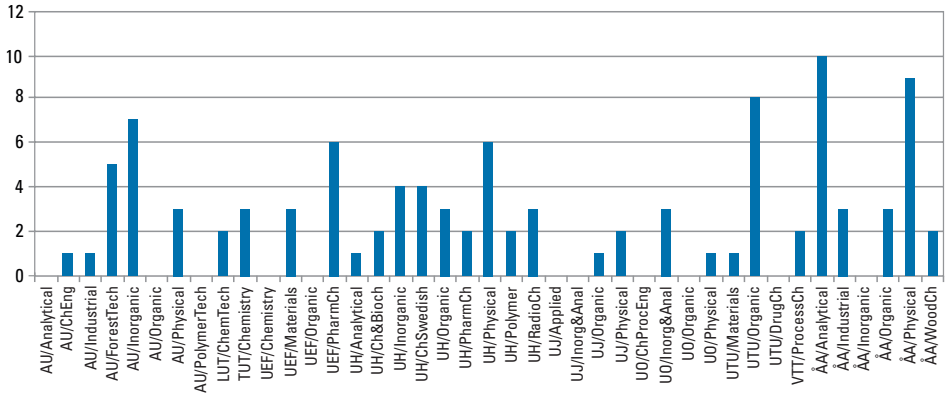


Figure 27. Visits abroad

Table 19. Countries visited and visitor countries

Senior visits abroad		Senior visits to the unit		Postgraduate visits abroad		Postgraduate visits to the unit	
USA	12	Russia	8	Germany	27	Germany	26
Germany	11	Spain	6	USA	14	Russia	18
Japan	9	Poland	5	Sweden	12	Spain	17
France	9	Japan	5	Japan	11	France	16
Denmark	7	China	5	France	10	Czech Rep.	13
Sweden	7	USA	4	Canada	8	Hungary	12
Canada	7	Sweden	3	UK	6	Italy	10
Netherlands	6	France	3	Spain	6	Poland	9
Spain	5	Italy	2	Netherlands	5	USA	8
UK	4	Iran	2	Australia	4	Sweden	7
Italy	4	Germany	2	Switzerland	3	Portugal	6
Russia	4	Australia	2	Norway	3	UK	5
Hungary	3	UK	1	Greece	2	Netherlands	5
New Zealand	3	Switzerland	1	Austria	2	Australia	4
Czech Republic	2	Slovenia	1	Denmark	2	Chile	4
Poland	2	Mexico	1	Italy	2	Turkey	4
Uruguay	1	Egypt	1	Hungary	2	Slovenia	3
Estonia	1	Brazil	1	China	2	Romania	3
Slovenia	1	Argentina	1	Belgium	1	India	3
Switzerland	1			Czech Rep.	1	Estonia	3
Austria	1			Ireland	1	China	3

Table 19. (continued)

Senior visits abroad		Senior visits to the unit		Postgraduate visits abroad		Postgraduate visits to the unit	
China	1					Norway	2
Australia	1					Latvia	2
						Slovakia	2
						Bulgaria	2
						Uruguay	1
						Greece	1
						Columbia	1
						Panama	1
						Jordan	1
						Switzerland	1
						Serbia	1
						Brazil	1
						Japan	1
						New Zealand	1
						Venezuela	1
						Kuwait	1

B. Curricula vitae for the panel members

Professor Claudine Buess-Herman, Université Libre de Bruxelles, Belgium

Claudine Buess-Herman is Full Professor of Analytical Chemistry at the Faculty of Sciences of the Université Libre de Bruxelles (ULB). She got her PhD from ULB in 1978 and was appointed from assistant, lecturer to Full Professor in 1997. Since 1989, she directs the Laboratory of Analytical and Interfacial Chemistry. Her research interests are in electrochemistry and interfacial chemistry with activities that are mainly focused on the modification of surfaces for the optimisation of processes such as electrocatalysis, sensing or electrodialysis. She has published six monographs and more than 80 reviewed papers and 120 conference proceedings. She has served as Division Officer and National Secretary of the International Society of Electrochemistry and has long been a member of the Board of the Journal of Electroanalytical Chemistry. She has been active as an expert for the EU (NANOPHEN 6th programme), NATO, the International Science Foundation, the European Space Agency (ESA) and several national science foundations. She is also co-founder of EuCheMS (European Association for Chemistry and Molecular Science).

Professor Jennifer Green, University of Oxford, UK

Jennifer Green is Professor of Inorganic Chemistry in the Chemistry Department of the University of Oxford. She joined the university as an undergraduate student in 1960 and obtained her BA in 1964 and her PhD and MA in 1967. She was appointed a Fellow of St. Hugh's College in 1969 and was made a Professor in 1999. She has served on the editorial boards of Organometallics and Inorganic Chemistry and is a member of the Conseil Scientifique of the CNRS (France). Professor Green's research is in the area of electronic structure of d- and f-block transition metal compounds and their reactivity. She has been active in the application of photoelectron spectroscopy to gas-phase inorganic molecules and in using density functional theory to model reaction mechanisms of organometallic compounds. She has 288 refereed publications.

Professor Helena Grennberg, Uppsala University, Sweden

Helena Grennberg is Professor of Organic Chemistry at Uppsala University, Sweden. She got her BSc in 1988 and her PhD in 1992, both from Uppsala. After a postdoctoral period in Paris, she got a position as assistant senior teacher at the Department of Chemistry, Uppsala University in 1994. She became docent and senior lecturer in 1996 and was promoted to a professorship in 2005. Her research and teaching interests span several themes, including organometallic chemistry, synthesis, catalysis, supramolecular chemistry, dyes for solar cells and the chemistry of fullerenes, carbon nanotubes and graphene. She has published more than 50 peer-reviewed papers, five reviews and has co-authored two high-school chemistry

textbooks. She has since 2005 organised and chaired seven scientific conferences with national as well as international participation. She holds commissions of trust at Uppsala University (vice-chair of the faculty board for PhD education and head of the chemistry BSc programme), within the Swedish Chemical Society (member of the main board and the board of the division of organic chemistry) and within EuCheMS (member of main executive board and chair of the division of organometallic chemistry).

Professor Søren Rud Keiding, Aarhus University, Denmark

Søren Rud Keiding is Professor in Physical Chemistry at the Department of Chemistry, Aarhus University. Since 1995, Keiding has co-directed the Femtosecond Laboratory. He obtained his PhD in physics from Aarhus in 1989, and worked at IBM Research in Yorktown Heights and at University of Southern Denmark before returning to Aarhus in 1995. In 2003, he was appointed director of the newly formed Engineering Graduate School at Aarhus and he participated in building what is now a thriving engineering school. In 2007, he resumed his research and teaching activities in femtosecond science and physical chemistry. His research activities have focused on the application of advanced laser techniques in the study of molecular phenomena, in particular liquid water. He has also worked on non-linear laser microscopy and non-linear effects in optical fibres. He is member of the Danish Academy of Technical Sciences and the Danish Academy of Natural Science. He has throughout his career worked in close collaboration with industry and was awarded the Industrial Price in 2003 in recognition of these activities. He has also actively been involved in the dissemination of natural science through countless public lectures on subjects such as Ferrari, guitars, water and lasers. He has published more than 100 papers in international journals and more than 30 PhD and MSc students have obtained their degrees from his laboratories.

Professor Torsten Linker, University of Potsdam, Germany

Torsten Linker is Full Professor of Organic Chemistry at the Department of Chemistry at the University of Potsdam since 2000. He was Head of the Department from 2005–2007. His research interests are in synthetic radical chemistry, carbohydrates, and stereoselective oxidation reactions. Linker is co-author of the book “Radicals and Radical Ions in Organic Synthesis”. He has served as a referee to various international journals and as a reviewer to the Deutsche Forschungsgemeinschaft (DFG). He received his Diploma from the Technical University of Darmstadt (1988) and his PhD from the University of Basel (1991). After his postdoctoral stay at the University of Edmonton, Alberta, Canada (1992) and Habilitation (1996) he was Heisenberg Professor at the University of Würzburg (1997) and Associate Professor at the University of Stuttgart (1998/99).

Professor Kenneth Ruud, University of Tromsø, Norway

Kenneth Ruud is Professor of Theoretical Chemistry at the University of Tromsø. He received his MSc in 1993 at the University of Oslo and his PhD from the same institution in 1998. After a postdoctoral period at the University of California, San Diego 1999–2000, he moved to the University of Tromsø, first as a postdoctoral researcher, then as associate professor, where he since 2002 has been a full professor in theoretical chemistry. He is currently Director of the Centre for Theoretical and Computational Chemistry, a Norwegian Centre of Excellence. His research interests include quantum chemistry method development, molecular electric, magnetic and vibrational properties, and the description of solvent effects. He has published 200 publications in international refereed journals. He has been awarded an Outstanding Young Investigator Award from the Norwegian Research Council and the Dirac medal of the World Association of Theoretically Oriented Chemists (WATOC). His current positions of trust include President of the Norwegian Chemical Society, member of the Board of the Division of Science of the Research Council of Norway, member of the Scientific Steering Committee of PRACE, member of the Core Groups of both the Physical and Engineering Standing Committee (PESC) of the European Science Foundation (ESF) and the ownership board of the Physical Chemistry Chemical Physics (PCCP), and he is a member of the board of the Division of Computational Chemistry of EuCheMS. He also serves on the editorial board of the International Journal of Quantum Chemistry and Advances in Physical Chemistry.

Directeur de Recherche Gabriel Wild, CNRS Nancy, France

Gabriel Wild has been Director of the Reactions and Chemical Engineering Laboratory (LRGP, Nancy, France, 270 members) since its creation in January 2010. He made is PhD (Dr-Ing thesis) in the University of Karlsruhe (Germany) in 1979 in the field of mass transfer, and his Habilitation (Dr ès sciences) at INPL Nancy in 1981. In 1979 he joined the CNRS unit Laboratoire des Sciences du Génie Chimique (LSGC: Chemical Engineering Science Laboratory) in Nancy as an "Attaché de recherche", became a "Chargé de recherche" (equivalent to associate professor) in 1981 and then "Directeur de recherche" (equivalent to full professor) in 1990.

From 2005 to 2009, he was Director of the Physical Chemistry of Reactions Laboratory (DCPR) in Nancy. This laboratory merged with LSGC to form the new LRGP in January 2010. From 2004 to 2008, he was the chair of the Working Party "Chemical Reaction Engineering" of the European Federation of Chemical Engineering.

His research interests concern mainly gas-liquid and gas-liquid-solid reactor engineering. He is the co-author of 100 articles in peer-refereed international journals and is one of three editors of the journal Chemical Engineering and Processing: Process Intensification.

C. Terms of reference for the panel

1 Objective of the evaluation

The objective of this evaluation is to evaluate chemistry research in Finland during the period 2005–2009. The panel is asked to look at the research from three different viewpoints: the field as a whole, the different subfields and the unit level. The evaluation report should present a critical assessment of the quality and relevance of chemical research in Finland. The quality, innovativeness and efficiency of the research should be compared with international standards. The panel is asked to provide recommendations for the future development of the research.

Additionally, the panel may consider the following items:

- Strengths, weaknesses, opportunities and threats of the research
- Impact on science and on society in general
- Resources (facilities, personnel, economic resources) and infrastructures
- Research network and collaborations (national, international and multidisciplinary)
- Education and career policies
- Any other issue the panel considers important.

The evaluation includes 41 research units in nine universities and one unit in a research institute. The evaluation is based on the evaluation forms filled in by the units and on the site visits by the evaluation panel. Visits are made to 35 units while the remaining six units are evaluated using the forms only.

2 Evaluation report and confidentiality

The results of the evaluation are collected into a report published by the Academy of Finland. The panellists will divide the work of writing the report among each other. The main responsibility for collecting and compiling text from the panellists is carried by the chair of the evaluation panel, who will be assisted by the coordinator of the evaluation. The Academy of Finland will provide editorial assistance for writing the report. The report will contain statements describing the research from three viewpoints: as a whole, the different subfields and for each evaluated research unit. The report will also contain recommendations by the panel.

Panel members will be provided with certain detailed information intended for evaluation purposes only. The panel members are asked to keep such information, knowledge, documents or other matters confidential. The extent to which detailed data on the units can be used in the final report must be agreed between the panel, the Academy of Finland and the coordinator. The panel members are also asked to keep the evaluation report confidential before the publication date. Any possible conflicts of interests are also determined and handled based on discussions between the panellists, the Academy of Finland and the coordinator.

D. The evaluation form

The evaluation form consists of two parts:

- Part I. Resources and research output of the unit
- Part II. Unit self-assessment

Part I: Selected parts of the information provided by the unit will be published in the evaluation report. Part II: The information provided by the unit will be used for evaluation purposes only and will not be published. No data concerning individual researchers will be published; the evaluation will not assess persons but the unit as a whole.

PART I. RESOURCES AND RESEARCH OUTPUT OF THE UNIT

1 GENERAL INFORMATION

A. Contact information

University
Evaluated Unit
Address
Phone
Internet website
Head of Unit
Phone
Email
Contact person for the evaluation, if not the Head of Unit
Phone
Email
Faculty or equivalent higher level of organisation
Head of Faculty or equivalent
Phone
Email

B. Unit's research profile within the field of evaluation

Estimate the percentage that chemistry research represents from all research done in your unit.

%

Give the information requested in the following Tables of Part I (personnel, funding etc.) only concerning the chemistry part of your research if not explicitly indicated otherwise.

Estimate the following chemistry subfield percentages respective to your all chemistry research (sum = 100%).

Table 1.1

Research	%
Analytical chemistry	
Inorganic chemistry	
Industrial chemistry	
Materials chemistry	
Organic chemistry	
Physical chemistry	
Polymer chemistry	
Theoretical chemistry	
Other research belonging to the field of evaluation (specify the subfield; you may add lines)	

2 RESOURCES

A1. Personnel

Include personnel funded through the university to which the unit belongs, or through some other funding source.

Include only those graduate students that have carried out their work in the unit.

Visiting research staff is not included here but in section A2 below (Tables 2.4 and 2.5).

Calculate full-time equivalents (FTE) for the evaluation period: (Total person-months for the category)/12/(5 years).

Table 1.2

	Person-months						
	2005	2006	2007	2008	2009	Total	FTE for the period
Professors							
Other senior researchers							
Postdoctoral researchers							
Total senior and postdoctoral							
Postgraduate students							
Other graduated academic staff							
Total postgraduate and other							
Total active research staff							
Research assistants and graduate students							
Administrative personnel							
Technical personnel							
Total assisting, admin. and technical							
All staff							

List the professors, other senior researchers and postdoctoral researchers for the evaluation period

Table 2.2

Name	Gender	Year of birth	Title	Degree	Degree awarded by	Year of awarding	Period of employment in the unit

Indicate the percentage of the research carried out by postgraduates and by PhDs.

Estimate also the percentage of the research funding used for basic and applied research.

Table 2.3

Type of research	Basic	Applied	Total
% Research funding			100
% Research done by postgraduates			
% Research done by PhDs			

A2. Visiting researchers

Include visiting researchers when the funding for the visit has been arranged through the activity of your unit (e.g. Academy of Finland, Tekes, EU funding).

Table 2.4

	Person-months						
	2005	2006	2007	2008	2009	Total	FTE for the period
Visiting professors							
Visiting senior researchers							
Visiting postdoctoral researchers							
Visiting postgraduate students							
All visiting researchers							

List the visiting professors, visiting senior researchers and visiting postdoctoral researchers here. The postgraduate students will be listed in section 4E, Visits to the unit, Table 4.7.

Table 2.5

Name	Gender	Title	Degree	Period of visit	Home organisation and subunit	Country	Source of funding

B. Funding

Table 2.6

		2005	2006	2007	2008	2009	Total
Core funding	Budget funding						
	Other						
External funding	Academy of Finland						
	Graduate schools (Min. Edu.)						
	Tekes						
	Other public sources						
	Industry						
	Private foundations						
	EU						
	Other foreign organisations						
Total							

3 RESEARCH OUTPUT

A. Number of scientific publications and other outputs

Table 3.1

	2005	2006	2007	2008	2009
1. Articles in refereed scientific journals					
2. Articles in refereed scientific edited volumes and conference proceedings					
3. Scientific monographs (excluding theses)					
4. Text books and other research volumes (e.g. edited proceedings)					
5. Research reports (e.g. laboratory reports)					
6. Other scientific publications (e.g. non-refereed articles)					
7. National patents, granted					
8. National patents, applied					
9. International patents, granted					
10. International patents, applied					
11. Other, specify					

B. Degrees

Table 3.2

	2005	2006	2007	2008	2009
Master's degree					
Number of postgraduate students					
Number of full-time postgraduate students					
Completed doctoral degree					

List of doctoral dissertations in 2005–2009

Table 3.3

Name (family name, given name)	Year of birth	Gender	Title of dissertation	Year of starting postgraduate studies	Year of completing degree	Years worked in the unit during post-graduate studies	Present employment (job description, organisation)

4 NATIONAL AND INTERNATIONAL COLLABORATION

Throughout this section, do not use abbreviations for institutes and universities but spell them out. Target the collaboration and visits to the period of evaluation (2005–2009).

More detailed content of the collaboration and important project consortia can be described in Part II: Collaboration.

A. Extent of collaboration

For your yearly production of refereed journal publications, give the percentages for co-authoring partners outside your unit.

Table 4.1

Percentage of refereed journal publications	2005	2006	2007	2008	2009
No co-author outside the unit					
Domestic co-author					
Foreign co-author					
Both domestic and foreign co-authors					

B. National collaboration

List your most important national collaborations. The collaborating organisation may also be from the same university or research institute, or industrial. The type of collaboration may be e.g. joint projects, personal collaboration, research mobility and networking.

The results may be:

- Refereed scientific publications
- Other publications
- Patents or other outputs
- Educational, MSc and PhD theses
- Facilities, instrumentation
- Prototypes, methodologies
- Networks.

Table 4.2

Main organisation and collaborating subunit	Type of collaboration and field of science	Results

C. International collaboration

List your most important international collaborations with the same criteria as in Section 4.B.

Table 4.3

Main organisation and collaborating subunit	Country	Type of collaboration and field of science	Results

D. Visits abroad

In the following, list only senior and postdoctoral researchers of Table 2.2. Do not include visits by the listed persons during their postgraduate studies. Minimum duration of visit is one month.

Table 4.4

Name	Target organisation and visited subunit	Country	Period of visit	Source of funding

In the following, list the visits abroad made by postgraduate students. Visits shorter than one month are not taken into account.

Table 4.5

Name	University and subunit	Country	Period of visit	Source of funding

E. Visits to the unit

Include visiting professors, visiting senior researchers and visiting postdoctoral researchers when the funding has not been organised through the activities of your unit. Minimum duration of visit is one month. Do not include visiting researchers from section 2. A2.

Table 4.6

Name and title of the visitor	Home organisation and visitor's subunit	Country	Field of science	Period of visit	Source of funding

In the following table, list the visits to the unit made by postgraduate students from other universities irrespective of the funding source. Visits shorter than one month are not taken into account.

Table 4.7

Name	University and subunit	Country	Period of visit	Source of funding

F. Industrial collaboration

In the following table, list only such collaboration in which senior and postdoctoral researchers listed in Table 2.2 have participated.

Table 4.8

Collaborating organisation and subunit	Country	Type of collaboration	Results of collaboration

In the following, list cases where industrial collaboration has constituted an essential part of completed postgraduate studies.

Table 4.9

Collaborating organisation and subunit	Country	Title of dissertation (form Table 3.3)

In the following, list MSc theses done in industry.

Table 4.10

Collaborating organisation and subunit	Country	Title of MSc thesis

5 OTHER SCIENTIFIC AND SOCIETAL ACTIVITIES

Throughout this section, include only senior and postdoctoral researchers of Table 2.2. Target the activities to the period of evaluation (2005–2009). Do not use acronyms of journals, conferences, institutions etc., but spell them out.

Invited presentations in scientific conferences

Table 5.1

Name	Title of presentation	Name of conference	Year

Memberships in editorial boards of scientific journals

Table 5.2

Name	Journal	Period

Representatives in international scientific boards, committees etc.

Table 5.3

Name	Board etc. and task	Period

Prizes awarded to researchers, honours, scientific positions of trust etc.

Table 5.4

Name	Prize, position etc.

Representatives in committees, scientific advisory boards and companies, or other similar tasks primarily not of an academic nature

Table 5.5

Name	Company, board etc. and task	Period

PART II. UNIT SELF-ASSESSMENT

A. Describe the unit's research and strategy (max. 2 pages).

B. SWOT evaluation of the unit's scientific strengths, weaknesses, opportunities and threats (expertise, funding, facilities, organisation; max. 2 pages)

C. Assess the research infrastructure available (max. 1 page).

D. Most important publications

Include a numbered list of the most important publications of the unit during 2005–2009. The number of listed publications: 5–8 publications for each professor together with his research group.

List the publications in order of importance (for each professor). Give reasons for your assessment of importance (original findings and new insights) shortly after each paper.

Send the unit's ten most important publications to kemia@aka.fi as a zipped file or paper copies.

E. Evaluate the unit in relation to its leading scientific competitors (max. 1 page).

F. Collaboration (max. 2 pages)

Describe the most important collaborative projects and consortia (max. 1 page).

Describe the most important outcomes of the collaboration (max. 1 page).

G. Societal impact (max. 1 page)

Describe the societal impact of the unit's activities.

Describe the unit's public visibility.

H. Administrative and educational load (max. 0.5 page)

Describe the nature of the administrative and educational load.

I. Funding

Assess from your point of view the funding from the following sources:

Funding by the Academy of Finland for promoting the scientific, educational and societal impact of research (max. 0.5 page).

List the researchers that have held an Academy post (Academy Professor, Academy Research Fellow, Postdoctoral Researcher's Project).

Name	Position	Period

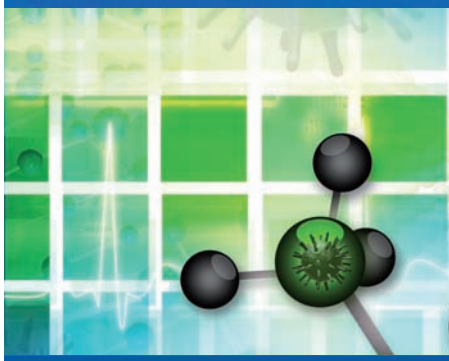
Funding awarded by other funding organisations for promoting the scientific, educational and societal impacts of research. Assess especially Tekes and EU funding (max. 1 page).

Funding obtained from industry for promoting the scientific, educational and societal impacts of research (max. 1 page).

J. Future prospects

Assess the future prospects of your unit and your research field both globally and on a Finnish scale. How do you expect the situation to look like after 5–10 years?

Chemistry research in Finland in 2005–2009 has been evaluated by an international expert panel. This evaluation report describes the panel's observations as to the quality of chemistry research and its different subfields and the interviewed units. The observations are accompanied by recommendations for improvement on both a general and unit level. The report also contains statistical material on the resources and outputs of the research.



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